# TGD AND EEG

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# Contents

# List of Figures

## 0.1 Background

*T(opological) G(eometro)D(ynamics)* is one of the many attempts to find a unified description of basic interactions. The development of the basic ideas of TGD to a relatively stable form took time of about half decade [16]. The great challenge is to construct a mathematical theory around these physically very attractive ideas and I have devoted the last twenty-three years for the realization of this dream and this has resulted in seven online books [1, 2, 4, 5, 3, 6, 7] about TGD and eight online books about TGD inspired theory of consciousness and of quantum biology [10, 8, 9, 13, 11, 12, 14, 15].

Quantum T(opological)D(ynamics) as a classical spinor geometry for infinite-dimensional configuration space, p-adic numbers and quantum TGD, and TGD inspired theory of consciousness have been for last decade of the second millenium the basic three strongly interacting threads in the tapestry of quantum TGD.

For few yeas ago the discussions with Tony Smith generated a fourth thread which deserves the name 'TGD as a generalized number theory'. The work with Riemann hypothesis made time ripe for realization that the notion of infinite primes could provide, not only a reformulation, but a deep generalization of quantum TGD. This led to a thorough and extremely fruitful revision of the basic views about what the final form and physical content of quantum TGD might be.

The fifth thread came with the realization that by quantum classical correspondence TGD predicts an infinite hierarchy of macroscopic quantum systems with increasing sizes, that it is not at all clear whether standard quantum mechanics can accommodate this hierarchy, and that a dynamical quantized Planck constant might be necessary and certainly possible in TGD framework. The identification of hierarchy of Planck constants whose values TGD "predicts" in terms of dark matter hierarchy would be natural. This also led to a solution of a long standing puzzle: what is the proper interpretation of the predicted fractal hierarchy of long ranged classical electro-weak and color gauge fields. Quantum classical correspondences allows only single answer: there is infinite hierarchy of p-adically scaled up variants of standard model physics and for each of them also dark hierarchy. Thus TGD Universe would be fractal in very abstract and deep sense.

TGD forces the generalization of physics to a quantum theory of consciousness, and represent TGD as a generalized number theory vision leads naturally to the emergence of p-adic physics as physics of cognitive representations. The seven online books [1, 2, 4, 5, 3, 6, 7] about TGD and eight online books about TGD inspired theory of consciousness and of quantum biology [10, 8, 9, 13, 11, 12, 14, 15] are warmly recommended to the interested reader.

## 0.2 Basic Ideas of TGD

The basic physical picture behind TGD was formed as a fusion of two rather disparate approaches: namely TGD is as a Poincare invariant theory of gravitation and TGD as a generalization of the old-fashioned string model.

### 0.2.1 TGD as a Poincare invariant theory of gravitation

The first approach was born as an attempt to construct a Poincare invariant theory of gravitation. Space-time, rather than being an abstract manifold endowed with a pseudo-Riemannian structure, is regarded as a surface in the 8-dimensional space $H = M^4_+ \times CP_2$, where $M^4_+$ denotes the interior of the future light cone of the Minkowski space (to be referred as light cone in the sequel) and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [2, 18, 19, 5]. The identification of the space-time as a submanifold [21, 22] of $M^4 \times CP_2$ leads to an exact Poincare invariance and solves the conceptual difficulties related to the definition of the energy-momentum in General Relativity [Misner-Thorne-Wheeler, Logunov *et al*]. The actual choice $H = M^4_+ \times CP_2$ implies the breaking of the Poincare invariance in the cosmological scales but only at the quantum level. It soon however turned out that submanifold geometry, being considerably richer in structure than the abstract manifold geometry, leads to a geometrization of all basic interactions. First, the geometrization of the elementary particle quantum numbers is achieved. The geometry of $CP_2$ explains electro-weak and color quantum numbers. The different H-chiralities of $H$-spinors correspond to the conserved baryon and lepton numbers. Secondly, the geometrization of the field concept results. The projections of the $CP_2$ spinor connection, Killing vector fields of $CP_2$ and of $H$-metric to four-surface define classical electro-weak, color gauge fields and metric in $X^4$.

### 0.2.2 TGD as a generalization of the hadronic string model

The second approach was based on the generalization of the mesonic string model describing mesons as strings with quarks attached to the ends of the string. In the 3-dimensional generalization 3-surfaces correspond to free particles and the boundaries of the 3- surface correspond to partons in the sense that the quantum numbers of the elementary particles reside on the boundaries. Various boundary topologies (number of handles) correspond to various fermion families so that one obtains an explanation for the known elementary particle quantum numbers. This approach leads also to a natural topological description of the particle reactions as topology changes: for instance, two-particle decay corresponds to a decay of a 3-surface to two disjoint 3-surfaces.

### 0.2.3 Fusion of the two approaches via a generalization of the space-time concept

The problem is that the two approaches seem to be mutually exclusive since the orbit of a particle like 3-surface defines 4-dimensional surface, which differs drastically from the topologically trivial macroscopic space-time of General Relativity. The unification of these approaches forces a considerable generalization of the conventional space-time concept. First, the topologically trivial 3-space of General Relativity is replaced with a "topological condensate" containing matter as particle like 3-surfaces "glued" to the topologically trivial background 3-space by connected sum operation. Secondly, the assumption about connectedness of the 3-space is given up. Besides the "topological condensate" there is "vapor phase" that is a "gas" of particle like 3-surfaces (counterpart of the "baby universies" of GRT) and the nonconservation of energy in GRT corresponds to the transfer of energy between the topological condensate and vapor phase.

## 0.3 The five threads in the development of quantum TGD

The development of TGD has involved four strongly interacting threads: physics as infinite-dimensional geometry; p-adic physics; TGD inspired theory of consciousness and TGD as a generalized number theory. In the following these five threads are briefly described.

### 0.3.1 Quantum TGD as configuration space spinor geometry

A turning point in the attempts to formulate a mathematical theory was reached after seven years from the birth of TGD. The great insight was "Do not quantize". The basic ingredients to the new approach have served as the basic philosophy for the attempt to construct Quantum TGD since then and are the following ones:

a) Quantum theory for extended particles is free(!), classical(!) field theory for a generalized Schrödinger amplitude in the configuration space $CH$ consisting of all possible 3-surfaces in $H$. "All possible" means that surfaces with arbitrary many disjoint components and with arbitrary internal topology and also singular surfaces topologically intermediate between two different manifold topologies are included. Particle reactions are identified as topology changes [23, 24, 25]. For instance, the decay of a 3-surface to two 3-surfaces corresponds to the decay $A \rightarrow B + C$. Classically this corresponds to a path of configuration space leading from 1-particle sector to 2-particle sector. At quantum level this corresponds to the dispersion of the generalized Schrödinger amplitude localized to 1-particle sector to two-particle sector. All coupling constants should result as predictions of the theory since no nonlinearities are introduced.

b) Configuration space is endowed with the metric and spinor structure so that one can define various metric related differential operators, say Dirac operator, appearing in the field equations of the theory.

### 0.3.2 p-Adic TGD

The p-adic thread emerged for roughly ten years ago as a dim hunch that p-adic numbers might be important for TGD. Experimentation with p-adic numbers led to the notion of canonical identification mapping reals to p-adics and vice versa. The breakthrough came with the successful p-adic mass calculations using p-adic thermodynamics for Super-Virasoro representations with the super-Kac-Moody algebra associated with a Lie-group containing standard model gauge group. Although the details of the calculations have varied from year to year, it was clear that p-adic physics reduces not only the ratio of proton and Planck mass, the great mystery number of physics, but all elementary particle mass scales, to number theory if one assumes that primes near prime powers of two are in a physically favored position. Why this is the case, became one of the key puzzless and led to a number of arguments with a common gist: evolution is present already at the elementary particle level and the primes allowed by the p-adic length scale hypothesis are the fittest ones.

It became very soon clear that p-adic topology is not something emerging in Planck length scale as often believed, but that there is an infinite hierarchy of p-adic physics characterized by p-adic length scales varying to even cosmological length scales. The idea about the connection of p-adics with cognition motivated already the first attempts to understand the role of the p-adics and inspired 'Universe as Computer' vision but time was not ripe to develop this idea to anything concrete (p-adic numbers are however in a central role in TGD inspired theory of consciousness). It became however obvious that the p-adic length scale hierarchy somehow corresponds to a hierarchy of intelligences and that p-adic prime serves as a kind of intelligence quotient. Ironically, the almost obvious idea about p-adic regions as cognitive regions of space-time providing cognitive representations for real regions had to wait for almost a decade for the access into my consciousness.

There were many interpretational and technical questions crying for a definite answer. What is the relationship of p-adic non-determinism to the classical non-determinism of the basic field equations of TGD? Are the p-adic space-time region genuinely p-adic or does p-adic topology only serve as an effective topology? If p-adic physics is direct image of real physics, how the mapping relating them is constructed so that it respects various symmetries? Is the basic physics p-adic or real (also real TGD seems to be free of divergences) or both? If it is both, how should one glue the physics in different number field together to get *The Physics*? Should one perform p-adicization also at the level of the configuration space of 3-surfaces? Certainly the p-adicization at the level of super-conformal representation is necessary for the p-adic mass calculations. Perhaps the most basic and most irritating technical problem was how to precisely define p-adic definite integral which is a crucial element of any variational principle based formulation of the field equations. Here the frustration was not due to the lack of solution but due to the too large number of solutions to the problem, a clear symptom for the sad fact that clever inventions rather than real discoveries might be in question.

Despite these frustrating uncertainties, the number of the applications of the poorly defined p-adic physics growed steadily and the applications turned out to be relatively stable so that it was clear that the solution to these problems must exist. It became only gradually clear that the solution of the problems might require going down to a deeper level than that represented by reals and p-adics.

### 0.3.3 TGD as a generalization of physics to a theory consciousness

General coordinate invariance forces the identification of quantum jump as quantum jump between entire deterministic quantum histories rather than time=constant snapshots of single history. The new view about quantum jump forces a generalization of quantum measurement theory such that observer becomes part of the physical system. Thus a general theory of consciousness is unavoidable outcome. This theory is developed in detail in the books [10, 8, 9, 13, 11, 12, 14, 15].

#### Quantum jump as a moment of consciousness

The identification of quantum jump between deterministic quantum histories (configuration space spinor fields) as a moment of consciousness defines microscopic theory of consciousness. Quantum jump involves the steps

$$\Psi_i \rightarrow U\Psi_i \rightarrow \Psi_f \ ,$$

where $U$ is informational "time development" operator, which is unitary like the S-matrix characterizing the unitary time evolution of quantum mechanics. $U$ is however only formally analogous to Schrödinger time evolution of infinite duration although there is *no* real time evolution involved. It is not however clear whether one should regard U-matrix and S-matrix as two different things or not: $U$-matrix is a completely universal object characterizing the dynamics of evolution by self-organization whereas S-matrix is a highly context dependent concept in wave mechanics and in quantum field theories where it at least formally represents unitary time translation operator at the limit of an infinitely long interaction time. The S-matrix understood in the spirit of superstring models is however something very different and could correspond to U-matrix.

The requirement that quantum jump corresponds to a measurement in the sense of quantum field theories implies that each quantum jump involves localization in zero modes which parameterize also the possible choices of the quantization axes. Thus the selection of the quantization axes performed by the Cartesian outsider becomes now a part of quantum theory. Together these requirements imply that the final states of quantum jump correspond to quantum superpositions of space-time surfaces which are macroscopically equivalent. Hence the world of conscious experience looks classical. At least formally quantum jump can be interpreted also as a quantum computation in which matrix $U$ represents unitary quantum computation which is however not identifiable as unitary translation in time direction and cannot be 'engineered'.

### The notion of self

The concept of self is absolutely essential for the understanding of the macroscopic and macro-temporal aspects of consciousness. Self corresponds to a subsystem able to remain un-entangled under the sequential informational 'time evolutions' $U$. Exactly vanishing entanglement is practically impossible in ordinary quantum mechanics and it might be that 'vanishing entanglement' in the condition for self-property should be replaced with 'subcritical entanglement'. On the other hand, if space-time decomposes into p-adic and real regions, and if entanglement between regions representing physics in different number fields vanishes, space-time indeed decomposes into selves in a natural manner.

It is assumed that the experiences of the self after the last 'wake-up' sum up to single average experience. This means that subjective memory is identifiable as conscious, immediate short term memory. Selves form an infinite hierarchy with the entire Universe at the top. Self can be also interpreted as mental images: our mental images are selves having mental images and also we represent mental images of a higher level self. A natural hypothesis is that self $S$ experiences the experiences of its subselves as kind of abstracted experience: the experiences of subselves $S_i$ are not experienced as such but represent kind of averages $\langle S_{ij} \rangle$ of sub-subselves $S_{ij}$. Entanglement between selves, most naturally realized by the formation of join along boundaries bonds between cognitive or material space-time sheets, provides a possible a mechanism for the fusion of selves to larger selves (for instance, the fusion of the mental images representing separate right and left visual fields to single visual field) and forms wholes from parts at the level of mental images.

### Relationship to quantum measurement theory

The third basic element relates TGD inspired theory of consciousness to quantum measurement theory. The assumption that localization occurs in zero modes in each quantum jump implies that the world of conscious experience looks classical. It also implies the state function reduction of the standard quantum measurement theory as the following arguments demonstrate (it took incredibly long time to realize this almost obvious fact!).

a) The standard quantum measurement theory a la von Neumann involves the interaction of brain with the measurement apparatus. If this interaction corresponds to entanglement between microscopic degrees of freedom $m$ with the macroscopic effectively classical degrees of freedom $M$ characterizing the reading of the measurement apparatus coded to brain state, then the reduction of this entanglement in quantum jump reproduces standard quantum measurement theory provide the unitary time evolution operator $U$ acts as flow in zero mode degrees of freedom and correlates completely some orthonormal basis of configuration space spinor fields in non-zero modes with the values of the zero modes. The flow property guarantees that the localization is consistent with unitarity: it also means 1-1 mapping of quantum state basis to classical variables (say, spin direction of the electron to its orbit in the external magnetic field).

b) Since zero modes represent classical information about the geometry of space-time surface (shape, size, classical Kähler field,...), they have interpretation as effectively classical degrees of freedom and are the TGD counterpart of the degrees of freedom $M$ representing the reading of the measurement apparatus. The entanglement between quantum fluctuating non-zero modes and zero modes is the TGD counterpart for the $m-M$ entanglement. Therefore the localization in zero modes is equivalent with a quantum jump leading to a final state where the measurement apparatus gives a definite reading.

This simple prediction is of utmost theoretical importance since the black box of the quantum measurement theory is reduced to a fundamental quantum theory. This reduction is implied by the replacement of the notion of a point like particle with particle as a 3-surface. Also the infinite-dimensionality of the zero mode sector of the configuration space of 3-surfaces is absolutely essential. Therefore the reduction is a triumph for quantum TGD and favors TGD against string models.

Standard quantum measurement theory involves also the notion of state preparation which reduces to the notion of self measurement. Each localization in zero modes is followed by a cascade of self measurements leading to a product state. This process is obviously equivalent with the state preparation process. Self measurement is governed by the so called Negentropy Maximization Principle (NMP) stating that the information content of conscious experience is maximized. In the self measurement the density matrix of some subsystem of a given self localized in zero modes (after ordinary quantum measurement) is measured. The self measurement takes place for that subsystem of self for which the reduction of the entanglement entropy is maximal in the measurement. In p-adic context NMP can be regarded as the variational principle defining the dynamics of cognition. In real context self measurement could be seen as a repair mechanism allowing the system to fight against quantum thermalization by reducing the entanglement for the subsystem for which it is largest (fill the largest hole first in a leaking boat).

### Selves self-organize

The fourth basic element is quantum theory of self-organization based on the identification of quantum jump as the basic step of self-organization [I1]. Quantum entanglement gives rise to the generation of long range order and the emergence of longer p-adic length scales corresponds to the emergence of larger and larger coherent dynamical units and generation of a slaving hierarchy. Energy (and quantum entanglement) feed implying entropy feed is a necessary prerequisite for quantum self-organization. Zero modes represent fundamental order parameters and localization in zero modes implies that the sequence of quantum jumps can be regarded as hopping in the zero modes so that Haken's classical theory of self organization applies almost as such. Spin glass analogy is a further important element: self-organization of self leads to some characteristic pattern selected by dissipation as some valley of the "energy" landscape.

Dissipation can be regarded as the ultimate Darwinian selector of both memes and genes. The mathematically ugly irreversible dissipative dynamics obtained by adding phenomenological dissipation terms to the reversible fundamental dynamical equations derivable from an action principle can be understood as a phenomenological description replacing in a well defined sense the series of reversible quantum histories with its envelope.

### Classical non-determinism of Kähler action

The fifth basic element are the concepts of association sequence and cognitive space-time sheet. The huge vacuum degeneracy of the Kähler action suggests strongly that the absolute minimum space-time is not always unique. For instance, a sequence of bifurcations can occur so that a given space-time branch can be fixed only by selecting a finite number of 3-surfaces with time like(!) separations on the orbit of 3-surface. Quantum classical correspondence suggest an alternative formulation. Space-time surface decomposes into maximal deterministic regions and their temporal sequences have interpretation a space-time correlate for a sequence of quantum states defined by the initial (or final) states of quantum jumps. This is consistent with the fact that the variational principle selects preferred extremals of Kähler action as generalized Bohr orbits.

In the case that non-determinism is located to a finite time interval and is microscopic, this sequence of 3-surfaces has interpretation as a simulation of a classical history, a geometric correlate for contents of consciousness. When non-determinism has long lasting and macroscopic effect one can identify it as volitional non-determinism associated with our choices. Association sequences relate closely with the cognitive space-time sheets defined as space-time sheets having finite time duration and psychological time can be identified as a temporal center of mass coordinate of the cognitive space-time sheet. The gradual drift of the cognitive space-time sheets to the direction of future force by the geometry of the future light cone explains the arrow of psychological time.

**p-Adic physics as physics of cognition and intentionality**

The sixth basic element adds a physical theory of cognition to this vision. TGD space-time decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, ...$. p-Adic regions obey the same field equations as the real regions but are characterized by p-adic non-determinism since the functions having vanishing p-adic derivative are pseudo constants which are piecewise constant functions. Pseudo constants depend on a finite number of positive pinary digits of arguments just like numerical predictions of any theory always involve decimal cutoff. This means that p-adic space-time regions are obtained by gluing together regions for which integration constants are genuine constants. The natural interpretation of the p-adic regions is as cognitive representations of real physics. The freedom of imagination is due to the p-adic non-determinism. p-Adic regions perform mimicry and make possible for the Universe to form cognitive representations about itself. p-Adic physics space-time sheets serve also as correlates for intentional action.

A more more precise formulation of this vision requires a generalization of the number concept obtained by fusing reals and p-adic number fields along common rationals (in the case of algebraic extensions among common algebraic numbers). This picture is discussed in [E1]. The application this notion at the level of the imbedding space implies that imbedding space has a book like structure with various variants of the imbedding space glued together along common rationals (algebraics). The implication is that genuinely p-adic numbers (non-rationals) are strictly infinite as real numbers so that most points of p-adic space-time sheets are at real infinity, outside the cosmos, and that the projection to the real imbedding space is discrete set of rationals (algebraics). Hence cognition and intentionality are almost completely outside the real cosmos and touch it at a discrete set of points only.

This view implies also that purely local p-adic physics codes for the p-adic fractality characterizing long range real physics and provides an explanation for p-adic length scale hypothesis stating that the primes $p \simeq 2^k$, $k$ integer are especially interesting. It also explains the long range correlations and short term chaos characterizing intentional behavior and explains why the physical realizations of cognition are always discrete (say in the case of numerical computations). Furthermore, a concrete quantum model for how intentions are transformed to actions emerges.

The discrete real projections of p-adic space-time sheets serve also space-time correlate for a logical thought. It is very natural to assign to p-adic pinary digits a $p$-valued logic but as such this kind of logic does not have any reasonable identification. p-Adic length scale hypothesis suggest that the $p = 2^k - n$ pinary digits represent a Boolean logic $B^k$ with $k$ elementary statements (the points of the $k$-element set in the set theoretic realization) with $n$ taboos which are constrained to be identically true.

### 0.3.4 TGD as a generalized number theory

Quantum T(opological)D(ynamics) as a classical spinor geometry for infinite-dimensional configuration space, p-adic numbers and quantum TGD, and TGD inspired theory of consciousness, have been for last ten years the basic three strongly interacting threads in the tapestry of quantum TGD. For few yeas ago the discussions with Tony Smith generated a fourth thread which deserves the name 'TGD as a generalized number theory'. It relies on the notion of number theoretic compactifiction stating that space-time surfaces can be regarded either as hyper-quaternionic, and thus maximally associative, 4-surfaces in $M^8$ identifiable as space of hyper-octonions or as surfaces in $M^4 \times CP_2$ [E2].

The discovery of the hierarchy of infinite primes and their correspondence with a hierarchy defined by a repeatedly second quantized arithmetic quantum field theory gave a further boost for the speculations about TGD as a generalized number theory. The work with Riemann hypothesis led to further ideas.

After the realization that infinite primes can be mapped to polynomials representable as surfaces geometrically, it was clear how TGD might be formulated as a generalized number theory with infinite primes forming the bridge between classical and quantum such that real numbers, p-adic numbers, and various generalizations of p-adics emerge dynamically from algebraic physics as various completions of the algebraic extensions of rational (hyper-)quaternions and (hyper-)octonions. Complete algebraic, topological and dimensional democracy would characterize the theory.

What is especially satisfying is that p-adic and real regions of the space-time surface could emerge automatically as solutions of the field equations. In the space-time regions where the solutions of field equations give rise to in-admissible complex values of the imbedding space coordinates, p-adic solution can exist for some values of the p-adic prime. The characteristic non-determinism of the p-adic differential equations suggests strongly that p-adic regions correspond to 'mind stuff', the regions of space-time where cognitive representations reside. This interpretation implies that p-adic physics is physics of cognition. Since Nature is probably extremely brilliant simulator of Nature, the natural idea is to study the p-adic physics of the cognitive representations to derive information about the real physics. This view encouraged by TGD inspired theory of consciousness clarifies difficult interpretational issues and provides a clear interpretation for the predictions of p-adic physics.

### 0.3.5 Dynamical quantized Planck constant and dark matter hierarchy

By quantum classical correspondence space-time sheets can be identified as quantum coherence regions. Hence the fact that they have all possible size scales more or less unavoidably implies that Planck constant must be quantized and have arbitrarily large values. If one accepts this then also the idea about dark matter as a macroscopic quantum phase characterized by an arbitrarily large value of Planck constant emerges naturally as does also the interpretation for the long ranged classical electro-weak and color fields predicted by TGD. Rather seldom the evolution of ideas follows simple linear logic, and this was the case also now. In any case, this vision represents the fifth, relatively new thread in the evolution of TGD and the ideas involved are still evolving.

#### Dark matter as large $\hbar$ phase

D. Da Rocha and Laurent Nottale [26] have proposed that Schrödinger equation with Planck constant $\hbar$ replaced with what might be called gravitational Planck constant $\hbar_{gr} = \frac{GmM}{v_0}$ ($\hbar = c = 1$). $v_0$ is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. This is rather near to the peak orbital velocity of stars in galactic halos. Also subharmonics and harmonics of $v_0$ seem to appear. The support for the hypothesis coming from empirical data is impressive.

Nottale and Da Rocha believe that their Schrödinger equation results from a fractal hydrodynamics. Many-sheeted space-time however suggests astrophysical systems are not only quantum systems at larger space-time sheets but correspond to a gigantic value of gravitational Planck constant. The gravitational (ordinary) Schrödinger equation would provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale [D6].

Already before learning about Nottale's paper I had proposed the possibility that Planck constant is quantized [E9] and the spectrum is given in terms of logarithms of Beraha numbers: the lowest Beraha number $B_3$ is completely exceptional in that it predicts infinite value of Planck constant. The inverse of the gravitational Planck constant could correspond a gravitational perturbation of this as $1/\hbar_{gr} = v_0/GMm$. The general philosophy would be that when the quantum system would become non-perturbative, a phase transition increasing the value of $\hbar$ occurs to preserve the perturbative character and at the transition $n = 4 \rightarrow 3$ only the small perturbative correction to $1/\hbar(3) = 0$ remains. This would apply to QCD and to atoms with $Z > 137$ as well.

TGD predicts correctly the value of the parameter $v_0$ assuming that cosmic strings and their decay remnants are responsible for the dark matter. The harmonics of $v_0$ can be understood as corresponding to perturbations replacing cosmic strings with their n-branched coverings so that tension becomes $n^2$-fold: much like the replacement of a closed orbit with an orbit closing only after $n$ turns. $1/n$-sub-harmonic would result when a magnetic flux tube split into n disjoint magnetic flux tubes. Also a model for the formation of planetary system as a condensation of ordinary matter around quantum coherent dark matter emerges [D6].

**Dark matter as a source of long ranged weak and color fields**

Long ranged classical electro-weak and color gauge fields are unavoidable in TGD framework. The smallness of the parity breaking effects in hadronic, nuclear, and atomic length scales does not however seem to allow long ranged electro-weak gauge fields. The problem disappears if long range classical electro-weak gauge fields are identified as space-time correlates for massless gauge fields created by dark matter. Also scaled up variants of ordinary electro-weak particle spectra are possible. The identification explains chiral selection in living matter and unbroken $U(2)_{ew}$ invariance and free color in bio length scales become characteristics of living matter and of bio-chemistry and bio-nuclear physics. An attractive solution of the matter antimatter asymmetry is based on the identification of also antimatter as dark matter.

**p-Adic and dark matter hierarchies and hierarchy of moments of consciousness**

Dark matter hierarchy assigned to a spectrum of Planck constant having arbitrarily large values brings additional elements to the TGD inspired theory of consciousness.

a) Macroscopic quantum coherence can be understood since a particle with a given mass can in principle appear as arbitrarily large scaled up copies (Compton length scales as $\hbar$). The phase transition to this kind of phase implies that space-time sheets of particles overlap and this makes possible macroscopic quantum coherence.

b) The space-time sheets with large Planck constant can be in thermal equilibrium with ordinary ones without the loss of quantum coherence. For instance, the cyclotron energy scale associated with EEG turns out to be above thermal energy at room temperature for the level of dark matter hierarchy corresponding to magnetic flux quanta of the Earth's magnetic field with the size scale of Earth and a successful quantitative model for EEG results [M3].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [M3]. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar(k) = \lambda^k(p)\hbar_0$, $\lambda \simeq 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, ...$ [M3]. Also integer valued sub-harmonics and integer valued sub-harmonics of $\lambda$ might be possible. Each p-adic length scale corresponds to this kind of hierarchy and number theoretical arguments suggest a general formula for the allowed values of Planck constant $\lambda$ depending logarithmically on p-adic prime [C6]. Also the value of $\hbar_0$ has spectrum characterized by Beraha numbers $B_n = 4cos^2(\pi/n)$, $n \geq 3$, varying by a factor in the range $n > 3$ [C6]. It must be however emphasized that the relation of this picture to the model of quantized gravitational Planck constant $h_{gr}$ appearing in Nottale's model is not yet completely understood.

The general prediction is that Universe is a kind of inverted Mandelbrot fractal for which each bird's eye of view reveals new structures in long length and time scales representing scaled down copies of standard physics and their dark variants. These structures would correspond to higher levels in self hierarchy. This prediction is consistent with the belief that 75 per cent of matter in the universe is dark.

*1. Living matter and dark matter*

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of EEG [M3]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [L2, M3]. A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [M3].

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by following observations. First, the argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of $\hbar$ at all. Secondly, the failure of the perturbation theory assumed to lead to the increase of Planck constant and formation of macroscopic quantum phases could be precisely due to the emergence of a large number of new degrees of freedom due to spin glass degeneracy. Thirdly, the phase transition increasing Planck constant has concrete topological interpretation in terms of many-sheeted space-time consistent with the spin glass degeneracy.

*2. Dark matter hierarchy and the notion of self*

The vision about dark matter hierarchy leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [J6, M3]. The larger the value of Planck constant, the longer the subjectively experienced duration and the average geometric duration $T(k) \propto \lambda^k$ of the quantum jump.

Quantum jumps form also a hierarchy with respect to p-adic and dark hierarchies and the geometric durations of quantum jumps scale like $\hbar$. Dark matter hierarchy suggests also a slight modification of the notion of self. Each self involves a hierarchy of dark matter levels, and one is led to ask whether the highest level in this hierarchy corresponds to single quantum jump rather than a sequence of quantum jumps. The averaging of conscious experience over quantum jumps would occur only for sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. The quantum parallel dissipation at the lower levels would give rise to the experience of flow of time. For instance, hadron as a macro-temporal quantum system in the characteristic time scale of hadron is a dissipating system at quark and gluon level corresponding to shorter p-adic time scales. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self corresponds at the highest dark matter level to single moment of consciousness. Self would experience the average over the sequence of moments of consciousness associated with each sub-self but there would be no averaging over the separate mental images of this kind, be their parallel or serial. These mental images correspond to sub-selves having shorter wake-up periods than self and would be experienced as being time ordered. Hence the digits in the phone number are experienced as separate mental images and ordered with respect to experienced time.

*3. The time span of long term memories as signature for the level of dark matter hierarchy*

The simplest dimensional estimate gives for the average increment $\tau$ of geometric time in quantum jump $\tau \sim 10^4$ $CP_2$ times so that $2^{127}-1 \sim 10^{38}$ quantum jumps are experienced during secondary p-adic time scale $T_2(k=127) \simeq 0.1$ seconds which is the duration of physiological moment and predicted to be fundamental time scale of human consciousness [L1]. A more refined guess is that $\tau_p = \sqrt{p}\tau$ gives the dependence of the duration of quantum jump on p-adic prime $p$. By multi-p-fractality predicted by TGD and explaining p-adic length scale hypothesis, one expects that at least $p=2$-adic level is also always present. For the higher levels of dark matter hierarchy $\tau_p$ is scaled up by $\hbar/\hbar_0$. One can understand evolutionary leaps as the emergence of higher levels at the level of individual organism making possible intentionality and memory in the time scale defined $\tau$ [L2].

Higher levels of dark matter hierarchy provide a neat quantitative view about self hierarchy and its evolution. For instance, EEG time scales corresponds to $k=4$ level of hierarchy and a time scale of .1 seconds [J6], and EEG frequencies correspond at this level dark photon energies above the thermal threshold so that thermal noise is not a problem anymore. Various levels of dark matter hierarchy would naturally correspond to higher levels in the hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question.

The level would determine also the time span of long term memories as discussed in [M3]. $k=7$ would correspond to a duration of moment of conscious of order human lifetime which suggests that $k=7$ corresponds to the highest dark matter level relevant to our consciousness whereas higher levels would in general correspond to transpersonal consciousness. $k=5$ would correspond to time scale of short term memories measured in minutes and $k=6$ to a time scale of memories measured in days.

The emergence of these levels must have meant evolutionary leap since long term memory is also accompanied by ability to anticipate future in the same time scale. This picture would suggest that the basic difference between us and our cousins is not at the level of genome as it is usually understood but at the level of the hierarchy of magnetic bodies [L2, M3]. In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible social rules and moral.

## 0.4 Bird's eye of view about the topics of the book

The TGD based general view about EEG developed in this book relies on the following general picture.

1. TGD Universe is fractal containing fractal copies of standard model physics at various space-time sheets and labeled by the collection of p-adic primes assignable to elementary particles and by the level of dark matter hierarchy characterized partially by the value of Planck constant labeling the pages of the book like structure formed by singular covering spaces of the imbedding space $M^4 \times CP_2$ glued together along a four-dimensional back. Particles at different pages are dark relative to each other since purely local interactions defined in terms of the vertices of Feynman diagram involve only particles at the same page. Fractality includes also a hierarchy of conscious entities-selves- and also moment of consciousness identified as quantum jump has fractal structure.

2. A central notion is that of magnetic body. Magnetic body acts as an intentional agent using biological body as a motor instrument and sensory receptor. There is an entire hierarchy of magnetic bodies associated with various body parts and characterized by the respective p-adic length scale $L_p = L(k)$, $p \simeq 2^k$, and the level of dark matter hierarchy labeled by rational number characterizing the value of Planck constant involved. There are indications that the values of Planck constant given by $\hbar = 2^{11k_d}\hbar_0$ are favored in living matter. The values of $p$ and $\hbar/\hbar_0$ could be seen as kind of intelligence and spiritual quotients.

3. Magnetic body controls the biological body and receives information from it. The hierarchy of EEGs (more generally the counterparts of EEG associated with $Z^0$, and $W$ bosons and gluons) consisting of dark bosons with energies above thermal threshold by the large value of $\hbar$, is the central aspect of this activity.

4. Cyclotron radiation assignable to cyclotron Bose-Einstein condensates at magnetic body and Josephson radiation assignable to Josephson junctions associated with the cell membrane and other electret type structures abundant in living matter are in a dominant role concerning communication and control. In particular, Cyclotron and Josephson frequencies correspond to EEG frequencies which together with p-adic length scale hypothesis leads to a highly predictive scenario.

5. The vision about DNA as topological quantum computer leads to a rather detailed view about how genome and cell membrane interact. Nucleotides and lipids would be connected by magnetic flux tubes carrying dark matter with varying values of Planck constant and define braiding affected by the 2-D flow of the lipids in liquid crystal state and giving rise to a topological quantum computation with program modules defined by standard liquid flow patterns resulting via quantum self organization process in presence of metabolic energy feed.

6. Sensory qualia could be associated with the generalized di-electric breakdowns between sensory organ and its magnetic body behaving somewhat like a capacitor. The cyclotron phase transitions of Bose-Einstein condensates of biologically important ions generated by the dark EEG photons at the magnetic body generate magnetic somatosensory qualia identifiable as our cognitive and emotional qualia. Long ranged charge entanglement made possible by $W$ MEs (topological light rays) are essential element of all motor control and generate exotic ionization of nuclei (new nuclear physics predicted by TGD) in turn inducing classical electric fields at space-time sheets carrying ordinary matter. These fields generate various responses such as ionic waves and nerve pulses yielding the desired physiological responses.

The plan of the book is roughly following. The chapter describing the magnetic sensory canvas hypothesis is followed by a model for nerve pulse and by three chapters devoted to EEG. A speculative chapter discussing the possible role of exotic neutrinos in hearing and cognition concludes the book.

The seven online books about TGD [1, 2, 4, 5, 3, 6, 7] and eight online books about TGD inspired theory of consciousness and quantum biology [10, 8, 9, 13, 11, 12, 14, 15] are warmly recommended for the reader willing to get overall view about what is involved.

# 0.5 The contents of the book

## 0.5.1 Magnetic Sensory Canvas Hypothesis

There are very general objections against the idea that ultimate sensory representations are realized inside brain. For instance, any computer scientist, unless informed about materialistic dogmas, would argue that the processing of the sensory data must be separated from its representation. How this could occur if sensory and other representations are realized inside brain, is however difficult to see.

In TGD approach these objections lead to the view that the magnetic flux tube structures associated with the primary sensory organs and higher levels of central nervous system define a hierarchy of sensory and other representations outside brain with magnetic flux tubes serving as the sensory canvas to which place coding by magnetic transition frequencies generates sensory sub-selves and associates with them various sensory qualia and features by quantum entanglement. Thus brain could be much like a RAM memory containing a collection of features in random order and the ordering would be induced by the sensory map to the magnetic sensory canvas.

MEs define the sensory projections and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size at least. Thus TGD based view about sensory representations is a diametrical opposite of the standard view in which sensory representations are miniatures.

The construction of a more detailed model is based on the following assumptions.

1. Sensory qualia are at the level of primary sensory organs having their own magnetic bodies and entangled with the cognitive and symbolic representations of the perceptive field in brain in turn entangled with the points of the sensory magnetic canvas. The entanglement between primary sensory organs and brain and TGD based view about long term memory resolves the basic objections against this view, and one can understand the differences between sensory experience, imagination, dreams, and hallucinations and various strange phenomena like synesthesia, Anton's syndrome, and blind sight.

2. Second essential element is the mirror mechanism of long term memories. To remember something in the geometric past at temporal distance $T$ is to look at a magnetic mirror with length $L = cT/2$. At quantum level quantum entanglement is involved and means sharing of mental images between recent me and the me of the geometric past (or some other self responsible for the memory representations). This requires that magnetic flux tubes involved with long term memories have astrophysical lengths with light year being the natural length unit. For magnetic fields this indeed makes sense. This picture can be applied to construct a model of long term episodal and declarative memories. The magnetic body (the "me") uses brain as a time mirror by generating a negative energy ME representing a signal propagating along magnetic flux tube to the brain and entangling magnetic body with brain. The negative energy ME is time reflected as a positive energy ME able to communicate classical information to the magnetic body possibly using p-adic cognitive code. Phase conjugate laser wave is the physical counterpart of negative energy ME.

3. Libet's findings about strange causal anomalies related to the passive aspects of consciousness support strongly the notion of magnetic body and lead to the conclusion that sensory experiences are geometric memories of magnetic body in time scale of .5 seconds about what happens in at the level of material body. Libet's findings about active aspects of consciousness in turn allow to conclude that motor activity is very much like active precognition and mirror image of sensory perception. A beautiful general scenario unifying sensory perception, long term memories, and motor action emerges and allows to explain phenomena like sensory rivalry difficult to understand in neuro-science framework. It must be however admitted that sensory canvas hypothesis is far from being established even in TGD framework: one can also defend the minimal model in which personal magnetic body is responsible only for the realization of long term memories and sensory, symbolic, and cognitive representations are realized only at the level of the material body.

4. Dark matter hierarchy based on a hierarchy of increasing values of Planck constant predicts a hierarchy of generalized EEGs. The generalized EEGs make it possible for the magnetic bodies to receive sensory information from biological body and quantum control it. The resulting

detailed model of ordinary EEG predicts correctly the band structure and narrow resonance bands.

### 0.5.2 Quantum model of nerve pulse

The basic idea behind the model of nerve pulse is that some kind of quantum jump reduces the magnitude of membrane potential below the threshold leading to the generation of nerve pulse. Several identification of this quantum jump have been discussed during years but no really convincing option has been found. The evolution of ideas about dark matter hierarchy and associated hierarchy of Planck constants led to a breakthrough in several sectors. The assignment the predicted ranged classical weak and color gauge fields to dark matter hierarchy was the crucial step and led among other things to a model of high $T_c$ superconductivity predicting the basic scales of cell, to a generalization of the genetic code to a hierarchy of genetic codes, and also to a generalization of EEG to a hierarchy of EEGs, ZEGs, and WEGs and of the colored variant of EEG. The newest input comes from the model of DNA as topological quantum computer and experimental findings challenging Hodgkin-Huxley model as even approximate description of the situation.

*1. New view about nerve pulse generation*

The model of nerve pulse has developed through several tortuous twists reflecting the development of the basic ideas of TGD inspired theory of consciousness and of bio-systems as macroscopic quantum systems. The chapters about EEG and ZEG provide a necessary background for the model of nerve pulse. The chapters [M4, M5] written before dark matter revolution provide a detailed discussion of basic aspects of EEG. The newest chapter [M3] related to EEG provides a very general vision about the hierarchy of EEGs based on dark matter hierarchy and about its generalization to ZEG and even WEG ($Z$ and $W$ denote for dark $Z^0$ and $W$ boson fields with interaction range which can be arbitrary long at higher levels of dark matter hierarchy). This model derives from the model of bio-superconductivity as quantum critical high $T_c$ super-conductivity [J1, J2, J3].

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several manners for how this could happen.

Quite recently I learned that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of tqc. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to

neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

3. The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that solitonic velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as tqc sine also microtubule-cell membrane systems are good candidates for performers of tqc. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane tqc would represent higher level tqc distinguishing between multi-cellulars and mono-cellulars.

4. New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD predicts that ordinary fermionic ions (such as $K^+$, $Na^+$, $Cl^-$) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic $W$ bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

*2. The function of neural transmitters*

TGD leads to a general view about the functions of membrane oscillations, nerve pulse and neural transmitters. 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 analogous to tastes and odors but providing information about external world whereas ordinary receptors give information about nearby environment. At our level of hierarchy these qualia probably correspond to emotions in consistency with the finding that neurotransmitters can be identified as information molecules. Neurotransmitters might 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.

*3. Empirical evidence for axonal super-conductivity*

A p-adic hierarchy of super-conductivities is the basic prediction of TGD inspired model of living matter. The many-sheeted model of the effective electronic super-conductivity explains at quantitative level the findings of Hafedh Abdelmelek and his group about the reduction of the axonal resistivity in the range of physiological temperatures. Although the original model is probably non-realistic the observations are consistent with the recent views about nerve pulse.

*4. Microtubular level*

The view about what happens at the micro-tubular 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. Micro-tubular 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.

What happens at the micro-tubular level during the nerve pulse, how gel phase differs from sol phase, and what occurs in sol-gel transition, belong to the principal challenges for quantum theories of consciousness. Charge entanglement associated with various bosonic ions allows to tackle these questions. The Bose-Einstein condensates of hydrogen atoms at tubular $k = 139$ space-time sheets form a bundle behaving like a liquid crystal identifiable as the gel phase. Positive and negative energy IR photons at energy of .1 eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this B-E condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler has demonstrated that photons with this energy have a maximal effect on cells.

Negative energy MEs are especially important: they make possible intentional action at the micro-tubular level, they are crucial for the understanding of the micro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called seesaw mechanism of energy metabolism. Seesaw mechanism minimizes dissipative losses and allows to understand how micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions, and thus define fundamental micro-tubular representation of declarative long term memories. Also the notion of micro-tubuli as quantum antennae becomes precisely defined.

The model of DNA as topological quantum computer brings in a new element. Microtubule-axonal membrane system could perform topological quantum computation just as DNA-membrane (nuclear and perhaps also cell membrane) system has been proposed to do. The braiding of the magnetic flux tubes connecting microtubules to axon would define tqc programs and also provide a representations for sensory input from sensory organs in time scale shorter than millisecond if one assumes that gel-sol-gel transition of microtubule accompanies the nerve pulse. Whether one it one say that nerve pulse is initiated at microtubular or axonal level or by both collectively is not clear since the magnetic flux tubes connecting these two systems make them to act like single coherent whole.

### 0.5.3 Dark Matter Hierarchy and Hierarchy of EEGs

The model for EEG and ZEG follows neatly from the general model of high $T_c$ superconductivity. A fractal hierarchy of EEGs and ZEGs is predicted labelled by p-adic length scales and an integer $k_d$ characterizing the value of $\hbar$ at various levels of dark matter hierarchy. To make the representation self-contained this model is discussed in detail before proceeding to the models of EEG and ZEG.

*1. General mechanisms of bio-superconductivity*

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the 'dropping' of charged particles from atomic space-time sheets to larger space-time sheets. The possibility of large $\hbar$ quantum coherent phases makes the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

A crucial element is quantum criticality predicting that new kind of superconductivity, "boundary superconductivity", appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei besides large $\hbar$ variant of ordinary superconductivity in the interior. The Cooper pairs of interior and boundary supra currents are different with interior Cooper pairs being BCS type. These two superconducting phases compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living matter. Also high $T_c$ superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic and $Z^0$ magnetic flux tubes and sheets are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for wormholy Cooper pairs. The fact that the critical magnetic ($Z^0$ magnetic) fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high $T_c$ bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature besides Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged.

*2. Bose-Einstein condensates at magnetic flux quanta in astrophysical length scales*

The new model for the topological condensation at magnetic flux quanta of magnetic field of .2 Gauss which explains the findings of Blackman and others (Earth's magnetic field has nominal value .5 Gauss) is based on the dark matter hierarchy with levels characterized by the value of $\hbar(k_d) = \lambda^{k_d}\hbar_0$, $\lambda \simeq 2^{11}$.

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

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

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

*3. Fractal hierarchy of magnetic flux sheets*

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

There are several manners to achieve quantization of magnetic flux with dynamical $\hbar$. From the point of view of EEG and ZEG especially interesting are flux flux sheets which have thickness $(5/\sqrt{2}) \times L(169)/\lambda = 8.8$ nm carrying magnetic field having strength $B = .2$ Gauss explaining the findings of Blackman and others. These flux sheets are slightly thinner than the 10 nm thick cell membrane and total transversal length $5L(168 + 5 \times 22) = 5L(256) = 5.7 \times 10^8$ km from flux quantization at $k_d = 4$ level of dark matter hierarchy necessary in order that the energies associated with cyclotron frequencies are above thermal threshold. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure.

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

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

*4. Fractal hierarchy of EEGs and ZEGs*

There are three contributions to EEG besides neural noise: Schumann frequencies, cyclotron frequencies, and the frequencies associated with Josephson junctions determined by the sum of the constant voltage and voltage perturbation determined by the superposition of cyclotron frequencies. Cyclotron contribution can be interpreted as a control signal from a magnetic body in question labelled by $k_d$ and affects both the ions at the flux sheets traversing DNA and the Josephson junction. The coherent state of photons generated by Josephson current corresponds to a reaction to this signal received by the magnetic body as a feedback. Schumann frequencies can be assigned to the control by magnetic body of Earth and correlate with the collective aspects of consciousness.

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

In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. One explanation is that right *resp.* left brain hemisphere corresponds to $Z = 2$ *resp.* $Z = 1$ quantization condition $Z\int BdS = n\hbar$ for the magnetic flux. $Z = 2$ case allows only doubly charged bosonic ions at magnetic flux sheets. $Z = 1$ case also also singly charged ions be their bosons or fermions and for this option magnetic field is scaled down by a factor of 1/2. The alternative explanation is that during sleep only Bose-Einstein condensates of singly charged exotic ions resulting when color bond inside nucleus becomes charged are present. This reduces the scale of cyclotron frequencies by a factor 1/2 and leaves only theta and delta bands. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. For $k_d = 3$ and magnetic field scaled up by $\lambda$ and flux tube area scaled down by $\lambda^{-2}$ DNA frequencies are scaled up to kHz for $Z = 2$ flux quantization and might define neuronal synchronization frequencies.

The generalization of the model for EEG hierarchy to the case of ZEG is straightforward and cyclotron frequency spectrum is essentially the same. $Z^0$ ions are obtained when nuclear color bonds become charged and the combination of ordinary and exotic ionization can produce also em neutral $Z^0$ ions. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

*5. The effects of ELF em fields on brain*

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in endogenous magnetic field $B = .2$ Gauss on vertebrate brains provide a test bench for the fractal hierarchy of EEGs. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and ZEGs.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions. They occur only in amplitude windows. The first one is around $10^{-7}$ V/m and second corresponds to the range $1 - 10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

The temperature interval has interpretation in terms of quantum criticality of high $T_c$ superconductivity (both interior and boundary super currents are possible in this interval). Amplitude windows correspond to resonant EEG bands if the voltage perturbations contribute to the voltages over Josephson junctions and are thus coded to EEG. That the effects occur only for cyclotron frequencies and in the amplitude windows can be understood if there is AND gate involved. The voltage signal affects the interior of the cell nucleus opening communication line to the magnetic body if a harmonic of cyclotron frequency is in question. The signal affects also the Josephson junction which sends a signal to magnetic body if the voltage of the perturbation is large enough and corresponds to a frequency in the resonance band of EEG. The response of the magnetic body affects nucleus only if the communication line is open. This AND gate eliminates very effectively the effects of neural noise.

*6. EEG, ZEG, and consciousness*

The interpretation of cyclotron phase transitions from the point of view of conscious experience is discussed. Cyclotron frequencies are ideal for communication, control, and coding purposes. One can also ask whether cyclotron transitions correspond to some sensory qualia. "General feeling of existence" possibly accompanying all sensory qualia is one possible identification for the quale involved. Also the possibility that cyclotron phase transitions could serve as quantum correlates for tastes and odors is discussed.

### 0.5.4 Quantum model of EEG and ZEG: part I

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

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

*1. Overall view*

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

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

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

*2. Basic contributions to EEG and ZEG*

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

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

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

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

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

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

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

*3. Emotions and cognition as sensory qualia of magnetic body*

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

*4. Right brain sings and left brain talks*

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

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

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

*5. p-Adic cognitive codes*

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

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

### 0.5.5 Quantum model of EEG and ZEG: part II

In the previous chapter the overall TGD based view about EEG was discussed. According to this view, the basic function of EEG is to induce cyclotron phase transitions at the magnetic body and thus to produce what might be called higher level sensory qualia identified as emotions and cognitions. In this chapter the relationship between EEG and nerve pulse patterns is discussed in TGD framework.

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. The deep difference between TGD and the conventional neuroscience is the presence of the hierarchy of magnetic bodies, cyclotron transitions, and MEs. This makes possible to consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits.

Nerve pulses generate 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. Pendulum metaphor suggests how spike patterns amplify EEG waves at frequencies, which appear as resonances in the autocorrelation function of the spike sequence: when the pendulum is kicked at correct half of its period its oscillation frequency remains unchanged but amplitude and phase suffer discontinuous changes. The EEG waves generated by subsequent nerve pulses tend to interfere constructively resulting in amplification if the EEG frequency corresponds to a resonance frequency of the spike autocorrelation function.

*1. Generalization of the model for sensory receptor and new view about hearing*

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. In TGD framework on ecan consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits and dark matter hierarchy challenges the earlier speculative TGD inspired models for sensory qualia and sensory organ. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be considered. The question arises whether sensory organs define not only sensory, but also corresponding cognitive and emotional representations. The fact that nerve pulses tend to destroy the temporal coherence of cognitive and emotional representations encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further ideas. For instance, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in the case of vision and hearing.

*2. Features*

Walter Freeman has identified spatially amplitude modulated synchronous but non-periodic EEG patterns serving as correlates for conscious percepts. The identification as MEs is possible and the spectrum of durations for the synchronous time patterns encourages the interpretation of these patterns as an electromagnetic realization of genetic code words. A compression of memetic code words defined by the nerve pulse patterns giving rise to abstraction and classification would be in question.

The representation would be achieved by the amplitude modulation of the alpha waves by higher harmonics of alpha frequencies. In the case of hearing the contraction seems to be un-necessary and memetic code could perhaps be realized also at the level of features. This would explain the completely exceptional role of the language in cognition.

*3. Synchronization*

Synchronization in and between various cortical areas is known to occur with millisecond precision. Also disjoint brain regions can be in synchrony. This is difficult to understand without synchronizing agent oscillating at kHz frequency. In TGD framework magnetic body is the natural agent inducing the synchrony and MEs could induce the synchronization. Synchronization would naturally occur at the frequency corresponding to a duration of the bit of the memetic code.

*4. Stochastic resonance*

Concerning the mapping of EEG frequencies to nerve pulse patterns, stochastic resonance promotes itself as a basic mechanism. In bistable systems stochastic resonance allows to amplify very weak periodic signals by utilizing white noise. Stochastic resonance is known to be relevant also at the neuronal level as demonstrated by the autocorrelation functions for spike sequences exhibiting peaks at the harmonics of the signal frequency. Neuron is however far from being bistable system, and this raises the question whether bi-stability might be present at some deeper quantal level.

*5. Temporal codings*

The conventional view that the information content of conscious experience is determined completely by rate coding from nerve pulse patterns does not seem plausible in TGD framework. Indeed, p-adic cognitive codes define an entire hierarchy of binary codes associated with the p-adic frequencies and frequency coding would apply only to the average intensity of the sensory input. For high stimulus intensities the duration of the bit of the p-adic cognitive codeword tends to become shorter. This is comparable to the increase of the speech rate during a high state of arousal, and conforms with the observed shift of EEG towards higher frequencies in this kind of situation. There is a lot of experimental evidence supporting the existence of various kinds of temporal codings, and these codings are discussed in TGD framework.

### 0.5.6 Quantum model for hearing

The statistical physics vision for qualia inspires the working hypothesis that quantum number increments determine qualia independently of the context (other quantum numbers). This hypothesis; the fact that hearing is frequency and time sense; and the observation that energy is conjugate to time together inspire the idea that energy increment determines some essential sub-quale of the hearing sensation common to all sensory experiences. Hearing would thus involve the time-like counterpart of force sense and the gradient of the total energy of non-f with respect to subjective time would be the physical variable sensed.

The universal character of energy (or rather power–) quale need not lead to paradoxes. The frequency range involved with hearing is at least three orders of magnitude wider than the EEG frequency range associated with other sensory inputs. Thus the contribution of the other senses to the energy aspect of the auditory sensation might be just a very low intensity noise. Hearing could be seen as a sense specialized to the energy and time aspects of sensation. This hypothesis might well be testable, for instance, by artificially inducing cortical deafness and by finding whether some aspect of hearing is still experienced. Note that neutrino spin flip is additional aspect of hearing in the model to be discussed, and might give the essential contribution to what it feels to hear.

*1. Generalization of the model for sensory receptor and new view about hearing*

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. In TGD framework one can consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits and dark matter hierarchy challenges the earlier speculative TGD inspired models for sensory qualia and sensory organ. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be considered.

The question arises whether sensory organs define not only sensory, but also corresponding cognitive and emotional representations. The fact that nerve pulses tend to destroy the temporal coherence of cognitive and emotional representations encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further ideas. For instance, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in the case of vision and hearing.

*2. Possible roles of neutrinos in hearing*

One can imagine several roles for exotic neutrinos in TGD inspired theory of consciousness and it is good to provide an overall summary first.

1. Dark matter hierarchy allows to consider cognitive and emotional representations based on cyclotron phase transitions for Cooper pairs of dark neutrinos at $Z^0$ magnetic flux quanta.

2. The notion of cognitive neutrino pair represents genuinely many-sheeted physics and is the key element of the original quantum model for hearing. The neutrino and antineutrino of the pair correspond to light-like causal horizons defining the throats of a $CP_2$ sized wormhole contact. In condensed matter the pair could have nearly vanishing total energy. Quite generally, many fermion states of the Universe, which have vanishing net fermion numbers, have interpretation as quantum superpositions of Boolean statements with the presence/absence of fermion coding for 1/0. Cognitive neutrino pairs would be a particular example of this representation and naturally related to logical aspects of cognition.

   In the basic variant of the model the frequency increment of the cyclotron transition of exotic neutrino involving also spin flip codes for the pitch of the sound. The basic prediction is that several cognitive (phoneme based) and emotional (pitch based) representations of the auditory input corresponding to various levels of the dark matter hierarchy are possible. Also cognitive neutrino pairs could define this kind of representation and since a rather low level of dark matter hierarchy is in question it is possible that this particular representation does not correspond to the representation of pitch at our level of the dark matter hierarchy.

3. There are two models for memetic codons in terms of temporal sequences of cognitive neutrino pairs. In the first model the existence or non-existence of cognitive neutrino pair (more precisely, the existence of a topological sum contact connecting the neutrino and antineutrino at parallel space-time sheets) in this sequence codes for a bit. The generation of a topological sum contact between $CP_2$ type extremals representing neutrino and antineutrino at parallel space-time sheets would transform 0 to 1. In the second variant of the model spin direction for the cognitive neutrino codes for a bit. In this case wormhole contact must carry spin one and consist of a left handed neutrino and its antineutrino. In this case $Z^0$ magnetic spin-spin interaction is expected to correlate the spin directions tightly and favor parallel spins so that the system behaves like spin one object and both spins flip in the $Z^0$ magnetic field residing at either space-time sheet. Also Coulomb interaction between neutrino and antineutrino at light-like wormhole throats contributes to the binding energy. The long ranged $Z^0$ Coulombic interaction of neutrino with dark matter, say dark protons, can induce large Coulombic binding energy and further reduce the mass of cognitive neutrino pair and even change the sign of energy so that cognitive neutrino pairs could be generated spontaneously.

*3. Cognitive codes and cognitive neutrino pairs*

This conceptual framework leaves a lot of room for detailed models. Perhaps the most realistic view inspired by the general model of cognition and by the general vision about dark matter is that the memetic codon is represented as $Z^0$ magnetic body as quantum state at $\delta H_\pm = \delta M^4_\pm \times CP_2$. The super-position of zero energy pairs of memetic codons associated with $\delta H_+$ and $\delta H_-$ could be interpreted as a representation of a Boolean function. Therefore the size scale of representation is measured in terms of the photon wavelength associated with the typical frequency in audible range.

Since super-canonical Hamiltonians depend on the radial light-like coordinate of $\delta M^4_+$ via a power law and define logarithmic waves, logarithmic representation of codon is highly suggestive. This would mean that the 3-surface $X^3_k$ representing k:th bit at $\delta H_\pm$ has size proportional to say $2^k$ (also more general scalings are possible). This allows to distinguish between bits, which is essential for generating selective spin flip inducing conscious bit. The most natural mechanism inducing the flip on spontaneously magnetized $X^3_k$ is based on $Z^0$ ME carrying transversal $Z^0$ magnetic field with constant direction and having transversal sizes identical to that of $X^3_k$.

This representation does not favor large numbers of bits, and the requirement that cyclotron energies are in the range defined by thermal energy at room temperature and the energy 2 eV of photons which are still visible, favors 6-bit memetic code.

One can construct more complex $6n$-bit codes (more generally $mn$-bit codes) by allowing several levels of dark matter hierarchy labelled by the values of $\hbar_{eff}/\hbar_0 = 2^{6k}$, $k = k_0, ..., k_0{+}n$. In this manner it is also possible to construct a fractal variant of the memetic code as a structured representation in which various levels of dark matter hierarchy (self hierarchy) represent m-bit bunches of information at various levels of abstraction. Given level in hierarchy experiences the level below as a mental image and the levels below that level are experienced as averages. This loss of information is an unavoidable consequence of having bird's eye of view.

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# Chapter 1

# Magnetic Sensory Canvas Hypothesis

## 1.1 Introduction

There are very general objections against the idea that the ultimate sensory representations are inside brain. For instance, any computer scientist, unless informed about materialistic dogmas, would argue that the processing of the sensory data must be separated from its representation. How this could occur if sensory and other representations are realized inside brain, is however difficult to see. The classical experiments of Libet relating to the active and passive aspects of conscious experience [38, 27, 22] provide a strong empirical support for the view that signals from central nervous system (CNS) spend .3-.5 seconds to propagate somewhere else. If the propagation occurs with the velocity of light, the distance in question is measured using the circumference of the Earth as a natural unit.

### 1.1.1 Sensory canvas hypothesis

In TGD approach these objections lead to the view that the magnetic flux tube structures associated with the central nervous system (CNS) could define a hierarchy of sensory, symbolic, and cognitive representations outside brain with magnetic flux quanta of the magnetic bodies serving as the canvas to which place coding by magnetic frequency generates sub-selves (mental images about "simple feeling of existence") and associates with them various sensory qualia and symbolic and cognitive features by quantum entanglement. Thus brain could be much like a RAM memory containing a collection of features in random order and the ordering would be induced only by the sensory map to the magnetic sensory canvas. Are our sensory representations at the magnetic flux tubes of Earth's magnetic field or are personal magnetic bodies needed? Since space travellers experience the world very much like us and have survived, the most plausible conclusion is that the magnetic sensory canvas is personal. This conclusion is also supported by the fact that the value of the magnetic field explaining the harmonics of 15 Hz as $Ca^{++}$ cyclotron frequencies is .2 Gauss rather than .5 Gauss.

### 1.1.2 Why the world is not experienced to rotate as head rotates?

The question which originally led to the notion of the sensory magnetic canvas was "Why the world is not experienced to rotate as head rotates?". If one assumes that sensory representations are completely inside the cortex and that the positions of various visual mental images in the visual cortex remain fixed with respect to cortex as is done in the standard neuroscience, the entire sensory representation rotates thus with the head and one could argue that the world is experienced to rotate.

If one accepts the sensory magnetic sensory canvas hypothesis situation changes. Assuming that

1. the objects of the perceptive field induce sensory mental images (sub-selves) already at the level of sensory organs (in particular, retinas) and representations at corresponding magnetic bodies;

2. these mental images, being self-organization patterns, whose boundaries are determined by the gradients of illumination, do not rotate as the head or eye rotates;

3. the points of the retina correspond to fixed points of the visual cortex in topographic manner;

4. the projections to the sensory magnetic canvas from the visual cortex occur orthogonally;

one can answer the question. Note that the personal sensory magnetic body is fixed with respect to head and rotates with it whereas the representation projected to it and defining a self-organization pattern does not. In other words, magnetic body acts like a canvas.

MEs define this sensory projection and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size at least. Thus TGD based view about sensory and other representations is a diametrical opposite of the standard view in which sensory representations are miniatures.

Some comments about terminology are in order. Sensory representations involve besides the primary sensory qualia the symbolic representations constructed by brain giving meaning for the sensory input. I will use also the phrase "cognitive representation". Space-time correlates for cognitive representations are tentatively identified as p-adic space-time sheets coinciding with real space-time sheets in resolution defined by some cutoff length scale: in general the intersection with real space-time sheets is discrete set of rational points common to reals and p-adic number fields. p-Adic space-time sheets are also identified as correlates for intentions and the realization of intention as action is tentatively identified as a quantum jump replacing p-adic space-time sheet with a real one in such a manner that conservation laws are satisfied.

### 1.1.3 Model for the sensory representations

The construction of a more detailed model is based on the following assumptions.

1. Sensory qualia are at the level of primary sensory organs having their own magnetic bodies and entangled with the cognitive and symbolic representations of the perceptive field in brain in turn entangled with the points of the sensory magnetic canvas. The entanglement between primary sensory organs and brain and TGD based view about long term memory resolves the basic objections against this view, and one can understand the differences between sensory experience, imagination, dreams, and hallucinations and various strange phenomena like synesthesia, Anton's syndrome, and blind sight.

2. Second essential element is the mirror mechanism of long term memories. To remember something in the geometric past at temporal distance $T$ is to look at a magnetic mirror with length $L = cT/2$. At quantum level quantum entanglement is involved and means sharing of mental images between recent me and the me of the geometric past (or some other self responsible for the memory representations). This requires that magnetic flux tubes involved with long term memories have astrophysical lengths with light year being the natural length unit. For magnetic fields this indeed makes sense. This picture is of course dramatically over-simplified. A more realistic model of long term episodal and declarative memories in which the magnetic body uses time mirror mechanism by sending entangling negative energy ME to the brain making possible sharing of mental images. From brain negative energy MEs are time reflected back as positive energy MEs and are possibly amplified. Positive energy MEs can give rise to classically communicated declarative memories. This means that the distance along a flux tube of the personal magnetic body codes for the temporal distance to geometric past.

3. The already mentioned findings of Libet about strange causal anomalies related to the passive aspects of consciousness lead to the conclusion that sensory experiences are geometric memories of the personal magnetic body in time scale of .3-.5 seconds about what happens in at the level of material body. Libet's findings about active aspects of consciousness in turn allow to conclude that also motor activity must involve time mirror mechanism with negative energy topological light rays sent to the geometric past and inducing the neural activity as a response. Without this mechanism we could not survive using .3-.5 seconds old sensory data. A beautiful general scenario for the realization of intentions and unifying sensory perception, long term memories, and motor action emerges and allows to explain phenomena like sensory rivalry difficult to understand in neuroscience framework.

The flux tube structure associated with the Earth's magnetic field could define or at least closely relate sensory canvases of Mother Gaia and of smaller magnetospheric selves. It is quite conceivable that also magnetosphere contains various kinds of representations of the information from brain and body. The local direction of Earth's magnetic field at cortex should fix the orientation of the projectors associated with the sensory representations in the co-rotating inner magnetosphere. Pyramidal neurons contain magnetic crystals and also haemoglobin molecules are magnetic and their alignment with the local magnetic field of Earth would make this possible.

These representations could be responsible for the third person perspective which is also an integral part of our consciousness: the mechanism providing the third person aspect would be sharing of the mental images by quantum entanglement. Out-of-body experiences and near death experiences could be one particular manifestation for this component of consciousness. The magnetospheric representations could be also responsible for long term memory representations.

There are reasons to believe that also the non-rotating outer magnetosphere might contain representations. For these representations the projectors should be parallel to the flux tubes of a magnetic field which is stationary with respect to Earth. The flux tubes of the outer magnetosphere might be able to penetrate to some extent the inner magnetosphere and attach to brain or body. For instance, the magnetic field created by the magnetic particles in lungs is of the same magnitude as the magnetic field in the plasma sheet at the night side of Earth.

### 1.1.4 EEG as a communication and control tool of magnetic body

The progress made during the year 2005 in the understanding of the dark matter hierarchy stimulated a quantum leap in many branches of TGD with the model of the magnetic body included. This forced some updating of also this chapter although I tried to not destroy the original flavor of the chapter. I also added a section about about a hierarchy of generalized EEGs associated with the dark matter hierarchy making possible for the magnetic bodies to receive sensory information from biological body and quantum control it. The chapter "The Hierarchy of Generalized EEGs and Dark Matter Hierarchy" [M3] provides a detailed vision about magnetic body as an intentional agent receiving sensory input from the biological body and using it as a motor instrument.

In this chapter a general vision about the magnetic sensory canvas hypothesis is discussed. The discussion continues in [N1]. These chapters are not a reviews of the final results after the dust has settled but document the development of ideas as it has occurred and is still occurring. There are many mammoth bones and little inconsistencies, and often the simple final picture is achieved by a lot of painful sidetracking. The very name "Magnetic sensory canvas hypothesis" of this chapter is a good example of this problem: both symbolic, cognitive and sensory mental images entangle with the magnetic body so that the attribute "sensory" is somewhat misleading. Furthermore, motor control aspect is equally important. Perhaps a better title would be "Magnetic body hypothesis". My sincere apologies for the reader for this: I can do only my best!

## 1.2 Where me is?

A concrete model of consciousness requires a specification of the self that I am used to call "me". The standard neuroscience approach would not hesitate in identifying "me" with the neural activities or of their seat and thus localizing it inside head. The notions of the many-sheeted space-time and ELF ME allow to take a fresh look at the problem.

### 1.2.1 Is "me" outside my body or does it contain it?

There are several both TGD based arguments and arguments based on basic facts about sensory experiencing supporting the view that "me" is not completely inside my head or physical body. More precisely, it might be possible to identify visual and auditory fields more or less as an extension of my body as the following arguments suggest.

1. p-Adic cognitive maps discussed [E6] map typically inside to outside and vice versa. Does this imply that the cognitive and sensory maps of the external world are outside my body? Am I looking the sensory image of the external world in the spherical mirror provided by my brain. I know that the image of the external world is in question but I do not realize that I am not that

image. Of course, "me" could contain also the body and the sensory mental images about body would be located in body region and help to generate the illusion that I am nothing but my body, or actually brain as well-informed neuroscientist would believe. To get rid of the mirror illusion one must break the mirror and physical death is the final manner to achieve this. Near death experiences indeed involve the experience of looking one's own body from outside (these experiences are discussed in [H8] and [I3]).

A further interesting point is that imbedding-space points p-adically near to each other are faraway in the real sense. Simple intentions have p-adically small space-time sheets as their correlates and corresponding desires represented by their real counterparts have a maximal number of rational imbedding space points in common. Thus simple desires have large real space-time sheets as their correlates. Therefore astrophysical and even cosmic length scales are natural for cognition and intention, and the evolution of cognition from small to large length scales in a p-adic sense corresponds to the evolution from long towards short real length scales like a carving of a statue by adding details. The learning of a motor skill proceeding from clumsy whole-body movements to refined movements involving a minimal number of body parts is an excellent example of this aspect of cognitive evolution.

2. The paradigm of four-dimensional brain leads to believe that long term memories are perceptions with the objects of the perceptive field located in the geometric past (and Libet's experiments lead to the conclusion that sensory percepts are memories in time scale of .5 seconds!). But why not also the objects of visual and auditory field *spatially* external to me should not be sensorily represented outside my body. Same applies also to the parts of body external to the brain. This leaves several options. For instance, fundamental sensory representations could be realized using entanglement with the objects of the perceptive field as an auxiliary tool to deduce distances and sizes of objects of the perceptive field. Perceptive field would in some sense become a part of its sensory representation. It could also be that sensory representations occur at magnetic bodies and in quite different length scales.

We indeed experience external world like an external observer looking at the projection of the image of the external world on a sensory canvas defined by brain: the orientation or motion of canvas does not matter.

### 1.2.2 Sensory canvas hypothesis and some problems related to sensory representations

There are several basic problems related to the sensory representations, which could be solved if "me" is outside my body.

#### Problems with reference frames

The problems related to reference frames associated with retina, head and body result if one assumes that the reference frame of the conscious observer is that of brain as is natural to assume if brain is the seat of conscious experience.

1. Retina defines the reference frame for patterns of neural activity and topographical mapping of neural activity in retina to the visual cortex means that the motion of eye induces a motion of the pattern of neural activity inside brain. Why saccadic motion or larger scale rotation of eye (resulting from the change of the direction of gaze) does not give rise to experienced motion of the external world relative to head?

2. Also my head and body can move. Why I do not experience world moving around when I turn my head or move my body? The picture of world at the surface of cortex changes its position certainly. It is difficult to imagine how brain could be able to compute and make the corrections cancelling *totally* this sensation.

Essentially brain is able to experience the external world as it would look like if seen from outside with eyes and brain serving as a moving canvas at which the visual information is projected. That is: the conscious observer effectively looks the situation, not in the reference frame of the head, but in the reference frame of the environment. As if the sensory representation (defined to include also symbolic and cognitive aspects besides purely sensory aspects) would be realized outside cortex at some kind of canvas stationary with respect to head by utilizing the topographic map between retina and visual cortex, and by projecting data from the visual cortex in a direction orthogonal to it. Although the head and canvas rotate, the projected sensory picture realized as a self-organization pattern, would remain stationary.

**Problems related to stereovision and perspective**

There are also problems related to the stereo vision.

1. How the position coordinate of the objects of the external world orthogonal to the retina is represented in cortex. How the three-dimensional representation is possible inside the very thin cortex? It seems that there is a projective mapping involved mapping the exterior of sphere to its interior but how can we experience the inverse of it, if the inverse mapping is not realized physically somehow?

2. The standard argument is that stereo vision produces three-dimensionality, is not totally convincing. Contrary to what text books tell me to experience, I stubbornly see three-dimensionally also using single eye (I have not tested how long this heretic sensory perception lasts). Note that one must make a clear difference between stereo vision as sensory experience and as cognitive experience with information about distances.

3. There is no doubt that the distances of objects of the perceptive field are determined somehow by brain but how they are represented consciously? Again, a projection to the external world is the most natural manner to represent the result of the computations realistically.

4. If sensory representations are realized outside brain, the phenomenon of the perspective would become trivial since it is the basic aspect of projective geometry. More precisely, the distance resolution $\Delta L$ for the objects of perceptive field is essential. The angular resolution for objects decreases as $\Delta\theta = \Delta L/R$ as a function of distance of the objects so that very distant objects with a given spatial separation cannot be resolved for each other. If the tracks of the railroad cannot be resolved very far from each other, it is natural to expect that they are experienced to converge to single point.

### 1.2.3 Are the primary sensory organs the seats of sensory qualia?

There are also many strange facts about sensory perception, which cease to be so strange if "me" is outside my body or rather, contains it. The most elegant picture results when one assumes that primary sensory qualia are seated at the level of sensory organs, and entangle with the cognitive and symbolic representations produced by brain. These mental images in turn would entangle with the magnetic body of astrophysical size.

1. Imagination could be understood as perception without sensory qualia. During dreaming and presumably also hallucinations the back-projection into eyes would "qualiafy" the symbolic representations. The movements of eyes during REM sleep could be understood as a part of this process. Similar phenomenon is associated also with ears: here $Z^0$ magnetic flux tubes might be involved with the back projection and auditory canvas might be $Z^0$ magnetic body. It is perhaps not a mere coincidence that the frequency $f \sim 10^3$ Hz which corresponds to a wavelength of order head size is critical frequency from the point of view of the neurophysiology of hearing, and that the duration of a single bit of the memetic codon is of the order of millisecond. That physical pain is not experienced during dreams would be due to the natural absence of the back-projections producing pain.

2. The hallucinations in which some objects of the perceptive field are either miniature sized of gigantic could be understood. The back-projection to the retinae would realize faithfully the unrealistic relative sizes of the imagined objects.

3. The phenomenon of phantom leg could be understood if the mirror mechanism of long term memories is accepted. Phantom leg would in the geometric past and the pain would be remembered pain or rather, sharing of the pain experienced in the geometric past subjectively now. Phantom leg could be also genuine in the sense that it could consist of magnetic flux tube structures and MEs which remain when the biological organization at the atomic space-time sheet is destroyed.

4. How do I know that nerve pulse activity represents something outside my material body and not inside it? How do I know that the sound I hear does not originate inside my head? If the basic sensations are created already at the level of sensory organs, the boundary between internal and external worlds, it is easier to understand why we can make this distinction. If one accepts the possibility of entanglement of the sensory organs with the objects of the perceptive field, it is even easier to understand why we are able to tell that the sound originates from the external world. This would also help to deduce the distances and sizes of the objects of the perceptive field.

5. This general view generalizes also to the motor actions. In some sense, motor imagination would be a motor action starting from some level above muscles and proceeding backwards in the geometric time. Thoughts as internal speech could be understood as a special case of this mechanism. Of course, the mechanism must involve both time directions and a more precise view about motor action as time reversal of memory recall, reducing at the limit of short time spans to sensory perception, will be discussed later.

Of course, one can invent objections against sensory magnetic canvas hypothesis and the hypothesis that primary sensory qualia are seated at the level of sensory organs.

1. Microwave hearing is a phenomenon in which microwaves generate a sensation of hearing [42]. There are several reasons to believe that the primary stimulus does not enter the ears but cortex [N1]. The hypothesis that sensory organs are the seats of the sensory qualia can be saved only if a back-projection from cortex to ears is involved. Microwave MEs would be able to generate something analogous to electrical stimulation of auditory areas. Note that back-projections to ears can generate oto-acoustic sounds heard even by outsiders. The auditory back projections could be realized also in terms of membrane oscillations. The back projection to eyes could also involve em MEs at visible frequencies.

2. If odors and tastes reduce to the binding of the chemicals to the sensory receptors, it is difficult to imagine that back-projection mechanism could produce odor hallucinations. Hence either long term sensory memories or, less probably, sharing of mental images by quantum entanglement should be in question. One can of course question the hypothesis that odor qualia require the chemical binding: there is evidence [43] that the odor perception of insects is analogous to infrared vision, seeing the infrared light generated by the odorant molecules [K3]. Moreover, olfactory receptors resemble visual receptors. If so, then odor sensations might be produced also by back-projection mechanism using IR MEs. Also hallucinated pain could be used as an objection since it is difficult to imagine why evolution would or could have produced a back-projection for the pain sensation. Long term memories as in the case of phantom pain could be however in question.

3. Is the sensory magnetic canvas really needed for sensory representations? Could the magnetic bodies associated with sensory organs be enough so that our magnetic body would be like a trees with roots identifiable as magnetic bodies of the sensory organs and carrying the fundamental sensory representations. Higher level symbolic and cognitive representations corresponding to the branches of the tree yielded by cortex would entangle with the sensory world represented by the roots. Brain would be really analyzer not the builder of sensory experience in this view.

   The requirement that long term memories are there, forces the introduction of the personal magnetic body with astrophysical size. It would be also in a conflict with fractality to exclude the entanglement in the length scale of the personal magnetic body if it is allowed in shorter length scales. This objection however forces to take seriously the possibility that the representations at the personal/cortical magnetic body are very abstract, and that the topographical mapping of the perceptive field to the personal magnetic body is un-necessary. One possibility is that the personal magnetic body is specialized to geometric memories with the length of magnetic flux tube defining the time span of the memory quite generally. In fact, the experimental findings of Libet force to conclude that sensory perception is a particular case of geometric memory.

4. This line of view forces to consider the possibility that seeing the object of the visual field is a more active process than we are accustomed to think. Could MEs emanate from eyes and form join along boundaries bonds with the object of the visual field so that seeing would be in certain sense like tactile sensing, touching by MEs, somewhat like the bats hear? The cartoon pictures in which rays emanate from eyes would contain a seed of truth. In the case of hearing the MEs could play a role of radar.

   The scaling law of homeopathy [K5] states that high and low frequency MEs appear as pairs. The high frequency MEs representing visible light from the external world might arrive along ELF MEs to the eyes, and eyes could even send very weak "radar rays" along MEs and reflected from the objects of the visual field. In particular, the MEs serving as radar rays might allow to deduce information about the distances to the objects of the visual field. This hypothesis does not imply that the magnetic bodies associated with the eyes would be of the same size as the visual field: much larger size is suggested by the 80 Hz resonance frequency involved with the retinae. Note also that we are able to see ordinary 2-dimensional pictures as 3-dimensional, and perceive a 3-dimensional object in a 2-dimensional picture containing only a chaotic set of points (auto-stereogram). Therefore brain can construct three-dimensional sensory percepts also without the active interaction with the external world.

In fact, the vision about magnetic body as active perceiver using the time mirror mechanism with negative energy MEs time reflected from the biological body as positive energy MEs realizes the idea about sensory perception as an active radar like process. Now brain and body becomes the objects at which time reflection occurs. Something similar is expected to occur at the lower levels of the hierarchy.

### 1.2.4 Altered states of geometric consciousness

The proposed view about sensory representations could explain several mysterious looking phenomena related to tactile senses of which representative examples are described in [38]. Phantom leg and projected pain (say feeling heart pain in left arm) are standard examples. Remote tactile sensing is experienced every-daily. For instance, car driver feels the wheels on the road. The projection to sensory canvas would explains this sensation but one could also consider the possibility that the car becomes a part of body by entanglement. One fascinating applications of remote tactile sensing is based on vision based vibratory sense: TV picture is coded into skin vibrations and patient soon learns to see the world in this manner. People learn also to "see" by hearing. These phenomena cease to be strange when one realizes that geometric qualia accompany in principle all senses. The hypothesis that also the objects of external world are represented as sensory sub-selves (mental images) such that also the visual, auditory and tactile sensory fields become parts of self, explains remote tactile sensing.

Some personal altered states of tactile consciousness resembling hypnagogic state deserve to be mentioned here. The state involves strong illusion of being fully awake and about transition to a state in which body is felt to be in fluctuating wavelike state changing its shape freely. Also the experience about flying to the roof is often involved. Often I can see own body (as 'insider', OBE is not in question) and it is often deformed in bizarre manner. A possible interpretation is that in absence of the sensory input from external world, the values of the spatial coordinates associated with mind like sheets representing body parts in the somatosensory cortex vary widely from their normal values and that dreamer can change these values in certain limits at his will.

## 1.3 A model for sensory representations, long term memories, and motor actions

In this section a model of sensory representations will be developed from the assumptions that sensory representations are realized on magnetic body (magnetic sensory canvas) and that sensory organs are the seats of the sensory qualia. It turns out that the model is essentially equivalent with the model of long term memories and that its temporal mirror image yields a general model for motor actions. The general vision is inspired by and explains Libet's strange findings about active and passive aspects of consciousness.

### 1.3.1 Magnetic body as the sensory canvas

Many-sheeted space-time concept makes it possible to project the sensory, symbolic and cognitive mental images the external world using MEs and magnetic flux tube structures.

1. Place coding by cyclotron frequency scale could easily wake-up mental images representing the positions of the objects of the perceptive field in the magnetic body. A more attractive manner to see the situation is to identify magnetic body as an active perceiver sending negative energy topological light rays time reflected at the biological body as positive energy topological light rays and providing information about its state much like the ordinary reflection of light provides information about the object of the perceptive field.

2. The distance of the point of the flux tube from the sensory organ could be coded to the thickness of the flux tube which in turn defines the cyclotron frequency. Most naturally, the strength of the field is the strength of the corresponding Maxwellian magnetic field and the density of the magnetic flux tubes is scaled accordingly from the requirement of the quantization of magnetic flux.

3. The radial EEG MEs assigned with the cortical axons in the TGD based model of EEG could serve as projectors having contacts with the magnetic flux tubes of the personal magnetic body. MEs would entangle cortical mental images and sensory mental images at sensory organs with the "simple feeling of existence" mental images at the points of the magnetic body. Note that the magnetic bodies of sensory organs could carry the fundamental sensory representations.

4. The EEG frequency and its harmonics associated with ME would induce magnetic quantum phase transitions at the magnetic canvas and wake-up mental image at a distance corresponding to the estimated distance of the object of the perceptive field but which need not be same. The association of visual colors with the points of the perceptive field would result from the retina-magnetic body entanglement. Auditory experience might involve a similar mapping but might use $Z^0$ magnetic field as canvas. Also ears contain strong back-projections necessary for auditory dreams.

5. EEG MEs serving as projections to the magnetic canvas results in the cyclotron transitions at the magnetic flux tubes of endogenous magnetic field having strength $\simeq .2$ Gauss (experiments of Blackman and others), which is 2/5 times the nominal value .5 Gauss for the Earth's magnetic field. At the magnetic flux tubes of the personal magnetic canvas similar process occurs. The rate for the transitions should be maximized in both cases. At the magnetic body this is achieved if the super-conduction ion at the magnetic flux tube is first 'kicked' to a smaller space-time sheet wherefrom it 'drops' back to the magnetic flux tube, and because of its zero point kinetic energy enters into a high $n$ cyclotron state, which in turn decays by emitting harmonics of the cyclotron frequency. The 'kicking' is achieved if the ELF ME responsible for the entanglement contain microwave MEs, which generate join along boundaries bonds connecting magnetic flux tube with smaller space-time sheets. This in turn leads to the breaking of super-conductivity and primitive metabolic cycle in which ions flow to the atomic space-time sheets and back to the magnetic flux tube. This would mean that the microwave radiation from brain serves as the 'food' of the primitive plasmoid like life form representing the simple 'feeling of existence' mental image at the magnetic sensory canvas.

   Both the quantum entanglement with the mediation of of ELF MEs giving rise to the fusion of mental images, and a classical communication by the transfer (say) microwave MEs and inducing self-organization at the magnetic body, are involved. This mechanism is the basic mechanism of remote mental interactions in TGD Universe.

6. An entire hierarchy of sensory representations are predicted and also primary sensory organs could have this kind of representations at their personal magnetic bodies. For instance, retinae

could carry this kind of representations realized in the same manner as the cortical representations. These representations would entangle with cortical representations.

### 1.3.2 The mental images at the personal magnetic body

The sizes of the images of the objects of the cortical sensory representation located outside the body would not correspond to the real size of the objects of the perceptive field. The sizes of ELF ME are typically of order Earth size and this gives upper bound for the size of the representative objects. If brain itself generates the magnetic canvas then it might be natural to expect that the scaling factor involved is one but one must be very cautious in making any strong conclusions. The problem are that it is not at all clear how this scaling factor could be achieved and how it could be useful. Furthermore, the requirement that the magnetic field strength along the flux tube varies very slowly supports the view that the sub-selves at magnetic body ("simple feeling of existence") can have sizes of order ELF ME.

The mapping of the apparent EEG wavelengths to ELF ME lengths $L = c/f$ defined by the formula $\lambda = v/f = (v/c)L$ for EEG frequency $f$ in terms of its apparent wavelength $\lambda = v/f$ would is consistent with the idea that cortical objects could be scaled-up by a factor $c/v \sim 10^7$! Thus these mental images could be even of the order of the size of Earth! If so they could be extremely stable against external perturbations. In particular, the motion of the head and body would not affect the magnetic and $Z^0$ magnetic fields in this distance scale so that the problem of reference frame would be solved since "me" would be understood as a gigantic magnetic structure using brain and body as a sensory and motor organ. Obviously, this picture is the diametrical opposite provided by the standard neuroscience.

A more detailed model for the sensory representations requires a more comprehensive view about the personal magnetic body. One can make only tentative guesses in this respect.

1. The personal magnetic body interacts with the external world, in particular, with the Earth's magnetic field and with the solar wind carried by the solar magnetic field. Hence the idea about personal magnetic body as a structure analogous to the Earth's magnetosphere is worth of testing. Personal magnetosphere could decompose into a part moving with the physical body and analogous to the inner magnetosphere, and a stationary, highly stretched, part analogous to the outer magnetosphere at the night side of Earth. Also part residing outside the Earth's magnetosphere should be present. Earth's magnetosphere-solar magnetic field interaction would be replaced by personal magnetosphere-Earth's magnetosphere interaction.

2. Solar wind might enclose part of the personal magnetic body inside the Earth's magnetosphere, whereas the interaction with the flux tubes of the Earth's magnetic field could force the flux tubes of the personal magnetic body to be more or less parallel to them. Incoherent summation of the personal and terrestrial magnetic fields, fractality, plus the fact that the field strengths associated with the flux tubes of the personal magnetic body should decrease much slower with the distance from Earth's surface than those of the Earth's magnetic field, are consistent the possibility that the flux tubes of the personal magnetic body with field strengths stronger that that of the Earth's magnetic field reside inside the magnetic flux tubes of the Earth's magnetic field in far-away regions. That part of the personal magnetic body which corresponds to field strengths weaker that the strength of the Earth's magnetic field could quite well have size measured in light years.

3. The highly self-organizing plasma sheet at the equitorial plane at the night side of the Earth's outer magnetosphere is an especially interesting structure as far as personal and magnetospheric sensory representations are considered. For the fractal option the plasma sheet of the Earth's magnetosphere would contain plasma sheets inside plasma sheets, in particular the plasma sheets associated with the personal magnetic bodies. Personal and magnetospheric sensory representations would correspond to different levels of the same fractal structure.

4. Also the intra-terrestrial part of the Earth's magnetosphere is important for the magnetospheric sensory representations and, if the fractality hypothesis holds true, also for the personal ones. The strange co-incidences of important cavity resonance frequencies of intra-terrestrial structures with EEG resonance frequencies, and the fractal correspondence between the architectures of

brain and magnetosphere [N1] support the view that personal magnetic body extends also to the interior of Earth. The flux tubes of the Earth's magnetic field (with field strength increasing faster than for the flux tubes of the personal magnetic body) would be however contained *inside* those of the personal magnetic body in this region. The intra-terrestrial consciousness would therefore represent sub-...-selves of ours, something analogous to Id whereas magnetospheric sensory representations would correspond to the super ego. This interpretation conforms with the proposal that intra-terrestrial life forms are possible in the many-sheeted space-time, and that crop circle formations could be interpreted as attempts of ITs to communicate about their existence [N2, N3].

5. Probably it makes sense to speak about $Z^0$ magnetosphere (both solar and terrestrial). $Z^0$ magnetic flux tube structures are crucial for the model of long term memories [H6], and the sizes of the flux tube structures associated with the personal $Z^0$ magnetic body should be measured in light years. This suggests that also much weaker personal magnetic and $Z^0$ magnetic fields with the lengths of the closed flux tubes measured in light years are relevant.

### 1.3.3 Cortex as a collection of attributes assigned to the objects of perceptive field represented at magnetic canvas

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

The view about MEs associating attributes to the object of the perceptive field by waking up sub-selves in the magnetic flux tube structure serving as a sensory canvas suggests an elegant interpretation for these facts.

1. Brain writes the music played by the sensory organs to notes. Accordingly, cortex can be regarded as a collection of regions specialized to represent various kinds of standard features interpreted as cognitive and symbolic representations for the sensory input whereas sensory qualia are realized at the level of sensory organs. Features need not be simple: arbitrary complicated collections of them, such as symbolic representations familiar faces are also possible features. Even entire dynamical processes (selves) could serve as features. Cortical mental images entangled also with sensory mental images a the level of sensory organs and at various organs. The pain in the heart is really in the heart.

2. Basic feature-regions are like computer records. The information about the position of the feature in perceptive field could be represented by the entanglement of the feature with a particular part of, say, primary sensory area representing a point of the perceptive sphere.

3. The direction of the point of the perceptive field could be coded basically by the direction of the magnetic flux tube emerging from the particular position of the sensory area providing map for solid angles of the perceptive field. The mechanism would be based on resonance with Alfven waves associated with the magnetic flux tubes of personal magnetic body amplifying MEs in the direction of magnetic flux tubes. The length (fundamental frequency) of ME would code for the distance of the point of the perceptive field to the distance of the point of the sensory magnetic canvas. Frequency coding could be achieved by varying the local value of the magnetic field responsible for generating the cyclotron frequency. This coding could be either dynamical or static in which case distance could be most naturally coded to linear structures, most naturally in direction orthogonal to the cortical surface.

4. Features would be basically associated with sensory organs, various neural pathways and brain areas and coded partially by nerve pulse patterns. Features could be practically all kinds of

sub-selves generated by brain activity. Primary qualia could be realized at the level of sensory receptors if entire sensory pathways entangle with the magnetic body. It seems that the identification of sensory organs as seats of sensory qualia is the most, and perhaps the only, plausible option in TGD framework.

5. Projector MEs would be orthogonal to the sensory area where they emanate. The topographic mapping of the perceptive field to the sensory areas would guarantee that sensory images would remain stationary under rotations of head: although sensory magnetic sensory canvas would move the image projected to it would be stationary. MEs and magnetic flux tubes must be parallel if Alfwen wave resonance is involved. In this manner the experiences could remain private and the contribution from the other brains would remain negligible. Note however that people in very intimate contact could gradually share there magnetic sensory canvases: the anecdotes about gradually developing telepathic communications between the teachers and students of the meditative practices could involve this kind of sharing of computer screen between several users.

6. In this coding EEG MES would entangle with essentially all symbolic information about the perceptive field and the spectroscopy of consciousness would be realized in a strong sense.

Of course, the extreme flexibility of the entanglement mechanism of binding means that one can imagine almost unlimited number of variants about this basic option and the proposed variant can be defended only as the simplest one found hitherto. One can also allow the possibility that the sequence of entanglements begins from the perceptive field with the primary mental images at the level of sensory organs being entangled with objects of perceptive field.

Fractality suggests that there is a hierarchy of representations. In particular, cortex areas, brain nuclei and even cells could possess their own representations. The inactivity of the primary sensory areas during REM sleep could mean that during dream state sensory representations are non-cortical lower level representations or realized at higher sensory areas. Of course, lower level structures could define the projections to the magnetic sensory canvas also during wake-up consciousness. For instance, relay station like nuclei could act as relay stations for the projections realized at the magnetic body. Any brain area defining topographical map of sensory data is could candidate for defining a sensory representation.

The projector regions could serve as kind of central entanglers. Also the nuclei believed to somehow generate EEG resonance frequencies responsible for the binding of mental images are good candidates for the central entanglers. Thalamus is believed to generate 40 Hz rhythm and is thus a good candidate for the central sensory entangler and projector. Hippocampus generates hippocampal theta and could be the central memory entangler and projector. Frontal lobes generate slow EEG waves during cognitive activities and could act as cognitive entanglers and projectors.

This kind of architecture is expected to be realized at various length scales. Perhaps even at the length scale of genes. The remaining question is how motor activities are realized in this picture. The metaphor for consciousness as a computer sitting at its own terminal, which originally stimulated my personal attempts to understand consciousness, might help here. Computer screen corresponds to the magnetic canvas. The one who sits there presumably corresponds to our magnetic body (as far as conscious-to-us intentions are considered). The central unit corresponds to the brain. Sensory projector MEs are generated automatically by nerve pulse activity and code the picture on the monitor. $W$ MEs as active quantum holograms acting as control commands generating nerve pulse patterns would provide a realization of keyboard. Thus it would seem that those aspects of the computer which are usually not regarded as fundamental in Turing machine paradigm are the most crucial for understanding the brain consciousness and computer programmers seem to mimic what happens inside (and outside) their own brain.

### 1.3.4 Place coding

If the personal magnetic body corresponds to the sensory experiencer and the intentional agent, the distance from the brain along the magnetic flux tube represents the temporal distance to the geometric past. It is however quite possible and even plausible that the length of the magnetic flux tube can code for some spatial distance and even more general geometric data. The arrow of the geometric time would order the spatial points. This kind of mapping from the spatial domain to the temporal domain to the personal magnetic body is naturally induced by any scanning like process performed by CNS, say saccadic motion or EEG waves propagating along cortex. Thus it makes sense to speak about place coding even if one does not assume that our body and environment are mapped to the personal magnetic body in a topographical manner.

The required place coding by frequency is easy to achieve. Any cylindrical flux tube for which magnetic field in the cylindrical coordinates is obtained from a vector potential $A_\phi(z,\rho,\phi) = B(z)\rho$ varying slowly with $z$ gives rise to a magnetic field whose z-component varies slowly with $z$ and for which the radial component $B_{rho} = \partial_z B(z)\rho$ is small. From the quantization of the magnetic flux the flux tube thickness behaves as

$$\frac{r}{r_0} \propto \frac{B_{earth}}{\sqrt{B(z)}} ~,$$

and flux tube gets thinner if the field strength increases and vice versa. It the strength of the magnetic field is that of Earth's magnetic field at the surface of the retina or secondary sensory organ, one obtains frequency coding

$$\frac{f}{f_{earth}} = \frac{B(z)}{B_{earth}} ~.$$

This means that a given EEG frequency associated with, say color mental image, induces a magnetic quantum phase transition at a definite value of $z$ and wakes up visual sub-self at that position. The resulting experience is colored point at a specific point of the visual field.

Optimal situation is achieved if the gradient of $B$ with respect to $z$ is very small. This would suggest that self sizes are of order of the size of ELF MEs waking-up the mental images. This would mean that the total increment of $B(z)$ along flux tube would be measured using $B_{earth}$ as a natural unit. p-Adic length scale hypothesis suggests that the thickness of the magnetic flux tube varies between two p-adic length scales and thus by a small power of 2.

It deserves to be noticed that a given EEG frequency $f$ can wake up a number of copies of sensory images corresponding to various ions at positions related to each other by

$$\frac{B(z_1)}{B(z_2)} = \frac{A_1 Z_2}{A_2 Z_1} ~.$$

Here $A_i$ and $Z_i$ denote the mass numbers and charges of the ions, results. If $B(z)$ varies very slowly along the flux tube, the number of separate mental images is however small since the condition above cannot be satisfied for too large ratios on the right hand side. If $B(z)$ increases along the flux tube, the images associated with the light ions are nearer to the eye than those associated with the heavy ions.

This observation suggests that ions with nearly the same mass numbers could give rise to multiple sensory representations associated perhaps with same sensory sub-self. Of course, the degeneracy of the mental images might be undesirable and could be eliminated by adjusting the gradient of $B$ to be so small that multiple sensory images are not generated inside given magnetic self. By a small adjusting of the strength of the magnetic field at eyeball or the radius of the secondary visual sensory organ could shifts between various types of ionic visual consciousness could be induced. For heavy ions, isotopic degeneracy would lead to large number of alternative modes of ionic consciousness and this might give rise to enhanced cognitive abilities.

How faithful is the metric correspondence between the visual field and its image at the magnetic body? The answer is to this question is not obvious. Also eyes are accompanied by magnetic bodies which could carry visual representations and primary sensory qualia. It could be that these representation are responsible for all what relates to the experienced metric aspects of the visual field. If this is the case, the representations at the personal magnetic body could be much more abstract and free from the constraint of the isometric correspondence. The hierarchy of sensory areas in brain indeed corresponds to an increasingly higher level of abstraction.

### 1.3.5 Magnetospheric sensory representations

It is difficult to exclude magnetospheric sensory representations if one accepts the notion of personal magnetic body and representations at it. These representations could give rise to the third person aspect of consciousness. Magnetosphere could contain multi-brained collective selves receiving sensory input from several brains simultaneously. Also $Z^0$ magnetosphere could contain representations carrying both sensory and and higher level symbolic and cognitive information from several brains.

The location of the magnetospheric representations could be stationary with respect to the inner magnetosphere. This would require that the MEs projecting the information to the magnetosphere emanate from the head in a direction which is fixed with respect to the local direction of the magnetic field of Earth (the MEs associated with the personal magnetic body would project in a direction orthogonal to the surface of cortex). Most naturally this direction would be the direction of the local magnetic field since this makes possible amplification based on Alfven wave resonance. Stationarity of the directions of MEs projecting to the magnetosphere could be achieved by the interaction of the magnetic dipoles with Earth's magnetic field forcing the directions of the magnetic dipoles to the direction of Earth's magnetic field and thus making brain a compass. Brain is indeed full of magnetic materials, human brain is a compass and humans have magnetic navigation sense.

Also eyes contain magnetic materials and presumably act as compasses so that eyes could generate the required magnetic fields defining a preferred reference frame for visual sub-selves. One can consider a hierarchy of compasses defined by the hierarchy of magnetic fields at various sheets of the many-sheeted space-time. For the sense of balance this kind of a preferred direction is essential.

Also a $Z^0$ magnetic compass based on Earth's magnetic field and $Z^0$ magnetic materials is possible. The fact that $Z^0$ magnetic fields are associated with hearing so closely in TGD framework supports the view that $Z^0$ magnetic compass could be related to the sense of balance. Children love to spin around. Since all atomic nuclei couple to $Z^0$ force, this spinning however generates net $Z^0$ currents generating additional $Z^0$ magnetic fields perturbing the Earth's $Z^0$ magnetic field. This in turn could cheat the $Z^0$ compass. This indeed happens. When the spinning stops, sensation of dizziness results and the world is experienced to spin.

### 1.3.6 Remote mental interactions and sensory magnetic canvas hypothesis

Could the possible sensory inputs from other brains to the personal magnetic body interfere with the sensory inputs from 'my brain'? This is probably not the case. It is however possible that the entanglement with the other magnetic bodies and possibly existing magnetospheric multi-brained selves leads to the sharing of mental images. Perhaps this is exactly what happens during sleep and actually makes possible development of social structures and culture. Note that this picture is consistent with what near death experiences and various altered states of consciousness achieved in meditative practices suggest.

There is some evidence for the possibility of a interaction between minds via projected sensory representations. Some dogs are able to anticipate the epileptic attacks of their master and are systematically trained for this purpose. Some dogs have an amazing skill to precognize that their master is coming home: ordinary sensory perception such as olfaction is excluded as an explanation. The practitioners of transcendental meditation claim that collective meditation can have a definite positive effect on conflict situations occurring at the other side of the world proportional to the square of the number of participants (coherence). The vision of Sheldrake [19] about morphogenetic fields making possible the claimed learning at the level of species could be modelled concretely in terms of this interaction.

The immediate prediction is that large scale phenomena affecting the magnetic field of Earth should have direct effects on our consciousness by the perturbation of the sensory representations at the other side of the world. There would be however no effect on primary sensory qualia if they are seated at the level of sensory organs nor on cognitive and symbolic mental images produced in brain. Telepathic sharing of mental images having would be one possible effect induced by Schumann resonances: the signature would be sensory experience with no neurophysiological correlates (in particular, there would be no back projection to sensory organs).

It is known that the statistics about mental states of patients of mental hospitals demonstrates strong correlation with magnetic storms induced by sun-spots. The magnetic perturbations induced by lightnings known as sferics are known to have a direct effect on EEG and brain functioning [21]. Tectonic activity, such as Earth quakes, can induce various kinds of hallucinations such as encounters with UFOs and religious experiences [92] perhaps involving sharing of mental images. Animals are even able to anticipate earth quakes. When the car ferry Estonia suffered a shipwreck for few years ago taking with it almost thousand people into the depths, hundreds of people reported they had experienced a nightmare obviously relating to this event. Sharing of mental images or sensory percepts produced by back-projection from symbolic representations created by or communicated to brain could be in question.

The known general features of remote mental interactions support the view that magnetospheric multi-brained selves serve as a kind of relay station or medium allowing the remote mental viewer to entangle with the target. Remote viewer would essentially see with the yes of this higher level self [H9, K4].

### 1.3.7 Mirror mechanism of geometric memories

The mirror mechanism of long term memories involves several purely TGD based features [H6].

1. The classical non-determinism making possible time-like quantum entanglement and sharing of mental images.

2. Space-time sheets with a negative time orientation allowing classical signals associated with negative energy MEs to propagate backwards in time and making possible entanglement.

3. The identification of the personal magnetic body as the experiencing intentional agent sending negative energy MEs parallel to the magnetic flux tubes to the brain acting as the time mirror. This option, forcing to take completely seriously the notion of the magnetic body, provides the most elegant identification of the time mirror discovered hitherto. If brain is identified as the sender of the negative energy MEs, the identification of the mirror and correct timing of pose problems. One possibility is that the closed flux loops associated with the personal magnetic and $Z^0$ magnetic bodies having sizes of order light years making it possible for negative energy MEs to repeatedly reflect along them and return back to the brain of the geometric past.

4. The possibility of MEs and magnetic flux tubes interacting weakly with the ordinary matter but strongly with living matter in cell length scales.

#### Mirror mechanism

Classically the mechanism of long term memory is extremely simple: one looks at time mirror at a distance of one light year and sees oneself in the geometric past at a distance of two years. Since the geometric past changes in each quantum jump, this mechanism explains why our long term memories are so unstable. One could see also other persons in the mirror and this could explain telepathic communications, the communications with the deceased, as well as identification experiences. The most natural identification of the seer is as the magnetic body and the mirror as the brain (my first guess was time mirror image of this!). The distance along the magnetic flux tube would corresponds to the distance to the geometric past.

For the time-mirror model of long term memory the ULF dark MEs must be generated both at the personal magnetic body and in the brain.

1. At the personal magnetic body cyclotron phase transition would give rise to negative energy neutral MEs sucking energy from the biological body of the geometric past. This radiation would be reflected back to the geometric future as positive energy neutral MEs. The response would depend on the state of the brain. Motor action would differ from memory recall only in that it would involve negative energy $W$ MEs inducing exotic ionization at both ends and leading to a physiological outcome. The entanglement via $W$ MEs could induce direct sensory memories relying on sharing and fusion of mental images.

2. The ULF radiation representing the response to the memory recall would correspond to Josephson radiation giving rise to a scaled up dark EEG in the relevant time scale characterized by the level of the dark matter hierarchy. The size of Josephson junctions assignable to cells and cell structures would be scaled up from cell membrane thickness by a power $\lambda^k$, $\lambda \simeq 12^{11}$ at the $k^{th}$ level of the dark matter hierarchy and magnetic flux quanta would define the Josephson junctions naturally [M3]. The de-coherence of higher level dark photons to single ordinary EEG dark photon or their decay to EEG dark photons is probably involved with the memory call and would transform the response from the geometric past to ordinary cognitive and emotional input at personal magnetic body.

The assumption that the lengths scales of MEs and magnetic structures are identical implies that the frequency of ME equal to the magnetic transition frequency $f_m$ fixes the length of the two MEs involved and thus the temporal location of the long term memory in the geometric past:

$$T = \frac{2}{f_m} \ .$$

This represents a frequency coding for the temporal location. In standard physics the idea about brain generating MEs with a frequency scale of the order of the inverse of lifetime does not make sense: in TGD context situation is different since this process occurs in subjective time. By the arguments discussed in more detail below, postive energy neutral MEs are ideal for communication of long term memories to the geometric future. The concrete mechanism for the generation of MEs as associated with transitions between almost degenerate configurations of spin glass with slightly different classical gravitational energies is discussed in [H6].

### More detailed model for long term memories

The realization of long term memories might be the basic function of the personal magnetic body.

1. Spontaneous episodal memories would be based on negative energy MEs entangling the geometric now with the geometric past and making possible sharing of mental images. In particular, sensory memories would rely on this mechanism. This mechanism could also make possible only the communication of the desire to remember to the geometric past in the case of an active memory recall and non-episodal memories. One can however wonder what distinguishes the resulting experience from precognition by the self of the geometric past: could it be that to precognize now is to remember in the geometric future? The fact that MEs represent channelled energy means that distance is not a problem as far as energetics is considered.

2. In the case of non-episodal memories the information could be communicated classically from the geometric past as 'bits' and be coded into the light like vacuum current associated with ME. If the magnetic body is the "me", positive energy MEs could simply travel along the same magnetic flux tube along which the negative energy ME arrived. Magnetic flux tube would act as a wave guide amplifying ME by Alfven resonance.

3. Neural MEs with negative energies are especially favored for quantum communications. The reasons are many-fold. The interaction with the matter is very weak in long length scales but strong in cellular length scales, negative energy implies that ME is identifiable as a virtual particle and analogous to a part of a Feynman diagram so that no dissipation is involved and quantum communication is possible. The reversal of the arrow of geometric time means also that there is not macroscopic dissipative dynamics which would spoil the quantum coherence.

4. The requirement that the receival process is highly selective suggests a resonance mechanism. This requires that the fundamental frequencies associated with MEs are somehow universal. p-Adic length scale hypothesis indeed predicts hierarchies of universal frequencies. A stronger requirement is that the receiving and sending structures are somehow similar, and many-sheeted space-time allows to realize this kind of option. Negative energy energy ME cannot be emitted unless there is a receiver absorbing the negative energy and in this manner providing energy for the sender by buy now-let others pay mechanism. The time mirrored positive energy ME can even amplify the reflected negative energy signal by stimulated transition to the ground state if the receiver is a many-sheeted analog of a population inverted laser.

5. Negative energy MEs represent time reversed level of the p-adic length scale hierarchy so that the dissipative effects associated with the space-time sheets with the normal arrow of time should not interfere with the quantum communication. This at least, when the energy of the negative energy ME has a magnitude larger than the thermal energy associated with the space-time sheets with which it interacts: there is simply no system which could make a transition to a lower energy state by the absorption of a negative energy ME. Furthermore, since systems with reversed arrow of geometric time are expected to have extremely low density, the dissipative effects in the reversed direction of time are expected to be small. Since the generation of negative energy MEs does not require energy feed, the memory recall to the geometric past occurs more

or less spontaneously, and the scanning of the geometric past becomes possible. In the case of precognition precognizer must intentionally receive negative energy MEs from the geometric future so that energy feed is needed. This perhaps explains why precognition is so rare. Note that p-adic variant of pre-cognition having interpretation as intentionality occurs easily since p-adic energy is conserved only in piecewise manner.

If this picture has captured something essential from the nature of the long term memories, the conclusion is that we are not at the top of the magnetic sensory hierarchy. Human body and brain generates extremely weak magnetic fields and the corresponding magnetic flux tube structures could make possible long term memories. Near death experiences [I3] could be understood in this framework if the weak magnetic fields associated with the higher levels of the fractal hierarchy of magnetic structures utilize brain and body as kind of sensory and motor organs. Note that there is a flux tubes inside flux tubes structure so that ordinary sensory experiences can be associated also with these flux tubes.

### 1.3.8 Sensory perception, motor action, and time

TGD view about sensory perception differs dramatically from that of the standard neuroscience in that sensory organs (plus possibly their magnetic bodies) are carriers of basic sensory representations and the magnetic body rather than body or brain is the experiencer with which we can identify ourselves. Magnetic body is also the intentional agent and both motor action, sensory perception, and long term memory which all involve also intentional elements, are based on the time mirror mechanism. Intentions are represented by p-adic MEs generated at the magnetic body. p-Adic ME is then transformed to a desire about a particular action and represented as a negative energy ME propagating to the direction of the geometric past. Actions are realized as responses to the negative energy MEs as various kinds of neural activities and as a generation of positive energy MEs. A more realistic model involves an entire sequence of this kind of steps proceeding like a sequence of sub-program calls downwards along the hierarchy of the magnetic bodies down to the level of CNS. A good metaphor is obtained by regarding magnetic bodies as bosses in the hierarchy of some organization and CNS as the lowest level ultimately realizing the desire of the big boss.

#### Sensory organs as seats of qualia

According to the music metaphor, sensory organs are responsible for the music whereas brain writes it into notes by building symbolic and cognitive representations communicated to the magnetic body. Back projection to the sensory organs is an essential aspect of this process and is discussed in [K3]. Sensory perception at the level of magnetic body involves the generation of negative energy MEs entangling with sensory organs involving possibly also brain as an intermediate entangler.

The assumption that sensory organs are carriers of the sensory representations entangling with symbolic representations realized at the level of cortex does not mean any revolution of neuroscience, just adding something what is perhaps lacking [K3]. One can also consider the possibility that sensory organs and their magnetic bodies define the sensory capacitors whose discharges give rise to sensory qualia and that these magnetic bodies give also rise to low level cognitive and emotional representations.

Neuronal/symbolic level would do its best to symbolically represent what occurs naturally at the level of qualia. Color constancy could be understood as a basic characteristic of color qualia represented symbolically at the neuronal level. Center-surround opponency for the conjugate colors is the neural counterpart for the contrast phenomenon in which the boundary for a region of the perceptive field with a given color carries the conjugate color (black-white opponency associated with the luminance is only a special case of this). The contrast phenomenon at the level of visual qualia could derive from the vanishing of the net color quantum numbers for the electrodes of the retinal color capacitors.

The basic prediction is the presence of the back projection at least in the sensory modalities in which hallucinations are possible. MEs with MEs mechanism is the most natural candidate for realizing the back projection, negative/positive energy MEs would realize the back projection based on quantum/classical communications, and the capacitor model of the sensory receptor can be applied to model photoreceptors and retina. This picture integrates nicely with the various speculations about the role of the ciliary micro-tubules in vision. The obvious question is how the presence and character of the back projection reflects itself in the structure of the sensory pathways and sensory organs.

Basic facts about how gastrulation and neurulation proceed during the development of the embryo, lead to testable hypothesis about the character of the back projection for various sensory modalities. According to the hypothesis, one can speak about "brain senses" and "skin senses" according to whether the back projection is based on quantum or classical communications.

#### How motor action differs from sensory perception?

There is a deep similarity between sensory perception and motor action in TGD framework, the basic difference being that classical signals propagate in different direction in CNS and in geometric time. Motor action is initiated by the magnetic body by the sending of negative energy to motor organs by generating negative energy MEs, and proceeds by similar processes backwards in the geometric time to the level of brain and magnetic body, very much like an instruction of a boss at the top of organization to the lower levels of hierarchy and induces lower level instructions. The analogy with computer program calls (quantum communications, desires) and their executions (classical signals, actions) is also obvious. Also classical signals from the magnetic body to the body and brain are possible.

Analogous picture applies to sensory perception with motor organs replaced by sensory organs except that the fundamental communications occur to geometric future from biological body to magnetic body via a hierarchy of EEGs. There is however also an active building of sensory percepts by feedback from the magnetic body which selects between quantum superposed alternative percepts already at the level of sensory organs.

Sensory *resp.* motor imagination differ from sensory perception *resp.* motor action only in that the magnetic body entangles with some higher level of CNS. Therefore there is no danger that imagined motor action would become real or that imagined sensory perception would be experienced as real. This picture is in accordance with the idea of quantum credit card implying maximal flexibility, and with respect to the geometric time would mean that motor actions are only apparently initiated from the brain.

#### Strange time delays of consciousness: experiments related to the active role of consciousness

Libet has carried out classical experiments about active and passive aspects of consciousness [38, 27]. It has gradually become clear that these experiments can be interpreted as a support for the identification of "me" as the personal magnetic body.The first class of experiments [38, 22] is related to the active role of consciousness. For example, the human subject moves his hand at free will. What happens is that neurophysiological processes (changes in EEG, readiness potential) start $T_1 = .35 - .45$ seconds before the conscious decision to move the hand whereas the awareness about the decision to move the hand comes $T_2 = .2 - .1$ seconds before the hand movement. Decision seems to be followed by the action rather than action by decision! This is in apparent accordance with the point of view that consciousness is indeed a passive spectator and the act of free will is pure illusion. What is interesting from the p-adic point of view, is that the most plausible estimates for the time delays involved are $T_1 \simeq .45$ seconds and $T_2 = .1$ seconds [22]. $T_1$ is very near to the p-adic time scale $T(6, 43) = .4$ seconds and $T_2$ to the fundamental p-adic time scale $T(2, 127)$ defining the duration of the memetic codon.

One can imagine two explanations for the paradoxal findings. The explanations turn out to be mutually consistent.

*1. The geometric past changes in quantum jump*

Quantum jump between histories picture explains the time delays associated with the active aspect of consciousness nicely and also gives an example of two kinds of causalities.

1. The simplest assumption is that the subjective experience of the hand movement corresponds to the moment, when subject person experiences that hand movement occurs.

2. The space-time surfaces (resulting as the final state of quantum jump) associated with the new quantum history differ in a detectable manner from the old quantum history already before

the moment of hand movement since otherwise the new space-time surface would contain an instantaneous and discontinuous jump from the initial to final body configuration, which is not allowed by field equations. Same argument applies to the state of brain. $\Delta T \sim .5$ seconds seems to be the relevant time scale.

3. The attempt of the experimenter to be objective means that in an ideal experiment the observations correspond to the new deterministic history in the associated quantum jump and hence experimenter sees neurophysiological processes as the (apparent) cause of the hand movement with respect to geometric time. With respect to the subjective time the cause of the hand movement is the decision of the subject person.

*2. Motor action is initiated from the magnetic body and proceeds to shorter length scales in reversed direction of geometric time*

The vision that motor actions are initiated by magnetic body by feeding negative energy to motor organs and proceed upwards in CNS in a reversed time direction is in accordance with the idea of quantum credit card implying maximal flexibility and would mean that motor actions are only apparently initiated from brain. Motor organs send negative energy MEs to get metabolic energy, say to cortex. If there is lapse $\sim .5$ seconds involved then the observed lapse would find explanation. This view concretizes the idea about the editing of the geometric past and is consistent with the more general explanation discussed above.

This view about motor action means that it proceeds from long length scales to short ones whereas in the standard neuroscience view motor motor action would be planned and initiated in the brain and proceed to the level of motor organs, from short to long length scales. This certainly seems to be the case if one looks only the classical communications (say nerve pulse patterns). The extreme coherence of and synchrony of motor activities is however in conflict with this picture: neuronal communications are simply too slow to achieve the synchrony. This has been emphasized by Mae-Wan Ho [41]. Since quantum communications proceed backwards in geometric time, classical signalling such as nerve pulses from brain to motor organs are actually reactions to the initiation of the motor action from the magnetic body.

#### Strange time delays of consciousness: experiments related to the passive role of consciousness

Libet's experiments [27] about the strange time delays related to the passive aspects of consciousness have served as a continual source of inspiration and headache. Every time I read again about these experiments, I feel equally confused and must start explanations from scratch.

What is so important and puzzling is that the backwards time referral of sensory experience is so immensely long: about .5 seconds. The time taken for nerve pulses to travel through brain is not more than .01 seconds and the time to arrive from sensory organs is at most .1 seconds (for axon with length of 1 meter and very slow conduction velocity 10 m/s). For the purposes of survival it would be advantageous to have a sensory input with a minimal time delay.

Why then this long delay? TGD inspired answer is simple: the "me" does not correspond to the material body but to the magnetic body associated with the physical body, and is analogous to the manual of electronic instrument, kind of a monitor screen to which sensory, symbolic and cognitive representations are projected by quantum and classical communications. Since the size of the magnetic body is measured using Earth's circumference as a natural unit, the long time lapse results from the finite velocity of light.

The following explanation is a variant of the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths. The basic sensory representations are realized at the level of the sensory organs and entangled with magnetic body whereas symbolic representations are either shared as mental images by or communicated classically to the magnetic body. This differs from the original scenario in which sensory representations were assumed to result by classical communications from brain to the magnetic body.

*1. Communications from brain to magnetic body*

One must consider two kinds of communications from body to magnetic body corresponding to positive energy MEs generated by at least brain and negative energy ME sent by magnetic body to at least sensory organs. The assumptions are following.

1. Negative energy MEs bound state entangle the magnetic body with the sensory representations realized at the level of sensory organs, and constructed using back projection from brain and possibly also from higher levels. Fusion and sharing sensory mental images is involved. Also the classical communication of memories to magnetic body could be involved with the build up of sensory and symbolic representations at the magnetic body. In both cases sensory representations are memories with the same time lapse determined by the length of the MEs involved, a fraction of second typically if the magnetic body is of an astrophysical size. During sensory and motor imagination magnetic body entangles by negative energy MEs with some higher level of CNS.

2. Symbolic representations in brain can entangle with the sensory representations entangling in turn with the magnetic body so that CNS defines tree like structure with roots corresponding to sensory organs and branches and leaves corresponding to the higher levels of CNS. Direction of attention selects some path along this tree somewhat analogous to the path defining computer file in some subdirectory.

3. Symbolic representations of the perceptive field can be projected to the magnetic body using also classical signalling by positive energy MEs with phase velocity in a good approximation equal to the light velocity. For instance, if perceptive field contains something important, classical signal to the magnetic body could induce the generation of negative energy MEs turning attention to a particular part of perceptive field. Projection to the magnetic flux tubes of the Earth's magnetic field is possible. The spatial direction of the object could be coded by the direction of ME located in brain whereas its distance could be coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results. Field pattern could be realized the coding of information to bits in some time scale, perhaps even in the time scale of millisecond associated with the memetic code. Positive energy MEs generated by brain realize the representation and this implies time delay. In the original model it was assumed that the direction and distance of the object of perceptive field are coded as direction and distance at the magnetic body. The representations are expected to be rather abstract, and it might be enough to perform this coding at the level of magnetic bodies associated with the sensory organs.

*2. Libet's findings*

Consider now Libet's findings. According to the summary of Penrose in his book 'Emperor's New Mind' these experiments tell the following.

1. With respect to the psychological time of the external observer subject person becomes conscious about the electric stimulation of skin in $\sim .5$ seconds.

2. Subject person feels no time delay. For instance, she can tell the time clock shows when the stimulus starts. This can be understood if the sensory representation, which is basically a geometric memory, takes care that the clock of the memory shows correct time: this requires backwards referral of about .5 seconds.

3. One can combine an electric stimulation of skin with the stimulation of the cortex. The electric stimulation of the cortex requires a duration longer than .5 seconds to become conscious. If the stimulation of the cortex begins (with respect to the psychological time of the observer) for not more than .5 seconds before the stimulation of the skin starts, both the stimulation of the skin and cortex are experienced separately but their time ordering is experienced as being reversed! If the cortical stimulation generates sensory mental image at sensory organ by back projection then one could understand the change of the time ordering as resulting from .5 second lapse for the generation of back projection.

4. If the stimulation of the cortex begins in the interval $.25-.5$ seconds after the stimulation of the skin, the stimulation of the skin is not consciously perceived. This effect is known as a backward masking. From the source it is not clear whether a minimal duration of .5 seconds of cortical stimulation is required for backward masking.

*3. Explanation of Libet's findings*

Consider now how one could understand these strange findings in the proposed model.

1. Visual and tactile sensory inputs enter into cortex essentially simultaneously so that the construction of symbolic representations at magnetic body is possible. The projection to the magnetic canvas by positive energy MEs and the generation of the magnetic quantum phase transition might quite well explain the time lapse of .5 seconds. The symbolic representation could contain also information about where to direct sensory attention. After this time interval negative energy ME possibly directing the attention to a particular part of the perceptive field would be generated and induce sharing of mental images .5 seconds in the geometric past. Note that this would automatically guarantee that symbolic and sensory representations at the magnetic bodies of sensory organs correspond to the same value of the geometric time.

2. The stimulation of the cortex lasting at least .5 seconds would generate a back projection to sensory organs. The minimal duration of .5 seconds for the cortical stimulation would seem rather natural in order to avoid back projections due to random neuronal fluctuations. This would explain why the temporal order of the sensory experiences generated by cortical and skin stimulation is reversed when cortical stimulation starts before the skin stimulation.

3. Consider now how the backwards masking could be understood. The cortical stimulation could generate a negative energy ME sent to the sensory organ and editing its geometric past at temporal distance of .5 seconds and depleting energy resources so that sensory organ cannot receive negative energy ME from magnetic body during the period of the cortical stimulation. Magnetic body would become sensorily blind to the input from the corresponding point of skin. Sensory blinding could be a clever manner to signal to the magnetic body that back projection is to be expected.

   The stimulated point of the cortical map would share the sensory mental image instead of the magnetic body and also give rise to a back projection: sensory mental image would be conscious to cortex but not to us! Magnetic body and cortex could be seen as competitors for resources in this kind of situation. Perhaps the electric stimulation induces some kind of neuronal starvation and forces the neuron to generate negative energy MEs entangling it with the sensory organs.

## 1.4 First attempts to relate sensory canvas idea to neuroscience

The challenge to relate sensory canvas hypothesis to the general qualitative features of EEG and to what is known about its evolution. The general knowledge about neural correlates of consciousness could also provide constraints for the model of how sensory representations are constructed. One could also try to find clear tests and even existing evidence for the hypothesis that there indeed are also other than neural correlates of consciousness (MEs projecting to the sensory canvas are obviously the candidate in present case).

There seems to be a general consistency of predictions of sensory canvas hypothesis with what is known about EEG. Mention only the evolution of EEG as the emergence of decreasing EEG frequency scales; the disappearance of alpha, beta and gamma bands from EEG during sleep; the existence of narrow coherent EEG sub-bands in all EEG bands; and also the complex fractal like coherency structures of EEG difficult to understand if EEG has a purely neural origin.

Brain is active also during sleep. Sensory canvas hypothesis encourages to think that, besides making possible consolidation of long term memories, this activity could serve the purposes of higher level multi-brained magnetic selves representing collective levels of consciousness receiving abstract non-sensory input from several brains at theta and delta frequencies. Of course, interaction could occur also in reverse direction and among other things explain the creative insights often achieved during sleep.

Computer metaphor would suggest that motor actions and sensory representations are basically identical procedures in TGD framework: only the final representation of the data file constructed by brain is different. As found, this is not quite the case: there is time reversal involved. Motor action is like precognitive recall whereas sensory experience is like geometric memory recall.

The considerations below rely on various review articles [47, 36, 25] about the recent situation concerning the understanding of EEG. Also the article [26] about neural correlates of consciousness, and the article [27] suggesting that primary sensory area V1 is crucial for conscious vision have been very useful in attempt to develop more concrete views about how sensory representations are constructed. I do not hesitate to admit that the model to be discussed is nothing more than a first attempt to relate the general idea of sensory canvas to the complex neuro reality and is severely restricted by my very limited knowledge about neuroscience (I am grateful for Gene Johnson for his patience while trying to teach me some basic facts about conscious brain).

### 1.4.1 Anatomical structure of the cortex and sensory canvas hypothesis

The anatomical structure and evolution of cortex inspires definite hypothesis about how brain constructs and realizes sensory representations at magnetic sensory canvas and how magnetic sensory canvas builds up motor actions. In order to avoid confusions I want to stress that sensory representations generated by brain are assumed to be symbolic representations assigning meaning to the raw sensory input and do not involve qualia, which in TGD Universe are most naturally assignable to the sensory organs.

#### Do primary sensory areas serve as gateways to the fundamental sensory canvas?

Is there single cortical magnetic body or several of them? Do various sensory areas define a hierarchy of magnetic bodies serving as sensory canvases (”sensory” is somewhat misleading here)? There are several arguments supporting the view that primary, and possibly secondary and tertiary sensory areas, but not necessarily higher areas, should be accompanied by separate magnetic bodies.

1. Computer metaphor encourages to consider the hypothesis that sensory representations and motor outputs have essentially the same character just like printout and monitor picture are different outputs of a same file in the case of a computer. First (with respect to the subjective time!) a rough sensory sketch is generated and then more and more details are added and the primary areas activate the final sensory representation just as in the case of motor output. As in the case of motor actions, higher levels of cortex simply select the activated sensory representation to be experienced consciously by us (binocular rivalry). The sequence of quantum entanglements proceeding from the magnetic body down to the magnetic bodies of sensory organs selects what is experienced consciously by us. There is probably a hierarchy of experiencers each characterized by particular selections.

2. The intention for motor activity is realized as p-adic MEs connecting magnetic body by entanglement sequence to motor organs and induces directly action at this level (buy now-let others pay principle and precise targeted realization of intention). This quantum communication like aspect is accompanied by classical communications from magnetic body to cortex and in terms of nerve pulse patterns from cortex to lower levels. Intention can be also initiated at higher level than motor organs and in this case motor imagination is in question.

3. Mental images are entangled with the mediation of the negative energy projector MEs along along magnetic flux tubes connecting magnetic bodies together. Hierarchical sequences of mental images result in this manner, and sensory qualia become associated with various higher level mental images. MEs can be thought of as representing radiation propagating in the wave channel represented by the magnetic flux tube and being reflected repeatedly. MEs need not be only simple cylindrical prototype MEs but can be also curved: this means that the number of reflections need not be too high. Magnetic flux tubes are essentially guides for MEs so that they do not ”lose their way”.

4. The motor-sensory analogy might provide also other new insights. For instance, basic elements making possible several potential motor actions might exist simultaneously as sub-selves representing imagined basic modules of motor activity at the level of cortex. The sequence of quantum entanglements would then select the desired motor action, much like the sensory percept is selected in the sensory rivalry. This would be like building a program from a set of active modules

selecting some subset of them or selecting one downwards path in a branching tree. The magnetic sensory representations associated with primary sensory organs without the higher level cognitive and symbolic associations could be seen as the counterparts of reflex actions.

**Neural correlates of visual consciousness and motor-sensory analogy**

The study of the neural correlates of visual consciousness reviewed in [26] allows to study the reasonability of the primary sensory areas as gateway to sensory canvas hypothesis and its variants.

1. Evolutionary argument suggests that both primary sensory organs and various sensory areas are accompanied by magnetic bodies providing increasingly abstract symbolic and cognitive representations for the sensory input. The neurons at the higher sensory areas indeed become increasingly complex and have increasingly wider receptive fields. In particular, in the case of vision the neuronal receptive fields at V4 and higher areas are also dynamical and determined by the attentional level. Color/orientation information and the information about motion are treated separately in parvo and magno cellular pathways in V1, V2 and V3 but not in V4 (for the organization of the visual pathways see [28]). These observations encourage the view that sensory areas define a hierarchy of separate magnetic bodies giving rise to more and more integrated conscious higher level representations of the sensory input. These representations define hierarchy of selves using the same brain and body.

2. The standard assumption about feed-forward hierarchy of the sensory areas leads to difficulties. For instance, in binocular rivalry of two competing visual stimuli feed to right and left eye, only the other stimulus is experienced at time. V1 and also V2 and V3 however contain neural representations of both stimuli. It has been also found that during the binocular rivalry the co-varying neural activities (seen by fMRI) in the extrastriatal visual cortex and in prefrontal cortex correlate with the subjective percept (rather than real stimulus) unlike the activity in V1 which represents both stimuli [29]. The manner to understand this is that quantum entanglement sequences starting from the magnetic body proceed down to sensory organs and select from V1, V2 and V3 only the second stimulus.

3. It is known that neural activity in parietal and frontal regions is involved with the change of the dominating stimulus and that the activity in visual areas is not enough for visual consciousness [26]. Thus the presence of neural representations of both stimuli in V1 but conscious experience of only one stimulus would support the view that neuronal activity is *not* enough to generate our conscious experience. If the hierarchy of entanglements proceeds from our magnetic body to frontal lobes and from there downwards it is easy to understand why the activity in frontal lobes is essential for selecting the consciously experienced stimulus. Obviously the sensory-motor loop would have counterpart in much longer length scales.

4. V1 seems to be necessary for visual consciousness. Pascual-Leone and Walsh have studied the visual hallucinations induced by transcranial magnetic stimulation [30]. The stimulation of V1 generates static and colored impressions whereas the stimulation of V5/MT generates moving non-colored phosphenes (in accordance with the fact that 'where' type information processing is color blind and 'what type' information processing at lowest levels is motion blind). This picture is consistent with the idea that the fundamental visual representations are realized at retinal magnetic bodies. The back-projections in question would be essential for the "qualiafication" of imagination during dreams and hallucinations.

5. The study also demonstrates that the stimulation of V1 *after*, rather than before, the stimulation of regions V5/MT sending feedback to V1 can prevent the generation of hallucination. Even more, [27] describes a case in which patient has lost visual consciousness when V1 is not intact. There is indeed a strong neural feedback to V1, V2 and V3 from the higher visual areas V5/MT and area V1 is activated simultaneously with MT in macaque. These findings are in conflict with what one might expect if sensory processing proceeds in strictly feed-forward manner. The necessity of V1 for our visual consciousness is obvious if entanglement sequences go through V1 down to the level of retinas. Feedback would also make possible "coloring" of the sensory map during ordinary wave-up experience. Perception would be creative act already at the level of sensory organs.

6. The timing of the interactions in the visual areas provides further hints about how sensory representations are constructed. According to [27] that early activation of V1 by magnocellular neurons in LGN occurs 20 ms earlier that the activation by parvocellular neurons. At this time also the feedback from V5/MT arrives to V1. This suggests that sensory map is constructed by making first a rough sketch using the sensory input from the magnocellular pathways (motion and position). For about 20 milliseconds later follows the coloring of the sensory map as well as the association of the higher level features to the map. This order is is consistent with the fact that highly developed parvocellular pathway is a newcomer in the evolution and that the information involved is not so vital for survival. Thus V1 would act as an effective 'active blackboard' as has been suggested [27] and by the sensory-motor analogy in TGD framework.

### 1.4.2 EEG and sensory canvas hypothesis

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

#### Why the endogenous magnetic field corresponds to .2 Gauss?

For years I erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking $Ca^{++}$ cyclotron frequency as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for $Ca^{++}$ is .2 Gauss and thus slightly smaller than the minimum value .3 Gauss of $B_E$. This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic field. This field value corresponds roughly to the magnitude of $B_E$ at distance 1.4R, $R$ the radius of Earth.

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions [M3]. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar(k) = \lambda^k(p)\hbar_0$, $\lambda \simeq 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, ...$ [M3]. Also integer valued sub-harmonics and integer valued sub-harmonics of $\lambda$ might be possible. Each p-adic length scale corresponds to this kind of hierarchy. Number theoretical arguments suggest a general formula for the allowed values of $\lambda$ [A9] as $\lambda = n$ where $n$ characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [C6]. The values of $n$ for which quantum phase is expressible using only iterated square root operation are number theoretically preferred and correspond to integers $n$ expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. $n = 2^{11}$ obviously satisfies this condition. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \rightarrow h = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L(k) \rightarrow nL(k)$ and $B \rightarrow B/n$.

$B = .2$ Gauss would corresponds to a flux tube radius $L = \sqrt{5/2} \times L(169) \simeq 1.58L(169)$, which does not correspond to any p-adic length scale as such. $k = 168 = 2^3 \times 3 \times 7$ with $n = 5$ would predict the field strength correctly as $B_{end} = 2B_E/5$ and predict the radius of the flux tube to be $r = 18\ \mu$m, size of a large neuron. However, $k = 169$ with flux $2h_5$ would be must more attractive option since it would give a direct connection with the Earth's magnetic field. Furthermore, the model for EEG forces to assume that also a field $B_{end}/2$ must be assumed and this gives the minimal flux $h_5$. Note that $n = 5$ is the minimal value of $n$ making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [E9].

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

Sensory canvas hypothesis combined with the scaling law suggests an entire hierarchy of sensory canvases. One must however keep mind open for the possibility that the flux tubes of Earth's magnetic field define only single sensory magnetic canvas.

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

Dark matter hierarchy correspond to a hierarchy of values of Planck constant coming as $\hbar = \lambda^k \hbar_0$, $k = 0, 1, 2, ...$ $\lambda \simeq 2^{11}$ is integer and and its harmonics and sub-harmonics cannot be excluded. The model for the hierarchy of generalized EEGs assigns to each level of dark matter hierarchy a typical time scale identifiable as typical time span of memories. From this one can conclude that $k = 7$ is the highest level contributing at personal levels of conscious experience. $k = 4$ assignable to ordinary EEG corresponds to the time scale determined by EEG frequency scale. In this case the hypothesis about evolution proceeding as the emergence of higher and higher levels of dark matter hierarchy at the level of personal consciousness is very natural.

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

p-Adic length scale hierarchy defines a hierarchy at each level of dark matter hierarchy and one can ask whether also the emergence of increasingly longer p-adic length scales characterizes evolution.

*1. Cerebellar, retinal, and cortical rhythms*

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

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

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

2. The micro-tremor of retina corresponds to 80 Hz frequency and would relate naturally to 40 Hz thalamocortical resonance frequency if the magnetic field in question corresponds to transversally scaled down magnetic flux sheets having $k = 167$ instead of $k = 169$. Note that $k = 167$ corresponds to the Gaussian Mersenne $(1 + i)^{167} - 1$.

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

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

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

The spin flip frequencies in EEG range (see the table 4) are $f_s(Cl) = 82$ Hz and $f_s(Rb) = 81$ Hz (80 Hz micro-tremor in retina); $f_s(K) = 39$ Hz and $f_s(Y) = 41$ Hz (both very near to 40 Hz thalamocortical resonance frequency); $f_s(Ag) = 34.2$ Hz, $f_s(Rh) = 26.6$ Hz (27 Hz resonance frequency in dog's cortex); $f_s(Ir) = 17$ Hz (narrow band in EEG [47]), $f_s(Au) = 14$ Hz (the sleeping spindle frequency).

These interpretations are however excluded in the dark matter based view since the ions are assumed to be ordinary ions topologically condensed to dark matter space-time sheets defining $\lambda^k$-fold coverings of $M^4$ so that spin flip photons would be ordinary ones and their energies would be extremely low and much below the thermal threshold. Of course, one must be very cautious with this kind of statements since the ideas about dark matter are still just a colleciton of rules.

*3. p-Adic length scale hierarchy as abstraction hierarchy*

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

*4. Objection against p-adic evolutionary hierarchy*

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

1. According to [40], the wake-up EEG of infants before 3 months age consists of 'fast' background activity. At three months posterior delta rhythm appears at 3-4 Hz and gradually shifts to 6-7 Hz during the first life year. According to [41], binding related 40 Hz oscillations are evident at the age of 8 months. Also the contrast sensitivity of vision improves rapidly to adult level at this age: this conforms with the hypothesis that EEG is essential for the construction of the sensory representations.

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

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

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

The work of Jaynes inspires the idea about child as a small bicameral nursed by the higher collective levels of consciousness. The location of the sensory motor and alpha rhythms in theta band could indeed be seen as an indication for a kind of magnetic nursery provided higher level magnetic selves and their presence would not corresponds to the infant's consciousness but to the consciousness of the "magnetic nurse". Rather interestingly, according to Jaynes [35] sitting in mother's lap can induce EEG in infants not possessing stable EEG yet. An interesting question is whether mother's EEG shows a correlation with that of infant and whether it deviates from ordinary EEG in theta band.

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

### EEG rhythms in contrast to evoked and event related potentials

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

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

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

#### Coherence of EEG and sensory canvas hypothesis

If the EEG measured at skull relates closely to the sensory representations, it must inherit high coherence from the high coherence of the sensory landscape. Also fractal like hierarchy is predicted. At higher frequencies associated with sensory representations in shorter length scales, coherence should be restricted in shorter range. Indeed, according to [47], 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 [47], very complex structures of coherence in bands around 3, 5 and 7 Hz and 13, 15 and 17 Hz are definitely inconsistent with simple dipole models for the generation of EEG patterns. The findings are however consistent with the view that several distant regions of cortex can project features to the same point of a sensory map and that the coherence reflects the coherence of the sensory map. Coherence regions could naturally correspond to the objects of the perceptive field. The high coherence in the band $4-5$ Hz during mental calculations [47], 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 [47], also increase of coherence between prefrontal and posterior cortical association areas have been reported during working memory retention in the range $4-7$ Hz.

The coherence lengths for EEG inside cortex are generally much shorter and complex patterns are encountered. Coherence length of order 2 cm is associated with cortical EEG structures which Freeman introduces as basic units of EEG activity [36] 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.

#### EEG synchrony

The place-coding hypothesis differs from binding by EEG synchrony hypothesis. The experiment carried out by Revonsuo originally deviced to test the binding hypothesis in fact supports the place-coding hypothesis. The interpretation for 40 Hz EEG frequency inspired by the binding hypothesis is as a synchronizing frequency necessary for the generation of unified percepts. This hypothesis has been studied using auto-stereograms [39]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when auto-stereogram was experienced as a set of random dots as compared to the situation when it was perceived as a coherent, symmetrical gestalt. The situation was same also in 8-13 Hz and 13-20 Hz beta bands. The finding is consistent with the place coding hypothesis.

On the other hand, when the conscious percept was transformed from a random set of points to a coherent gestalt, there was a detectable increase in 40 Hz power in the occipital and right posterior sites for EEG electrodes in a time window 500-300 ms before the unified percept was reported. No increase of power in beta bands was detected: this might be due to the fact that the widths of the measured bands are much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [47]. Note that in the model for a hierarchy of EEGs based on dark matter hierarchy beta band correspond to data communicated to the magnetic body [M3].

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

If the response is realized as a negative energy signal from the magnetic body to the geometric past, the time lapse due to the propagation of the sensory signal to the magnetic body is compensated since the negative energy signal travels to the geometric past. In this case the time lapse of 300-500 ms would correspond to the time it takes for the cyclotron phase transition at the magnetic body to occur so that the time lapse would not provide estimate for the distance to the magnetic body. The frequency scale of 40 Hz would suggest that the length scale involved is about $.75 \times 10^7$ m whereas 3 ms lapse would imply a length scale of $.5 \times 10^8$ meters if only positive energy signals are involved.

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

### Narrow EEG bands and sensory canvas hypothesis

Sensory canvas hypothesis predicts the existence of narrow EEG bands corresponding to the magnetic transition frequencies varying in the range determined by the thickness range for the magnetic flux tubes involved with the sensory representation. The most natural candidates for the magnetic transition frequencies are cyclotron frequencies and their harmonics. There is indeed evidence for this kind of bands [47].

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

2. Besides alpha band Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as sub-bands at 13, 15 and 17 Hz in beta band [47]. That beta disappears when eyes are closed conforms with the interpretation of these bands as being associated with sensory communications to the magnetic body. Hence these bands might be associated with the assignment of cognitive features to the points of the sensory canvas. Indeed, the evolutionary hierarchy sensory representations→ cognitive representations→ long term memories involving time like entanglement and making possible historical self, suggests this.

3. 40 Hz band has a width of about 8 Hz, contains several cyclotron frequencies, is associated with the primary sensory areas and disappears during sleep. This suggests that also this band is involved with the projection of the sensory qualia to the sensory canvas. The information about narrow sub-bands of EEG during hypnagogic states (the state between wake-up and sleep involving sensory hallucinations), during the schizophrenic hallucinations and hallucinations generated by sensory deprivation, and during lucid dreaming could provide interesting constraints on the possible sensory quale-EEG frequency correlations.

4. A well motivated guess is that 3, 5 and 7 Hz bands do not correspond directly to the sensory qualia experienced by our magnetic body. Hippocampal theta band (which actually extends

from about 4 to 12 Hz) could contain these narrow bands and be involved with the assignment of abstract features, such as concepts and verbal associations and emotions, to the sensory map crucial for the memories. The fact that alpha and theta waves are important during this period suggests that alpha and theta frequencies are involved with the generation of episodal memories.

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

### 1.4.3 How to test the sensory canvas hypothesis

In this subsection some tests for the new vision about sensory canvas hypothesis are proposed and some astrophysical phenomena possibly supporting the basic assumptions behind the new view are considered. The magnetospheric sensory representations associated with Mother Gaia, as opposed to the sensory representations realized at the personal magnetic body, are discussed in [N1].

#### Some simple tests

One could try to disturb the magnetic flux tubes or MEs responsible for the projection of the visual map to the external world *outside* the body somehow. If the visual experience is modified dramatically, one has an experimental argument supporting the new view. One could perhaps induce also magnetic quantum phase transitions outside the body by stimulating the super-conductors at magnetic transition frequencies and perhaps generate in this manner visual hallucinations. One could generate weak magnetic fields of roughly the same strength as the fields associated with the magnetic canvas and thus superposing with them. Slow modulations of the magnetic fields in these flux tubes might be possible so that cyclotron frequency scale changes and the objects of the perceptive field would be experienced to either contract or expand. Unfortunately (from the point of view of empirical testing), if sensory images are of order ME wavelength $L = c/f$, the sensory images might be extremely stable against perturbations.

One could also study what happens for the vision if the magnetic materials in brain or retina are not present in normal amounts. Or what happens when there is external magnetic field perturbing the magnetic field of Earth inside retina or cortex so that the compass defining the inertial reference frame does not function properly. Does this lead to a sensations associated with dizziness? Could the removal of Earth's magnetic field induce this kind of sensations or affect the visual experience? Probably this is not the case. The general model for EEG predicts that the magnetic flux quanta carrying dark matter responsible for sensory representations and motor control are present even if Earth's magnetic field is cancelled.

#### Tests for place coding

The hypothesis that EEG frequencies in narrow EEG bands code for the distance of an object of perceptive field can be tested. 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. The detection of EEG activity in V1 when percept changes in binocular rivalry would support the existence of strictly non-neural correlates of visual consciousness. Negative energy MEs are responsible for the entanglement, and one must ask what it is to detect negative energy MEs. MEs generate coherent light and phase conjugate laser waves at ELF frequencies are what comes in mind first. It is not at all obvious to me how one could observe these. The breakdown of second law in appropriate time scale might be one correlate for the presence of negative energy MEs.

#### 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 [46]. 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 the magnetic body associated with retina (the size would 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 the case of sensory rivalry: certainly this is not what standard neuroscience would suggest but would be worth of testing.

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

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

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

### 1.5.1 Fractal hierarchy of Josephson junctions

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

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

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

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

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

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

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

2. $k_d = 1$ would correspond to emergence of organs with sizes below 4 cm and bounded by epithelial sheets (double cell layers) of thickness about 10+10 $\mu$m.

3. $k_d = 2$ would correspond to layers of thickness 2+2 cm and structures with size smaller than 80 m. Obviously genuinely dark level is in question now. The layers of this Josephson junction could be assignable to left and right halves of central nervous system. The interpretation in terms of dark matter around the magnetic body of organs suggests also itself. $k_d = 3$ corresponds to the emergence of double layered dark matter structures of thickness 40+40 m and size scale below 160 km. Now dark matter condensed around magnetic bodies of magnetic bodies of organs could be in question.

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

**Fractal hierarchy of Josephson junctions and EEGs**

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

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

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

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

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

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

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

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

The reactions of the Josephson junctions corresponding to different p-adic length scales $k = 151, ..., 169$ (if really present!) to external electric field are different due to $V_1 \propto L(k) \propto 2^{(k-151)/2}$ proportionality and independence of $V$ on $k$.

*2. Thermodynamical considerations*

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

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

*3. Josephson frequencies*

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

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

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

The model identifying generalized EEG as coherent photons emitted by Josephson junction suggest that $k_d = 7$ corresponds to the highest level of dark matter hierarchy for humans. This brings in mind the seven chakras central for Eastern mystic traditions. The magnetic flux quanta would enter the body through organs which are assignable to a particular value of $k_d$ and chakras could be identified as groups of organs with a given value of $k_d$. An alternative possibility is that the space-time sheets at level $k_d$ are joined to the level $k_d+1$ by Josephson junctions. In this case it is not necessary to have connections directly from the level of DNA. The magnetic bodies involved include the magnetic body associated with biological body, presumably that associated with $k_d = 2$, magnetic body of Earth for $k_d = 4$, magnetic body associated with plasma sheet at night side of Earth's magnetosphere, the magnetic body of Sun for $k_d = 6$ and that of solar system for $k_d = 7$.

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

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

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

### What is the precise value of $\lambda$?

The precise value of $\lambda$ is important if one wants to assign the amplitude windows to resonance bands of EEG. $\lambda = 2^{11}$ is definitely favored over $\lambda = 2.17 \times 10^3$.

1. $\lambda = 2^{11}$ implies precise resonance between dark length scales and ordinary p-adic length scales. If $\lambda$ is integer and if it equals to $2^{11}$ then also lower powers of 2 can in principle appear in the dark matter hierarchy as sub-harmonics $\lambda/2^k$ (in general division by integer factors of $\lambda$ defines sub-harmonics). $\lambda$ is predicted to depend logarithmically on p-adic length scale, and the enhanced number of levels in dark matter hierarchy resonating with p-adic length scale hierarchy could be seen as one reason for why 10 nm-20 $\mu$m length scale is so special.

2. The interpretation of the Josephson period associated with the highest level of dark matter as the time scale for intentional action and memory allows to estimate the value of largest $k$ relevant for humans and it turns out that the scaled up Josephson frequency corresponds to a period of 80 years for this option meaning that $k_d = 7$ naturally corresponds to the highest level in the dark matter hierarchy associated with humans. For $\lambda = 2.17 \times 10^3$ Josephson period is about 121 years and $k_d = 7$ level of dark matter hierarchy is therefore not plausible.

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

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

#### Josephson frequencies for various levels of dark matter hierarchy

The following tables list the Josephson frequencies for doubly charged current carriers for the levels of dark matter hierarchy corresponding to $k_d = 0, ..., 7$ using the value .08 V/m for the resting potential for $\lambda = 2^{11}$ and $\lambda = 2.17 \times 10^3$. Note that there is no dependence on the p-adic length scale $k = 151, ..., 169$. Also the frequencies corresponding to the .05 V corresponding to the potential at which nerve pulse is generated are listed. For singly charged bosonic ions the frequency would be $f_J/2$. For fermionic ions Josephson currents are not of course possible.

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

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

| $k_d$ | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| $f_J(80\ mV)/Hz$ | 5.95e+13 | 2.74e+10 | 1.26e+7 | 5.82e+3 |
| $f_J(50\ mV)/Hz$ | 3.72e+13 | 1.71e+10 | 7.90e+06 | 3.64e+03 |
| $k_d$ | 4 | 5 | 6 | 7 |
| $f_J(80\ mV)/Hz$ | 2.68 | 1.20e-3 | 5.70e-7 | 2.63e-10 |
| $f_J(50\ mV)/Hz$ | 1.68 | 7.73e-04 | 3.56e-07 | 1.64e-10 |

Table 4. The Josephson frequencies $f_J = 2eV/2\pi\hbar$ of doubly charged particles corresponding to the resting potential .08 V and threshold potential .05 V for nerve pulse generation for $\lambda = 2.17 \times 10^3$.

Some comments are in order.

1. For $\lambda = 2^{11}$ the Josephson period for $k_d = 7$ is $\simeq$ 80 years, which roughly corresponds to the duration of human life cycle. $k_d = 6$ corresponds to $\simeq$ 14.3 days and $k_d = 5$ to $\simeq$ 10.1 minutes.
2. For $\lambda = 2.17 \times 10^3$ the corresponding periods are 121 years, $\sim$ 20.3 days, and $\sim$ 13.5 minutes. Obviously $\lambda = 2^{11}$ is favored over the value of $\lambda$ deduced from astrophysical considerations.

### 1.5.2 What is EEG made of?

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

#### Basic contributions to EEG and ZEG

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

1. Schumann resonances whose interpretation should be clear. These frequencies do not depend on magnetic field strengths assignable with magnetic flux sheets and characterize Earth's magnetic field and collective aspects of consciousness.
2. Cyclotron frequencies generated in cyclotron transitions of ions. An attractive guess is that cyclotron frequencies correspond to the control signals from magnetic body so that Josephson

junctions and magnetic body would form a closed feedback loop. These frequencies can be classified to those associated with bosonic and fermionic ions respectively. The transitions of Bose-Einstein condensates of bosonic ions are of special interest. The scale of these frequencies could be be subject to homeostatic regulation which is local and can vary even inside genes of a given nucleus.

3. The frequencies generated by Josephson currents as coherent photons. Harmonics of cyclotron frequencies shifted upwards and downwards by Josephson frequency $f_J = 3.72$ Hz. If the amplitude of the perturbation at cyclotron frequency is strong the EEG looks locally like it would consists of amplitudes with frequencies $f_\pm = f_J^1 \pm f_J$ during most of the cyclotron period so that the visual inspection of time evolution of EEG can be rather misleading. Since these frequencies are involved with communications to the magnetic body of Earth, the natural guess would be that they correlate with the neural processing.

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

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

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

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

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

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

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

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

### Classification of cyclotron frequencies

Consider now the classification of cyclotron frequencies.

1. Cyclotron frequencies can be classified those associated with atomic and molecular ions. For biologically important atomic ions most frequencies are above 7.5 Hz. For molecular ions frequencies are lower and for DNA sequences the frequencies are in delta band. Thermal stability condition suggest a lower bound of $\sim 1$ Hz for significant frequencies of this kind. Thus it would seem that delta band dominating during deep sleep corresponds to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions.

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

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

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

### Wake-up EEG

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

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

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

3. Beta band is above 12 Hz and associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous. The natural interpretation is as large amplitude satellite of alpha band involving the activation of communications to the magnetic body and large control signals with $f_J^1 \gg f_c$. Hence the spectra would for a considerable part of period $1/f_c$ effectively consist of frequencies $f_\pm = f_J \pm f_J^1$, where $f_J^1$ varies in frequency range characterized by the amplitude of perturbation. There is no definite resonance frequency since $\omega_1^J$ can vary continuously. Globally the situation is different since the spectrum can in principle be decomposed to frequencies $f_J \pm n f_c$. These two descriptions correspond to time domain and genuine frequency domain.

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

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

4. Odd higher harmonics of cyclotron frequency are expected to be the most important ones and would have interpretation as control signals from magnetic body. Satellites would correspond

to responses to magnetic body involving entire 160 km thick Josephson junction but certainly correlating strongly with what happens in brain (recall the analog of biological body with a receptor at cell membrane).

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

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

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

**Satellites exist as mirror pairs**

The existence of the mirror satellites might be regarded as a killer prediction. Amazingly, narrow EEG bands which are mirror images of each other with respect to alpha band have been reported [47]. 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 [47]. All these frequencies are expressible in the form $f_c \pm f_J$, $f_J = 5$ Hz, which is one half of the frequency 10 Hz of the memetic code and by 14 per cent higher than 3.7 Hz predicted assuming $\lambda = 2^{11}$. The value of $\lambda$ deduced from these frequencies would be $\lambda = 1902$ and about 7 per cent smaller than $\lambda = 2^{11}$. This estimate cannot be taken too seriously since it is quite possible that the thickness of Josephson junction is not scaled up completely exactly.

The cyclotron frequencies associated with the bands are 8, 10, and 12 Hz. The cyclotron frequencies of bosonic ions $^{80}Se^{2-}$, $^{64}Zn^{2+}$, and $^{55}Mn^{2+}$ for a magnetic field strength $B = .526$ Gauss are 8.00, 9.90, and 12.00 Hz. The cyclotron frequencies of bosonic ions $^{59}Co^{2+}$ and $^{56}Fe^{2+}$ would be 10.52 Hz and 11.36 Hz and the satellites are at frequencies 5.52 Hz and 6.36 Hz and 15.52 and 16.36 Hz. All these frequencies belong to the bands reported by Nunez since their widths are 1-2 Hz. Thus the frequencies of all bosonic ions in alpha band and in their satellites belong to the bands reported by Nunez for values of $\lambda$ and $B$ very near to their nominal values used in calculations!

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

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

**Alpha band dominance during relaxed state**

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

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

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

#### EEG during sleep

The EEG during sleep [40] provides a testing ground for the proposed anatomy of EEG. Sleep consists of 90 + 90 minute periods of NREM and REM sleep. This period is also the period of brain hemisphere dominances during wake up and day dreaming occurs with the same period as REM sleep. During REM sleep the EEG is essentially similar to that during wake-up. These observations inspire the hunch that brain hemisphere dominance dictates whether REM or NREM is in question. This turns out to be a correct guess.

*1. EEG during stage 1*

During stage 1 theta of deep sleep [40] waves in frequency range 4-8 Hz dominate and amplitudes increase when frequency is reduced. The control signals from magnetic body are expected to be weak so that $f_J^1 < f_J$ approximation should hold true implying that frequencies $f_J \pm f_c$ should dominate and EEG would look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/\omega_c$ and thus increase with decreasing $\omega_c$. The fact that amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

These facts does not conform with the general picture as such. If theta and beta bands are mere satellites of alpha band, both of them should be present during stage 1 sleep but this is not the case. The idea that cyclotron frequencies of heavier ions in $B_{end} = .2$ Gauss could replace those appearing during wake-up does not work. Theta band simply does not contain the cyclotron frequencies of biologically important ions for $B_{end} = .2$ Gauss. One can imagine two manners to resolve the difficulty.

*a) Two manners to quantize magnetic flux*

One way out of difficulty seems to be that the value of the magnetic field $B_{end} = .2$ Gauss associated with dark flux sheets is reduced by a factor of 1/2 to $B_{end}/2 = .1$ Gauss so that the quantized magnetic flux reduces from $2h_5$ to the minimal flux $h_5$. This looks very natural and would mean that the most important range 7.5-15 Hz of cyclotron frequencies would be scaled down to 3.75-7.5 Hz which indeed corresponds to the theta band. If one excludes $Ca^{2+}$, the range for bosonic ion reduces from $7.5-11.4$ to $3.75 - 5.7$ Hz. The satellites correspond to the range $.05 - 8.7$ Hz and $7.45 - 9.4$ Hz plus $Ca^{2+}$ satellites at 3.8 Hz and 11.2 Hz. With $Ca^{2+}$ forming a possible exception, the resulting frequency ranges are consistent with empirical facts. Of course, it is quite possible that magnetic body does not generate cyclotron transitions at $Ca^{++}$ cyclotron frequency.

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

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

2. Assume the quantization condition corresponds to $Z = 1$ for the right hemisphere and $Z = 1$ for the right hemisphere. The presence of fermionic ions implies additional cyclotron frequencies on left hemisphere and the presence of fermionic ions conforms with the old proposal that fermionic Fock states provide a realization of quantal version of Boolean algebra. This conforms with the view that left brain is more reductionistic and performs linear logic operations whereas right brain is more holistic.

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

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

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

*b) Exotic ions as a resolution of the problem?*

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

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

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

*2. EEG during stage 2*

Sleep spindles appearing in the state 2 of deep sleep are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [49]. The spindles .5-.1.5 seconds and appear with a period of about minute. In some sources frequency range 7-16 Hz is given as sleeping spindle range. The so called K-complexes are sudden increases in EEG amplitude but no change in frequency.

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

*3. EEG during stages 3 and 4*

Most of EEG power during deep sleep stages 3 and 4 is in the range .75-4.5 Hz [40]. This implies that control signals at cyclotron transition frequencies of ions from the magnetic body cannot be appreciably present and the control signals at cyclotron frequencies of molecular ions, such as DNA with cyclotron frequencies below 1 Hz, should be responsible for the EEG. The small amplitude of control signal implies $1/f_c$ behavior and large amplitude as compared to the corresponding amplitudes at higher bands at weak amplitude limit.

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

*5. EEG during sleep and sensory canvas hypothesis?*

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

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

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

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

## 1.6 Support for the magnetic sensory canvas hypothesis

Magnetic sensory canvas hypothesis is certainly the craziest idea inspired by TGD inspired theory of consciousness. The effects of atmospheric and magnetospheric electromagnetic phenomena to conscious experience would support the sensory canvas hypothesis. If sensory organs are the seats of primary sensory qualia, the possibility that atmospheric phenomena could induce extrasensory percepts is excluded. Sensory percepts based on back-projection mechanism might be however possible.

### 1.6.1 Atmospheric and ionospheric phenomena and sensory canvas hypothesis

The sounds claimed to be generated by auroras and meteors and the correlation of UFO reports and ET experiences with tectonic activity provide some clues in the attempt to develop magnetic sensory canvas hypothesis. Also various anomalous visual percepts and OBE experiences provide challenges for the model.

#### The sounds generated by auroras

There are claims that auroras generate audible sounds [16] (for the quantum model of auroras see [J3]). These sounds have not been detected by acoustic means. Of course, it might be only a matter of time when this is done.

A particular example of microwave hearing [42] could be in question. The microwave MEs generated in auroras could propagate like massless particles along ELF MEs to brain, and induce cortical perturbations modulated by ELF frequencies serving as modulating frequencies and determining the pitch of the sounds heard. The perturbations would be analogous to electric stimulation of cortex inducing sensory percepts by back-projection mechanism. The cortical perturbations would generate auditory sensations by the back-projection mechanism. Higher Schumann resonances are in the audible range and could also be mediated along the flux tubes from the magnetic body or magnetosphere to brain and induce audible sounds by the back-projection mechanism.

The TGD based model of hearing relies heavily on classical $Z^0$ fields and auditory canvas could be be actually $Z^0$ magnetic. Since all classical fields are expressible in terms of $CP_2$ coordinates, magnetic storms are expected to be accompanied by their $Z^0$ magnetic counterparts.

### The sounds generated by meteors

so some further evidence for the sensory canvas hypothesis. Since 16th century it is known that also meteors produce audible sounds. What is mysterious that there is no time lag due to the propagation through the atmosphere. The explanation is that it is very low frequency em waves which propagate to Earth and generate sounds by interacting with the objects at the surface of Earth. Joined by the International Leonid Watch - Croatia (ILWC) project, a group of scientists presented the first instrumental detection of elusive electrophonic meteor sounds. In November 1998, the researchers from the Croatian Physical Society and the University of Kentucky organized an expedition to Mongolia to observe the anticipated Leonid meteor shower and shed some light on the phenomenon [17].

The complete data analysis revealed two electrophonic sounds that provided several important clues about the nature of this longstanding astronomical mystery. It became clear that sounds were created when the meteors were crossing night-time ionosphere (the heights involved are in 85-110 km). The electrophonic sounds seem to be produced inside the measuring apparatus suggesting that electromagnetic energy is transformed to sound at this stage. The existing theories cannot however completely explain the phenomenon. The energy of the meteor does not seem to be high enough to invoke the electric fields needed to explain the electronically recorded sounds: only one percent of the electric energy is estimated to be transformable to acoustic form but the required conversion ratio seems to be 100 percent and perhaps even higher than this. The frequencies are much lower than the expected range 20-20.000 Hz range for sferics, which by the way is the range of audible sounds, not an accident in TGD universe. The fundamental frequencies are in the region 37-44 Hz but are consistent with the psychophysical correlate of the sound (deep 'pop').

Magnetic mirrors as carriers of the electromagnetic perturbations might allow a better understanding of the phenomenon. What is intriguing that the frequencies are in the range 37-44 Hz: this frequency range is the same as associated with the average value of the thalamocortical resonance frequency of 40 Hz. This frequency range should be associated with the sensory representations on the magnetic canvas. It is known that sounds near 40 Hz induce strong effect in EEG. The first hypothesis is that the interaction of these em fields with brain generates the perceived sound. On the other hand, in TGD framework these sounds are represented ultimately in the magnetic sensory canvas: thus the intriguing possibility is that the consciously perceived sounds are in fact generated by the direct perturbations of the magnetic or $Z^0$ magnetic auditory canvas and are genuine ESP effects.

The recorded electrophonic sounds could be induced by electromagnetic perturbations propagating along magnetic mirrors at multiples of the fundamental frequency $f = c/L$ determined by the length $L$ of the magnetic mirror and the mirrors might not only channel the electromagnetic energy very effectively but even act as resonators amplifying the em fields. In fact, in one of the models analyzed in [17], the electric fields on the surface of Earth must have the same strength as the electric fields created by the meteor in its immediate vicinity in order to explain the data! If the electric fields are channelled along the magnetic mirrors associated with the magnetic sensory canvases to the surface of Earth, the frequency spectrum is automatically in the 'thalamocortical' range instead of the expected $20-20.000$ Hz range for the sferics and one can understand why only few meteors generate electrophonic sounds. Notice that magnetic mirrors of length shorter than Earth's circumference would give rise to higher resonance frequencies than Schumann frequencies: the required length of the mirror would be roughly 1.26 Earth radii for 40 Hz frequency.

One can imagine tests for the sensory canvas hypothesis and for the possible ESP character of the heard sound (in the sense that the heard sound is induced cortically rather than received from environment).

1. One could construct acoustic amplifier in 37-44 Hz range so that human perceiver could hear both the direct ESP sound and the sound generated by the amplifier. This would mean hearing two 'pops', such that the interval between them is determined by the time used to the sensory processing and propagation of the sound from the external source. In fact, in the introduction of [17] it is mentioned that 'many witnesses heard sounds even before they heard the noise inside the house'. Assuming that the sounds are both heard and electronically detected, a neurophysiological model for the time lapse from the sensory input to the conscious percept would allow to test whether the consciously perceived sounds can have non-ESP origin. If the lag is too small, ESP interpretation is supported.

2. The human perceiver could use ear plugs. If 'pop' is heard also in this case, the only possible interpretation (excluding fraud) is that the sounds are generated either by the neuronal activity stimulated by the interaction of the ELF em perturbation with brain, that the sound is generated in body as physiophonic sound [54], or that a genuine ESP is in question. The phenomenon of physiophonic sound discovered by Antonio Meucci in 1842 means the amplification of external sounds or electromagnetic signals by musculature and their feed directly to the neural circuits (ears could be closed) and is a rather convincing explanation for the heard sounds. The possibility of fraud could be eliminated by excluding the possibility of the direct visual perception of the meteor and finding whether the heard sounds coincide with the electronically detected sounds.

**UFOs, ETs and magnetic perturbations**

Persinger has proposed a model explaining the encounters of extraterrestrials as hallucinations caused by the perturbations of Earth's magnetic field induced by the liberation of the tectonic energy at the lines of tectonic activity [92]. The model is based on well-established statistics about the effects of the perturbations of Earth's magnetic field on consciousness collected in mental hospitals. The lines of the tectonic activity are also accompanied by well established luminous phenomena which suggests that the model could be naturally combined with the explanation of UFOs as this kind of luminous phenomena.

The most obvious guess is that a beam of visible light or ions emerges from the region where the tectonic energy is liberated. If this beam somehow produces a localized ball lightning type phenomenon it could be interpreted as UFO. If the direction of the beam varies randomly the resulting UFO performs random butterfly like motion and in principle the velocity of motion can be super-luminal since a signal velocity is not in question. The motion would resemble that of a flicker's light spot in a roof. Many UFO candidates have indeed found to move in this manner and this is quite a challenge in the attempts to understand the technology used.

1. *Why a light spot rather than beam of light is observed?*

The challenge is to explain why a localized pseudo UFO rather than a beam of light is observed.

1. One could consider the possibility that a radial spray of electric flux emanates from the site of the tectonic activity and electrons accelerate in this field until they gain the energy needed to ionize the molecules of the atmosphere and produce visible light. The analog of vacuum discharge would be in question. The problem is that the drifting velocity is achieved very rapidly so that the model works only if the density of molecules of the atmosphere decreases sufficiently fast as function of height. This is not the case.

2. Suppose that the spot of tectonic activity emits $k_{em} = 1$ dark microwave photons including frequencies $f > 5$ GHz. In this case visible light could result via the de-coherence of the dark microwave photons to ordinary photons. The fraction of ordinary visible photons in the beam would behave as $1 - exp(-h/h_0)$ and at some critical height the beam would become visible as the visible photons scatter from the molecules of atmosphere.

3. Pseudo UFO could be a kind of a mini aurora produced by exactly the same mechanism as auroras. Similar mechanism could apply also to ball lightnings and other exotic luminous phenomena. The super-conducting magnetic flux tubes associated with the stream of magnetic flux assumed to emanate from the site of tectonic energy liberation would intersect with the magnetic flux tubes of Earth's magnetic field (or those emerging from the brain or body of the perceiver of ETs). This would lead to a reconnection process in which magnetic flux tubes having a local U-shape are generated. The inertia of the super-conducting ions (perhaps protons and electrons) would induce the leakage of the ions to the non-super-conducting atmospheric space-time sheet. This in turn would lead to a further ionization and the molecular electronic transitions would generate the visible light as in the case of auroras. Also electric fields could be involved as in the case of auroras. U-shaped structures would occur at definite height. By measuring the local electromagnetic fields one could perhaps test whether the orbit of the pseudo UFO correlates with the variation of the hypothesized stream of magnetic flux emerging from the site of the tectonic activity. The pseudo-UFO character could be tested by finding what kind of radar echoes the luminous region generates (if any).

2. *What about ET reports?*

The aurora mechanism could explain also the hallucinations as real encounters with other selves of the predicted self hierarchy rather than ETs. The tectonic activity could cause a similar perturbation of the personal sensory canvas and perhaps its temporal fusion with other sensory canvases, perhaps even with higher multi-brained sensory canvases possibly present. This would obviously induce genuine ESPs. The generalized motor response coming from the sensory canvas would be also involved but primary percept would occur before it. Brain would probably do its best to interpret the situation using concepts provided by the cultural background. Angels, spirits, demons, ETs, etc.. would be various narratives for the same phenomenon.

Also Schumann resonances are excited during tectonic activity and could correlate strongly with the experiences about encounters of ETs: this explanation is consistent also with option b). Similar mechanism might be behind hypnagogic experiences occurring at the boundary between wake and sleep. EEG is dominated by frequencies near the lowest Schumann frequency 7.8 Hz during hypnagogy and this might mean that the entanglement with other sensory canvases occurs with an enhanced probability.

Krishnamurti has told very movingly about experiences of literally being another one. Perhaps also other identification experiences, such as shamanic identification with animals, rely on the same mechanism. Also I have had strange hypnagogic experiences of being a totally different person for a moment. This picture would suggest that magnetic transition frequencies associated with the flux tubes of the magnetic sensory canvas emanating more or less vertically from the head code for the personal content of consciousness whereas Schumann frequencies relate with the transpersonal contribution to consciousness possibly present always and giving rise to a third person bird's eye of view about own person and amplified during hypnagogic experiences or by strong perturbations of Earth's magnetic field.

### Anomalous visual percepts and sensory canvas hypothesis

Sensory canvas hypothesis means that at the perceptual level we see using ELF− rather than visible light. Of course, if primary sensory qualia are at the level of sensory receptors, this seeing has the character of imagination. Even in this case brain could use back-projection to the sensory receptors assign sensory qualia with the imagination like perception. This would occur during dreaming and what is regarded as hallucinations.

One can also consider the possibility of "vision" as a sensory experience of the magnetic body based solely on the ELF input from brain and body having no correlate with the visible light entering into the retina or even with neural activity. The de-coherence of (for instance) dark ELF photons with frequencies above alpha band at $k_{em} = 4$ level of the dark matter hierarchy to ordinary visible photons could be responsible for this vision.

Even genuinely three-dimensional vision in which own body is seen as it would be seen by the external world suggests itself. The dropping of ions from the atomic space-time sheets to the magnetic flux tubes so that they end up to high $n$ cyclotron states decaying via the emission of photons at frequencies which are harmonics of the cyclotron frequency would generate the projector MEs needed for the sensory representation of the physical body or part of it as seen by the environment.

There is some evidence for this kind of anomalous vision.

1. Yogis have reported altered states of consciousness in which they see their own body three-dimensionally, that is simultaneously from all directions. This might have interpretation as ELF vision involving a feedback from magnetic sensory canvas to brain to "qualiafy" the percept. An alternative interpretation is that the visual experience is visual experience of some other self which is shared by quantum entanglement.

2. Becker tells in his book "Cross currents" [60] about a young cancer patient who told that he can see the interior of his own body. The patient could also locate the remnant of the tumor correctly. If sensory receptors are necessary for visual qualia, the needed data must be received from somewhere by brain, and be projected to the retinas like during dreaming. The simplest option is that body parts can in some sense "see" each other. In particular, brain can "see" body parts (note that bacteria possess a primitive IR vision based on micro-tubules). Bio-holography provides support for the body as a hologram. For instance, an electric stimulation of ear during

Kirlian imaging of a finger tip creates a Kirlian photo from which it is possible to abstract a hologram of ear (see [47] and [K5]). One can also imagine that magnetic body sees and the mechanism is the transformation of dark $k_{em} = 4$ microwave photons to visible photons.

3. Also the OBE experiences, for instance those associated with NDEs, could have an analogous interpretation. The sensory input from eyes would be absent but brain would give feedback to visual receptors to "qualiafy" the the input which it might receive from other levels of self hierarchy. If even the input from neural activity is absent during NDEs so that the visual experience should be determined by the background ELF component emanating from the brain and body. The third person perspective associated with OBEs might be always present but be masked by the strong sensory input or by the absence of feedback to visual receptors. It is possible to have experiences about contact with deceased by a therapy based on rhythmic eye movements [52, 53]. The function of eye movements might be to establish a feedback to certain brain regions serving as receivers of input from magnetic bodies of deceased or from magnetosphere. I have developed a detailed model for various kind OBE experiences in [H10].

4. I have proposed thousand and one explanations for the beautiful flow visible when I close my eyes in a calm state of mind. During my "great experience" this background flow was accompanied by extremely vivid visual hallucinations. An additional item to the long list of explanations is following. The information characterizing the flow enters from or via brain to the visual receptors and is in this manner "qualiafied".

What has been said about magnetospheric third person aspect applies also to other senses. Interestingly, I often wake-up partially and realize that I hear my own snoring as an outsider (quite a dramatic experience!). Sometimes I have had an experience which might be interpreted by saying that the hearing in the first perspective is superposed with the hearing in the third person perspective. The third person hearing has a time lag so that a kind of double breathing results.

### 1.6.2 Taos hum

Taos hum is an experimentally well-established anomalous phenomenon which has escaped rational explanations (in the article [54] a thorough review about nocturnal taos hum is given and the following representation relies on this article). Very concisely, taos hum seems is apparently a subjective experience without identifiable objective counterpart and could thus provide an application for the sensory canvas hypothesis.

#### Basic facts

Taos hum is perceived in and around Taos, New Mexico but similar phenomena are experienced also in Northern America and Northern Europe. The hum is mostly heard during night time. Most people experience the hum as irritating and it causes nocturnal disturbances. From the tests based on psychophysical matching the frequency range of the hum has been deduced to be 40-80 Hz and whereas amplitude is around 60 dB. The hum is a regional phenomenon. The hum does not usually appear between sunrise and sunset. The pitch and intensity of the hum varies inside house and finds the largest magnifications on lower floors. Rooms modify the hum by adding distinctive harmonics to it. The pitch of the hum changes when one moves from outer wall to the interior rooms. Hallways and small alcoves raise the pitch considerably. The wavelengths involved vary between 3.9-7.8 meters for 40-80 Hz frequency range which suggests that resonance effects could be involved. It has been however impossible to identify any acoustic origin for the phenomenon. The presence of effectively acoustic effects suggests that gigantic amplification by the physical (and em!) body of the patient is involved.

Hum can involve also an experience about whirling or roaring wind, kind of vortex although nothing moves around, and coming from all directions. Also a strange amplification of distant sounds can be experienced. White light in the horizon in the direction where hum comes from can be also perceived. Experiences analogous to hum have been reported also in past, even in antique ('Aeolian wind'), but nowadays the number of victims of the hum has increased, which suggests a connection with the emergence of electronics and computers. The direction which hum is experienced to come from seems to be random.

The hum can be accompanied by irritating tactile sensations and neuralgic pain. The unfortunate individual who suffers of extreme HUM disturbances, seems to be controlled by very fundamental and autonomic response-reflexes when in its grips. Such sufferers may behave in semiconscious modes, modelling behavioral patterns seen only in animals. Typically the victim tends to get underground believing that this allows to get him rid of the hum. The victims of hum indeed tend to wake up with the realization that they have very strong and painful muscle tenure.

An important hint as regards to mechanism of hum is the fact that the temporal patterns of the shortwave radio static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the statics is present during night time.

All attempts to detect the hum instrumentally and to identify its source have failed. This has inspired various kinds of conspiracy theories about the nature of the phenomenon, for instance, the proposal the strong ELF power feed by submarine radars alone could explain the phenomenon.

#### Phenomena possibly related to taos hum

It is appropriate to discuss first some phenomena possibly related to the taos hum before considering the model for the phenomenon itself.

*1. Microwave hearing*

During the collaboration with Joaquim Fernandez related to the construction of a a model for so called Fatima miracle [51] I learned about the phenomenon of microwave hearing [42] in which microwaves generate an audible sensation. There is evidence that microwave hearing does not involve ears as receivers of the primary signal [48] and that the sensation of hearing could result as back-projection from cortex to ears.

This, and the correlation with microwave static suggest that taos hum could be a particular case of microwave hearing, and that the phenomenon involves ELF MEs along which microwave MEs propagate to the brain and body. The model of sensory representations implies that brain acts as a sending microwave antenna: a natural implication is that brain can act also as a receiving microwave antenna. The size of the brain hemisphere corresponds to a microwave frequency of order 3 GHz and smaller structures inside brain correspond to higher radio frequencies. If primary sensory organs are the seats of the sensory qualia and that back-projections cannot induce physical pain, the presence of the painful tactile sensations means that microwaves must interact also with the sensory receptors at the skin.

*2. Physiophonic effect*

Physiophonic effect is a phenomenon accidentally discovered by Antonio Meucci in 1842, in which vocal signals are electrically transmitted directly into the neurology of listeners [54]. Physiophonic sound can be often amplified to an enormous volume. A possible interpretation is as externally stimulated internal sound but one can of course wonder whether the transduction to sound is necessary.

Since the body (especially collagen network) is liquid crystal allowing piezoelectric effect in which mechanical vibrations are transformed to electric signal, external sounds could be transformed to electric fields. On course, LC property implies that also genuine sound is generated so that both ELF em fields and ELF sounds can act as amplified signals. One can ask whether strong back-projection to the ears is generated so that sound percept results. This would imply oto-acoustic sounds directly detectable by microphones not found in the case of taos hum.

*3. Microwave static and taos hum*

It is known that the temporal patterns of the shortwave static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the fact that the static is present during night time would explain why hum is experienced at night time.

### Possible ingredients for the model for taos hum

The facts about the role of the musculature, shortwave radio noise, and the role of acoustic environment combined with the model of microwave hearing based on the notion of dark photons [K6] give strong constraints on the model of taos hum.

*1. Taos hum as sensitivity to alien control commands*

Magnetic bodies control biological body by sending control commands to brain and body where they are transformed to nerve pulse patterns and various physiological waves. Also the lower levels of self hierarchy should control the respective levels of the hierarchy, in particular muscle cells, in a similar manner. In the case of hum patient the normal control signal could be replaced by a control signal from some external biological source, say plants, and would be responsible for the muscular vibrations amplified to the hum. In the worst situation the behavior of hum patients reduces to simple reflex actions: these reflex actions would be initiated by fake control signals.

The situation would be due to the failure of the em (or rather, electro-weak) immune system of the patient. In order to understand what is involved a brief discussion of model of motor control based on charge entanglement induced by $W$ MEs is necessary: a detailed model is discussed in [K5, K6].

1. The exotic ionization of dark matter induced by $W$ MEs generates dark plasma oscillations inducing electric fields which by many-sheeted variant of the Faraday law induce electric fields also at the space-time sheets where ordinary matter resides. Various ionic waves, in particular $Ca^{2+}$ waves and nerve pulse are examples of the physiological responses resulting in this manner.

2. Dark plasma frequency corresponds to a microwave photon with energy above the thermal threshold and the system must be able to provide dark photons with this energy to generate plasma oscillation patterns serving as control commands.

The electro-weak immune system could fail in the following manner.

1. In the healthy situation em immune system takes care the the body is tuned to the personal dark plasma frequencies and does not respond to control commands from alien magnetic bodies associated with say plants.

2. In an un-healthy situation persons plasma oscillation frequencies are tuned to some frequencies in the microwave static and microwave static provides the energy needed to generate plasma wave patterns and thus to realize control commands from the alien magnetic bodies. The plasmoids would induce microwave hearing and generalized motor actions at cellular level exhausting the personal metabolic sources and leading to the painful experiences and fatigue.

*2. Taos hum and microwave hearing*

The identification of the audible sensation associated with taos hum is in terms of microwave hearing explains the failure of the attempts to identify the source for taos hum. Amplitude modulation by ELF frequencies naturally associated with motor control would give rise to sensation of sound.

Concerning the model for microwave hearing, a good guideline is that the effect is expected to be possible as quantum effect only if the energies of the microwave photons are above the thermal threshold. This would require dark microwave photons $k_{em} = 1$ level of the dark matter hierarchy for which 5 GHz photons have energy above thermal threshold (6 cm wavelength). Same applies to other effects caused by dark microwave photons.

*3. Taos hum and microwave seeing*

The de-coherence of microwave photons to ordinary photons would produce the biological effects. This could explain also the reported perception of white light as resulting from the de-coherence of the microwave photons at the upper end of the spectrum: 1 mm microwave wavelength would correspond to 2.5 eV photon energy.

The de-coherence of dark microwave static to ordinary visible photons could make possible microwave vision during night time. This could explain why the static emerges after the sunset. Plants could also generate negative energy dark microwave photons with energies in the frequency bands of visible photons involved with photosynthesis to satisfy their metabolic needs when they do not receive sunlight. One can of course wonder whether the quartz in the rock heated during day-time could generate $k_{em} = 1$ dark microwave photons during night-time serving as a metabolic source.

*3. Taos hum as a failure of the electromagnetic immune system*

Taos hum starts immediately after the sunrise and stops after the sunset and seems to have a biological origin. The magnetic bodies of (say) plant cells could send $k_{em} = 1$ dark energy photons at microwave frequencies above 5 GHz: one reason is that they become visible in this manner.

Negative energy $W$ MEs in the same frequency range and responsible for quantum bio-control in the time scale of microwaves could be involved. Due to the failure of the electro-weak immune system the surrounding biosphere could induce generalized motor actions and these would exhaust the metabolic energy resources of the victim. This would explain why the hum is intolerable and the extreme fatigue caused by it.

The radio noise generated by computers and other sources of radio waves should not cause troubles if these radio waves correspond to ordinary photons. If not, then the microwaves in question could provide the energy needed to realize alien control commands based on ELF modulation.

*4. An explanation for 40-80 Hz modulation*

The model of bio-control based on dark matter hierarchy [M3] predicts that $k_{em} = 4$ level of the dark matter hierarchy corresponds to EEG frequency range from the requirement that dark EEG photons have frequencies above the thermal threshold. This level is involved with all life forms capable of genetic expression, in particular plants. Therefore the ELF modulation of microwave frequencies could be due to the control commands from $k_{em} = 4$ magnetic body normally meant to control the genetic expression of say plants. The modulation of the microwaves with EEG frequencies, in particular with the frequencies in the $37 - 44$ Hz thalamo-cortical resonance band, could force the patient to stay awake by not allowing the dominant EEG frequencies to drop down to theta and delta region of EEG as occurs during sleep.

*5. Is stochastic resonance involved?*

One could also ask whether the microwave static of victims of taos hum is anomalously amplified by some mechanism so that control commands from alien magnetic bodies can be realized. The transduction of weak microwave signals to mechanical oscillations by piezo-electric body liquid crystals, and the amplification of this signal in the presence of a metabolic energy feed to the musculature, could lead to this kind of situation.

Stochastic resonance with white noise generated by body provides one possible amplification mechanism. Micro-wave frequency would correspond to the amplified frequency. If so, one could perhaps understand why only some persons experience the hum and why the effect is strong at night time. White noise would be generated by body. White noise induces jumps between the states of the 2-state system with an average frequency $f_K$ (Kramers frequency) which depends on the autocorrelation function of the white noise and the properties of the 2-state system [M5]. If the Kramers frequency satisfies $f_R = 2f$, where $f$ is the frequency of the signal, a resonant amplification occurs. The dependence $f_K \propto exp(-\Delta V/D)$, where $\Delta V > 0$ is the height of the potential barrier separating the states of the 2-state system, implies and exponential sensitivity of $f_K$ on $1/D$, where $D$ is the intensity of the white noise. Hence the failure of the em immune system could be due to the too intense white noise produced by the body of the victim or due a too low height of the the potential barrier.

*6. Are electronic systems involved with the hum?*

The fact that the number of victims of hum has rapidly increased during the era of radio communications and computers and suggests that both radio noise and computers might be actively involved with the hum. Also ELF noise from electronic systems might be important if these systems generate $k_{em} = 4$ dark ELF photons.

Electronic instruments generate also frequencies in the range $40 - 80$ Hz, in particular the 50 Hz frequency associated with the household electricity. Also submarine radars generate very strong ELF signals. The liquid crystal character of human body implies that besides weak sound signals also these ELF signals can contribute to the signal amplified by musculature. If these signals correspond to $k_{em} = 0$ level of dark matter hierarchy, they should not have biological effects but whether this is the case is not all clear.

The strong coupling between magnetic flux tube structures associated the with computer networks and sensory canvases might be created by the magnetic reconnection process during night time when the shape of the flux tube structures changes. Also whole-daily use of a computer could generate magnetic mirror bridges between the computer and user's musculature and allow computer to feed fake control signals to muscles.

### Is hum possible in other sensory modalities?

The model of hum based on magnetic sensory canvas suggests that the effect is involved with all sensory modalities. Tactile sensations, in particular pain, are certainly involved. It was already mentioned that hum experiences can involve also perceptions of white light in the horizon in the direction from which hum came. In the model explaining the sensation of hum as being caused by the muscular sound, this sensation could result as a kind of cross-modal association accompanying very intense auditory sensation. In the model explaining the effect as ESP the presence light sensation could be understood as visual aspect of the ESP.

My personal experiences provide a candidate for the counterpart of taos hum in visual field. While closing eyes in a calm state of mind, I see a strange and complex flow consisting of small dots: for the first time I had this experience during my great experience roughly 15 years ago. The effect is easiest to achieve with lightly closed eyes but appears after some time also with tightly closed eyes. For lightly closed eyes the flow is more complex whereas for tightly closed eyes there is just a sink in the middle representing what I would call 'third eye', which is present practically always. Vortices and spiral vortices (compare with the whirling winds associated with hums) are typically involved and flow can have also weak coloring.

Could this flow be the visual counterpart of the taos hum? The very fact that the experience is pleasant and the appearance of diffuse white light during taos hum suggests that this interpretation need not be quite correct.

1. The effect is caused by the de-coherence of dark microwave photons or perhaps dark $k_{em} = 4$ EEG photons above alpha band to visible photons (during calm states of mind alpha band is very strong).

2. This effect is strongest when the eyes are only lightly closed. Perhaps ELF em waves from some source could provide the input to the retina which is magnetic structure and generate the visual sensation somehow (note that rotating non-colored Benham top can generate sensations of color). The de-coherence of $k_{em} = 4$ dark ELF photons to ordinary visible photons could be the mechanism.

3. I have proposed an interpretation for the flow in terms of the magnetic flux tube structure emerging from the retina. One can however wonder why just single central vortex rather than two? Could it be that pineal gland, which is also a magnetic structure and contains retinal pigments and is 'third eye' in rather literal sense, could be responsible for the 'third eye' component of the flow, and that during eyes lightly closed conditions turbulent retinal and single vortex like pineal contributions superpose? Could pineal vision be based on the de-coherence of EEG waves above alpha band to ordinary visible photons?

What is perhaps remarkable that the ability to have the flow experience has stabilized during last year or two, which is also the period during which various hum symptoms have developed. However, I experience the flow also when the computer is off: as a matter fact, I experienced the flow for 15 years ago when I did not work with computers.

### Personal experiences about hum

While learning about taos hum, I suddenly realized that I am perhaps not an objective outsider at all! I cannot tolerate the humming noise of the refrigerator: in order to sleep at all I try to insulate myself from the kitchen by cloth (I do not have door between) and use pillows on my ears in order to get rid of this extremely irritating sound. Even this is not enough and I wake-up very often during night-time. I also used to have terrifying experiences in which the noise of the refrigerator started to increase in volume and my body started to float and was attracted by the refrigerator as if it were a conscious creature wanting to fuse with, or rather steal, my consciousness (by the way this suggests that magnetic selves strongly interacting with my magnetic body might be really involved). I can also hear sounds, such as cracks from wall, as amplified to completely abnormal intensity (in fact I have always had abnormally sensitive ears).

I suffer also from almost intolerable hum of my computer at day-time and only while learning about taos hum, I realized that similar mechanism might be at work also here (note however that taos hum is strongest during night time, between 9 P.M. and 9 A.M.). Remarkably, the hum amplifies when I become conscious of it: I can work long times without noticing its presence at all. Neither am I aware of the refrigerator at daytime. To complete the picture, two years ago I began to suffer from chronic pain in head, neck and back which are due to strong muscle tensions. These pains correlate very strongly with working at the computer terminal. I have believed that this is due to the bad working ergonomy and poor quality of eye glasses. However it turned out that this was not the reason of pains. I have even suffered from temporal dizziness when pains have been worst and even lost my consciousness once: strangely enough, I heard before the loss of consciousness a strange whirling wind to blow (sic!), and realized only later that weather had been completely calm.

It seems that all these symptoms fit with those of a hum patient. Now only the source of radio waves would be my own computer and would act also at daytime via direct radio wave magnetic mirror bridges connecting the oscillating circuits of the computer to my musculature. When I am not aware of the noise, my brain does not project sensory input from muscles to the auditory canvas and I am saved from the hum sensation. I however feel the pain coming from the body all the time.

On basis of what has been said, it would seem that there is high time to consider the possibility that the electric pollution of environment is gradually making our life increasingly intolerable. One cannot even exclude demon like conscious virus like entities generated by the electronics and computers and fighting for survival with us.

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# Chapter 2

# TGD Inspired Model for Nerve Pulse

## 2.1 Introduction

The model of nerve pulse has developed through several tortuous twists reflecting the development of the basic ideas of TGD inspired theory of consciousness and of bio-systems as macroscopic quantum systems. The chapters about EEG and ZEG provide a necessary background for the model of nerve pulse. The chapters [M4, M5] written before dark matter revolution provide a detailed discussion of basic aspects of EEG. The newest chapter [M3] related to EEG provides a very general vision about the hierarchy of EEGs based on dark matter hierarchy and about its generalization to ZEG and even WEG ($Z$ and $W$ denote for dark $Z^0$ and $W$ boson fields with interaction range which can be arbitrary long at higher levels of dark matter hierarchy). This model derives from the model of bio-superconductivity as quantum critical high $T_c$ super-conductivity [J1, J2, J3]. The consistency with the model of DNA as topological quantum computer [O4] poses additional strong constraints on the model.

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several manners for how this could happen.

1. The first idea was that axonal membrane acts as a Josephson junction and that a soliton propagating along it induces the nerve pulse. The model for the high $T_c$ electronic superconductivity allowed to construct a detailed model for this Josephson junction and "timelike" and possibly also space-like soliton sequences are indeed present. Time-like soliton sequences however represent oscillations at a frequency of order $10^{13}$ Hz. For the scaled up dark matter variants of cell membrane Josephson junction at $k = 4$ level of dark matter hierarchy standing EEG waves at 5 Hz frequency can be identified as Josephson oscillations. It is however clear that moving solitons cannot correspond to nerve pulses.

2. The next working hypothesis was that $Z^0$ massless extremals (MEs, topological light rays) drifting along axon induce the nerve pulse. It became clear that this model [18] cannot be the whole truth although a pulse propagating along $Z^0$ or em MEs parallel to axon combined with drifting of ME cannot be excluded as initiator of the nerve pulse. In the recent model this idea is given up.

3. Dark matter revolution led to a much more elegant looking idea. Nerve pulse is generated as the charged entanglement induced by $W$ MEs connecting magnetic body and cell interior is reduced in a quantum jump leading to a state in which cell interior receives a positive exotic charge due to exotic ionization of a Bose Einstein condensate of the bosonic ions so that the value of the resting potential is reduced below the critical level. This process would occur only at the axonal hillock and one might hope that the rest would be more or less ordinary biochemistry. This need not be the case as the strange findings about ionic membrane currents discussed in [J3] demonstrate. It turns out that exchange of $W$ bosons could indeed be the primary cause of nerve pulse generation but that also other options are possible.

4. Quite recently I learned [106, 107, 108, 109, 110] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) [O4] leads to a rather precise model for the generation of nerve pulse.

### 2.1.1 General vision about living matter as a macroscopic quantum system

The following assumptions summarize the general vision achieved before the dark matter revolution. The picture is consistent with the findings of Libet about strange time delays of consciousness [38, 27] discussed in the article "Time, Space-time and Consciousness" in [17] and chapter [K1].

1. Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the cascade of negative energy MEs ends up to the glial cells serving as metabolic sources. The desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism. The population inverted many-sheeted laser system providing the energy source in brain or body would consist of bosonic ions or of Cooper pairs of fermonic ions in excited cyclotron states.

2. 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.

   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 MEs received from magnetic body communicate the desires of the magnetic bodies about motor actions to be performed and the response by positive energy MEs would realize these desires as nerve pulse patterns.

3. Positive energy interior MEs lie along interior of magnetic flux tubes of the personal magnetic body. These MEs could relate to the classical communication of the symbolic representations constructed from the data processed in the brain to the magnetic body. 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.

### 2.1.2 A general view about quantum control, coordination and communication inspired by dark matter hierarchy

The following general overview about quantum communication and control emerges from the model for EEG hierarchy as correlate for dark matter hierarchy discussed in detail in [M3].

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

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. A good guess is that in this case magnetic flux quanta are hollow cylindrical structures serving as templates for axons and possibly other similar structures and define the communication lines connecting cell membranes to the magnetic body.

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

4. In the length scales below the weak length scale $L_w$ also charged weak bosons behave as massless particles and the exchange of virtual $W$ bosons makes possible a nonlocal charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark $W$ boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy.

5. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Besides neutral massless extremals (MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The second nonlocal quantum control mechanism is based on em charge entanglement involving a superposition of ordinary ions/atoms and exotic ions connected by a $W$ massless extremal joining magnetic body and biological body. In quantum jump this state would be reduced to exotic charge state with some probability increasing with the strength of the classical $W$ field. Charged massless extremals could be seen as correlates for nonlocal quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K3].

6. These nonlocal quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control of nervous system by magnetic body. The generation of nerve pulse could rely on the spontaneous state function reduction occurring for charge entangled state reducing the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

### 2.1.3 The role of electronic super-conductivity

#### General mechanisms of bio-superconductivity

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the 'dropping' of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high $T_c$ macroscopic quantum phases are met.

The possibility of large $\hbar$ quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. This isolation might of course be present and make possible ionic super-conductivity. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

A crucial element is quantum criticality predicting that new kind of superconductivity, "boundary superconductivity", appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei besides large $\hbar$ variant of ordinary superconductivity in the interior. The Cooper pairs of interior and boundary supra currents are different with interior Cooper pairs being BCS type. These two superconducting phases compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living matter. Also high $T_c$ superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic and $Z^0$ magnetic flux tubes and sheets are especially interesting candidates for dark supra current carriers and might define Josephson junctions. In this case the Cooper pairs must have spin one and this is indeed possible for wormholy Cooper pairs. The fact that the critical magnetic ($Z^0$ magnetic) fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high $T_c$ bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and possibly proton Cooper pairs are possible at room temperature. The effects of ELF em fields on vertebrates suggest that Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged [F9] are there but the model of high $T_c$ super-conductivity does not favor them. It is of course possible that the temperature at dark magnetic space-time sheets is lower than at the visible space-time sheets.

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

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the value of $\hbar(k_d) = \lambda^{k_d}\hbar_0$, $\lambda = 2^{11}$. Much more general values of $\lambda$ are possible and some of them probably realized but these appear in the model of EEG.

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

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

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

### Experimental evidence for bio-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 [M4]. Already before the ideas inspired by the dark matter hierarchy the contact by Hafedh Abdelmelek and his group [67] led to a crucial step of progress in the understanding of this function. It became clear that genuine or effective electronic super-conductivity (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 explained 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. The breaking of the electronic super-conductivity is an essential aspect of the ordinary nerve pulse conduction in this model. Also the distinction between poikilotherms (such as frog) and endotherms (such as rabbit) can be understood. As it often happens, the most recent model is not consistent with this model but is preferred by its simplicity.

### Strange findings about cell membrane

There are very strange findings challenging the notions of ionic pumps and channels [33, 39, 40, 34], and suggesting a mechanism dramatically reducing the metabolic costs involved with the ionic pumping. Second finding is that ionic currents seem to be quantal and are same for polymer membrane than for cell membrane! A further strange finding [106] is that the propagation of nerve pulse does not cause heating of the cell membrane implied by the model of nerve pulse based on chemistry. This suggests that dissipation is absent also during nerve pulse propagation and that the process might not be chemical as assumed hitherto.

One can imagine two explanations.

1. The first explanation would be that ionic currents are actually dark supra currents flowing along larger space-time sheet connecting cell interior and exterior. The model of high $T_c$ super conductivity favors only electronic and protonic super conductivity at room temperature [J1] whereas the model for EEG favors the presence of Bose-Einstein condensates of ions. Bosonic ions are required: the new nuclear physics predicted by TGD [F9] allows to assign to fermionic ions their bosonic chemical equivalents. Even permanent connections with the cell exterior (by magnetic flux tubes, say) are possible since Josephson currents oscillate. One can of course consider the possibility that dissipation rate is small due to the large value of Planck constant even in the absence of super conductivity. Also the temperature could be lower at the magnetic flux tubes containing dark ions but this assumption will not be made.

2. Second model that one can imagine relies on the exotic nuclear physics predicted by nuclear string model [F9] and the predicted hierarchy of fractally scaled up variants of weak interaction physics. If weak interactions can be present in cell length scales, the exchange of virtual or real $W^{\pm}$ bosons between nuclei could induce purely quantal and non-dissipative charge transfer between cell interior and exterior. Also charge entanglement becomes possible. The emission of $W^{\pm}$ would modify the nucleus to an exotic charged state in which one of the neutral color bonds connecting nucleons is charged. Since $W$ exchange does not depend on cell membrane at all, the prediction would indeed be that ionic currents do not depend at all on the membrane in question. The model of nerve pulse however suggests that $W$ exchange can have only a role of a control signal.

One can argue that pumps in case of ordinary matter are needed only when the cell interior and exterior are connected by join along boundaries bonds and that this connection is built only for diagnostic purposes in order to measure the concentrations of ions by measuring the ionic currents by their dissipation. The remote metabolism made possible by many-sheeted lasers reduces further the energy costs when pumping actually occurs.

## 2.1.4 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.

#### Universe as a conscious hologram

1. 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, ... Super-conducting magnetic flux tubes are also important and act effectively as wave guides along which MEs propagate.

2. 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 the sole 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.

3. 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 and WEG) is involved. After dark matter revolution it became clear that MEs are the natural correlates for coherent states and Bose-Einstein condensates of dark matter bosons. It is still an open question whether ordinary laser light might be regarded as a special case of dark photons. Certainly the transformation of dark bosons to ordinary ones would occur through a de-coherence phase transition just like the transformation of laser light to ordinary photons.

#### Various kinds of MEs

One can imagine many kinds of MEs.

1. 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. Also MEs in time scales at least down to $10^{14}$ Hz corresponding to visible photons are predicted be important.

2. Also boundary MEs identified as MEs attached to the boundaries of matter carrying space-time sheet and drifting along it quantum jump by quantum jump by a velocity $v < c$ can be considered and $Z^0$ MEs of this kind were in a key role in the previous model for nerve pulse generation. 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 $v/c$.

3. Negative energy MEs, which correspond to phase conjugate laser light, make possible intentional action at the micro-tubular level, they are crucial for the understanding of the macro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called seesaw mechanism of energy metabolism (see the article "Time, Space-time and Consciousness" in [17]). Phase conjugate laser beams [19, 20] seem to be the standard physics counterpart of negative energy em MEs and negative energy photons accompanying them.

4. Fractality implies that MEs contain MEs within MEs: this conforms with the general ideas about dark matter hierarchy and p-adic length scale hierarchy. MEs within MEs is the topological correlate for de-coherence 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 [62] 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 could serve as correlates for remote quantum entanglement in cyclotron degrees of freedom. $W$ MEs would make possible charged 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 could induce a leakage of ions between different space-time sheets, breaking of super-conductivity 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.

#### The strange effects of ELF em fields on vertebrates as a key to the model for hierarchy of EWEGs

The experimental findings of the pioneers of bio-electromagnetism [58] demonstrate that electromagnetic radiation at the harmonics of cyclotron frequencies of various ions in magnetic field $B = .2$ Gauss, in particular $Ca^{+2}$ ion, are somehow involved with the bio-control. The dropping of ions from smaller space-time sheets to the super-conducting magnetic flux tubes of $B$ indeed generates cyclotron radiation. The generalization of this mechanism [16, K2] explains the findings of Gariaev [64] about radio waves induced by laser irradiation of DNA. The detailed model explaining various aspects of these findings on basis of TGD inspired model of high $T_c$ superconductivity led to a detailed model for the hierarchy of EWEGs (EW is for electro-weak) generated by Josephson junctions as Josephson and by cyclotron transitions of Bose-Einstein condensates of bosonic ions.

#### What could be the division of labor between different MEs?

To what kind of $Z^0$ MEs and em MEs correspond to has been one of the key questions for a long time. The evolution of ideas about dark matter hierarchy have led to the view that $Z^0$ MEs could serve as correlates for cognitive representations whereas em MEs correspond to as would correspond to sensory representations. This is of course highly speculative and must be taken with a big grain of salt.

Besides this also charged $W$ MEs are present and the most natural identification would be as correlates for charged entanglement. The reduction of charge entanglement between magnetic body and biological body leads to to a final state involving exotic ions and charge non-equilibrium inducing ordinary currents. Hence charge entanglement is ideal for quantum control purposes. Thus motor-sensory dichotomy could naturally correspond to neutral-charged dichotomy for MEs. At least in the case of nerve pulses this seems a highly attractive hypothesis.

Dark 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. Dark $Z^0$ would in turn define universal cognitive currency. This picture conforms with the TGD based model of hearing which involves classical $Z^0$ fields in an essential manner [M6]. Charge entanglement made possible by $W$ MEs would in turn be involved with motor actions understood in a very general sense. Already at the enzyme level long range weak interactions could be involved with what might be regarded as the bio-chemical counterpart of the motor control. In this picture cognition and motor control would rely on the new physics implied by the hierarchy of weak and color physics.

### 2.1.5 The most recent model for the generation of nerve pulse

Quite recently I learned [106, 107, 108, 109, 110] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) [O4] leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of tqc. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

3. The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that solitonic velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as tqc sine also microtubule-cell membrane systems are good candidates for performers of tqc. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane tqc would represent higher level tqc distinguishing between multi-cellulars and mono-cellulars.

4. New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [F9] predicts that ordinary fermionic ions (such as $K^+$, $Na^+$, $Cl^-$) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. Clearly, the temperature at dark magnetic flux tubes could be lower than the physiological temperature. The model for the role of DC currents and potentials in healing discussed in [J7] suggests that metabolic energy quanta of order 1 meV are involved in bio-control so that the temperature at magnetic flux tubes containing ions could be by a factor of order $10^{-2}$ lower than the physiological temperature. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic $W$ bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

### 2.1.6 What happens at the micro-tubular level during nerve pulse?

What happens at the micro-tubular 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 [17]). 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 [46] 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" of [17] minimizes dissipative losses and allows to understand how micro-tubular surfaces could provide dynamical records for the cellular sol-gel transitions, and thus define a fundamental micro-tubular representation of declarative long term memories.

As far as nerve pulse is considered, one ends up with the proposal that the soliton propagating along axon might be a shadow of a more fundamental soliton propagating along microtubular surface and inducing gel-sol-gel transition meaning disassembly and reassembly of tubulins which induces a braiding of magnetic flux tubes coding the details of the sensory signal below millisecond time scale to the braiding pattern.

## 2.2 Exotic charge transfer between cell interior and exterior as fundamental control mechanism

The notions of ionic channels and pumps associated with the cell membrane are central for the standard cell biology [38]. There are however puzzling observations challenging this dogma and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they not depend on the cell membrane at all [34, 35, 47, 39, 40]. One of the pioneers in the field has been Gilbert Ling [34], who has devoted for more than three decades to the problem, developed ingenious experiments, and written several books about the topic. The introduction of the book [33]) gives an excellent layman summary about the paradoxical experimental results.

It was a pleasant surprise to find that these experimental findings give direct support for the existence of an exotic charge transfer between cell interior and exterior.

Ionic supra currents and Josephson currents or the exchange of exotic $W$ bosons could be in question. For the first option, the experimental data led to a model for cell homeostasis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supercurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets. $Z^0$ super-conductivity in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

This control mechanism need not be the only one. Magnetic flux tubes serving as colored braid strands connecting different bio-molecules in highly selective manner and phase transitions reducing or increasing $\hbar$ could explain the mysterious precision of bio-catalysis as how the prebiotic evolution has led to the known biology [O4]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

### 2.2.1 Strange behavior of the intracellular water

The basic strange feature of cellular interior is related to its gelatinous nature and is in fact familiar for everyone. Although 80 percent of hamburger is water, it is extremely difficult to extract this water out. Ling [35] has demonstrated this at cellular level by using a centrifuge and cells for which cell membrane is cut open: centrifugal accelerations as high as 1000 g fail to induce the separation of the intracellular water.

The assumption that cytoplasm behaves like gel explains these findings. Egg is very familiar example of gel phase so that this proposal could have been made already by the pioneers. The dipolar nature of bio-molecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [34]. This cohesion gives rise to liquid crystal [22] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [34, 41, 42]. For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [I3]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [44] and led him to suggest that macroscopic quantum phases of electric dipoles might be possible. This concept, which is in central role in many theories of quantum consciousness, has not been established empirically.

### 2.2.2 Are channels and pumps really there?

Standard neurophysiology relies strongly on the concepts of what might be called hydro-electro-chemistry. The development of the theory has occurred through gradual improvements saving the existing theory.

The development began from the basic observation that cells are stable gelatinous entities not mixing with the surrounding water. This led to the hypothesis that cell membrane takes care that the contents of the cell do not mix with the cell exterior. It was however soon found that cell membrane allows some ions to flow through. The interaction between theory and experiment led gradually to the notions of ion channel and ion pump, which are still central for the standard paradigm of the cell [38]. Note that also 'electric pump' taking care that membrane potential is preserved, is needed.

These notions developed gradually during the period when cell was seen as a bag containing water and a mixture of various biochemicals. If cell biology would have started to develop during the latter half of this century and after the discovery of DNA, cell as a computer metaphor might have led to a quite different conceptualization for what happens in the vicinity of the cell membrane. Also the notion of liquid crystals [22] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [34, 41, 42].

For me it was quite a surprise to find that pump-channel paradigm is not at all so well-established as I had believed as an innocent and ignorant outsider. The first chapter of the book "Cells, Gels and the Engines of Life" of Gerald Pollack [33] provides a summary about the experimental paradoxes (the interested reader can find the first chapter of this book from web).

The standard theoretical picture about cell is based on the observation that cell exterior and interior are in a relative non-equilibrium. The measured concentrations of various atomic ions and organic molecules are in general different in the interior and exterior and cell membrane seems to behave like a semi-permeable membrane. There is also a very strong electric field over the cell membrane. In standard approach, which emerged around 1940, one can understand the situation by assuming that there are cell membrane pumps pumping ions from cell interior to exterior or vice versa and channels through which the ions can leak back. Quite a many candidates for proteins which seem to function like pump and channel proteins have been identified: even a pump protein for water [33]! This does not however prove that pumping and channeling is the main function of these proteins or that they have anything to do with how ionic and molecular concentrations in the interior and exterior of the cell are determined. It could quite well be that pump and channel proteins are receptors involved with the transfer of information rather than charges and only effectively act as pumps and channels.

There are several serious objections of principle against the vision of cell as a bag of water containing a mixture of chemicals. Even worse, the hypothesis seems to be in conflict with experimental data.

#### Selectivity problem

Cell membrane is extremely selective and this leads to an inflation in the complexity of channels and pumps. The problem might be christened as a dog-door problem: the door for dog allows also cat go through it. Channels cannot be simple sieves: it is known that channels which let some ions through do not let much smaller ions through. There must be more complicated criteria than geometric size for whether the channel lets the ion go through. Quite generally, channels must be highly selective and this seems to require complicated information processing to decide which ion goes through and which not. As a consequence, the models for channels inflate in their complexity.

#### Inflation in the number of pumps and channels

Channels and pumps for atomic ions and channels and pumps for an astronomical number of organic molecules are needed. The first question is where to put all those channels and pumps? Of course, one could think that pumps and channels are constructed by the cell only when they are needed. But how does the cell know when a new pump is needed if the cell as never met the molecule in question: for instance, antibiotic or curare molecule?

To realize how weird the picture based on channels and pumps is, it is useful to imagine a hotel in which there is a door for every possible client letting only that client through but no one else. This strange hotel would have separate door for every five point five milliard humans. Alternatively, the building would be in a continual state of renovation, new doors being built and old being blocked.

There is however an TGD based objection against this slightly arrogant argument. In TGD framework cell is a self-organizing structure and it might be that there is some mechanism which forces the cell to produce these pumps and channels by self-organization. Perhaps the basic characteristic of quantum control in many-sheeted space-time is that it somehow forces this kind of miracles to occur.

#### Why pumping does not stop when metabolism stops?

One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability of the notion of the ionic pump experimentally [34] by exposing cell to a cocktail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and stop also the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is the case also for the membrane potential so that also the notion of metabolically driven electrostatic pumps seems to fail. Of course, some metabolism is needed to keep the equilibrium but the mechanism does not seem to be a molecular mechanism and somehow manages to use extremely small amount of metabolic energy.

#### How it is possible that ionic currents through silicon rubber membrane are similar to those through cell membrane?

A crucial verification of the channel concept was thought to come in the experiment of Neher and Sakmann [37] (which led to a Nobel prize). The ingenious experimental arrangement was following. A patch of membrane is sucked from the cell and remains stuck on the micropipet orifice. A steady voltage is applied over the patch of the membrane and the resulting current is measured. It was found that the current consists of discrete pulses in consistency with the assumption that a genuine quantum level current is in question. The observation was taken as a direct evidence for the postulate that the ionic currents through the cell membrane flow through ionic channels.

The later experiments of Fred Sachs [39] however yielded a complete surprise. Sachs found that when the patch of the cell membrane was replaced by a patch of silicon rubber, the discrete currents did not disappear: they remained essentially indistinguishable from cell membrane currents! Even more surprisingly, the silicon rubber membrane showed ion-selectivity features, which were essentially same as those of the cell membrane! Also the currents through synthetic polymer filters [40] were found to have essentially similar properties: as if ion selectivity, reversal potential, and ionic gating would not depend at all on the structure of the membrane and were more or less universal properties. Also experiments with pure lipid-layer membranes [47] containing no channel proteins demonstrated that the basic features – including step conductance changes, flickering, ion selectivity, and in-activation– characterized also cell membranes containing no ionic channels.

The in-escapable conclusion forced by these results seems to be that the existing 60-year old paradigm is somehow wrong. Ionic currents and the their properties seem to be universal and depend only on very weakly on the properties of the membrane.

### 2.2.3 Cytoplasm as gel

The solution to the above described anomalies proposed by Pollack is that cytoplasm is gel phase [33]. Pollack describes in detail various aspects of cytoplasm as a gel phase and here only short summary can be given.

1. Cytoplasm can be regarded as a network consisting of cross-linked negatively charged proteins. Water is condensed around the proteins to form structured water. If protein is hydrophilic, water self-organizes around it as a multilayered structure: the number of molecular layers can as high as 600 and the thickness of the layered structure is a considerable fraction of micrometer. If the protein is hydrophobic, water forms another structured phase known as clathrate water: in this case the number of hydrogen bonds between water atoms is large. These phases can be regarded as intermediate between ice and water. Also ordinary ions have this kind of layered structure around them. Chemical cross-links tend to be stable with heat, pH, and solvent composition whereas physical cross-links formed by intermolecular interactions are sensitive to environmental interactions and are of special interest from the point of view of phase transitions.

2. Pollack proposes that the formation of polymers takes place in an environment containing layered water for the simple reason that monomers cannot diffuse to the layered water so that the probability of association with the end of the growing polymer increases.

3. Cell interior is populated by micro-tubules, various filamentary structures, and the so called micro-trabecular matrix. Micro-trabecular network divides cell into a compartments in such a manner that the typical distance between two proteins in water is about 5 nm: this corresponds to the p-adic length scale $L(149)$, the thickness of the lipid layer of cell membrane. This is probably not an accident and the micro-trabecular network might be closely involved with the highly folded network of intracellular membranes. There would be a layer of thickness of about 6 water molecules per given protein surface so that a dominating portion of intracellular water could be structured.

4. The layered water has several tell-tale signatures that have been observed in gels. It freezes at much lower temperature than ordinary water; various relaxation times are shorter since the energy transfer to the water lattice occurs faster than to non-structure water; the diffusion rates of particles into the structured water are much slower than to ordinary water by entropy argument; a simple geometric argument tells that the larger the size of the hydrated ion the lower the diffusion rate; strong gradients of ionic concentrations can form in gel phase as has been observed.

The identification of the cytoplasm as a gel has profound implications for the standard views about cell.

1. The original motivation for postulating semipermeable cell membrane, channels, and pumps was the need to hinder the diffusion of various ions between cell interior and exterior taking place if cytoplasm is ordinary water into which molecules are dissolved. If cytoplasm is in gel phase, cell membrane need not perform pumping and channeling anymore except perhaps in situations involving the formation of a local sol phase. This raises the question about the proper functions of the cell membrane.

2. It is possible to drill to cell membrane holes with size of order 1 $\mu$m without an appreciable effect on the functioning of the cell and also show that these holes remain as such for long periods of time [33]. It is also possible to splice cells into pieces continuing to function for days. That $K^+$ flux through cell membrane does not change when lipids are partially removed. These findings force to ask whether the assumption about the continuity of the cell membrane might be too strong [33]. Electron micrographs however demonstrate the presence of the bi-layered structure. What is intriguing that this structure is seen even in the absence of lipid layers. In TGD framework this paradoxical finding might be understood in terms of a presence of space-time sheets corresponding to p-adic length scales $L(k)$, $k = 149, 151$ as vacuum structures predicted also by TGD inspired model of high $T_c$ super-conductivity [J1].

3. There is also the strange finding that water flux through cell membrane is much higher than the flux through isolate lipid bi-layer as if some unidentified channels were present. In TGD framework this might be seen as an evidence for the presence of (wormhole) magnetic flux tubes as carriers of water molecules.

4. The fundamental assumptions about ionic equilibrium must be reconsidered, and the Hodkin-Huxley model for the generation of nerve pulse becomes more or less obsolete. Indeed, it has

been found that action potentials can be generated even in absence of $Na^+$ and $K^+$ ions playing a key role in Hodkin-Huxley model. Rather remarkably, the high concentration of $K^+$ ions and low concentration of $Na_+$ ions in cytoplasm could be understood on basis of gel property only. Also new view about cell (note membrane-!) potential emerges. The standard paradigm states that the resting potential is over the cell membrane. Potentials of same order of magnitude have been however seen in de-membraned cells (50 mV in slight excess of action potential and critical potential), colloidal suspensions, and gels which suggest that larger part of cell than mere cell membrane is involved with the generation of the action potential and one should thus speak of cell potential instead of membrane potential.

5. Pollack suggests that the phase transitions of the gel phase make possible to realize various functions at molecular and cellular level and represents empirical evidence for the phase transition like aspects assigned to these functions including sensitivity to various factors such as pH, temperature, chemical environment, electromagnetic fields, mechanical forces, etc... and the threshold behavior [33]. Also the responses are typical for phase transitions in that they involve dramatic changes in volume, shape, di-electric constant, etc.. With these motivations Pollack discusses phase transition based models for contraction, motility, secretion, transport or molecules, organized flow of particles during cell division, cell locomotion, contraction of muscle, generation of action potentials, etc.. For instance, the transport of bio-molecules along micro-tubule could involve propagating gel-sol-gel phase transition meaning also propagating melting of the layered water around micro-tubule.

6. Divalent ions, such as $Mg^{++}$ and $Ca^{++}$ can act as cross links between negatively charged proteins binding them to form networks. Monovalent ions cannot do this. Peripheral cytoskeleton is this kind of network consisting of micro-tubules and actin molecules cross-linked - according to Pollack- by $Ca^{++}$ ions. On the other hand, it is known that $Mg^{++}$ ($Ca^{++}$) ions dominate in the cell interior (exterior) and that the presence of $Ca^{++}$ ions in the cell exterior is crucial the for generation of nerve pulse. The influx of $Na^+$ ions having higher affinity to proteins can induce a phase transition to sol-like phase. Pollack suggests a model of nerve pulse based on this mechanism of gel-sol phase transition for peripheral cytoskeleton: this model does not actually explain why $Ca^{++}$ ions in the exterior of axon are necessary.

### 2.2.4 TGD based vision inspired by the findings

The vision about dark matter and the model of nerve pulse formulated in terms of Josephson currents brings an additional perspective to the role of pumps and channels and allows to avoid harmony with the standard views about their role.

1. In long length scales visible matter forms roughly 5 per cent of the total amount of matter. In TGD Universe the dark matter would correspond to matter with large Planck constant including dark variants of ordinary elementary particles. In living matter situation could be the same and visible matter could form only a small part of the living matter. Dark matter would be however visible in the sense that it would interact with visible matter via classical electromagnetic fields and photon exchanges with photons suffering Planck constant changing phase transition. Hence one can consider the possibility that most of the biologically important ions and perhaps even molecules reside at the magnetic flux quanta in large $\hbar$ phase.

2. Bosonic ions could form Bose-Einstein condensates at the flux tubes in which case supra currents flowing without any dissipation would be possible. The model for high $T_c$ super-conductivity suggests that only electronic and protonic super-conductivity are possible at room temperature. If so, Cooper pairs of fermionic ions are excluded. New nuclear physics predicted by TGD could however come in rescue here. The TGD based model for atomic nucleus assumes that nuclei are strings of nucleons connected by color bonds having quark and antiquark at their ends. Also charged color bonds are possible and this means the existence of nuclei with anomalous charge. This makes possible bosonic variants of fermionic ions with different mass number and it would be interesting to check whether biological important ions like $Na^+, Cl^-$, and $K^+$ might actually correspond to this kind of exotic ions.

This leads to the following TGD inspired vision about cell as a gel.

1. DNA as tqc hypothesis and cell membrane as sensory receptor provide possible candidates for the actual functions of the cell membrane and ionic channels and pumps could act as kind of receptors. That standard physics is able to to describe gel phase is of course a mere belief and (wormhole) magnetic flux tubes connecting various molecules (DNA, RNA, aminoacids, biologically important ions) would be "new physics" cross-links could explain the strong correlations between distant molecules of the gel phase.

2. Dark ionic currents are quantal currents. If the dark ions flow along magnetic or wormhole magnetic flux tubes connecting cell interior and exterior, their currents through cell membrane would be same as through an artificial membrane.

3. Pumps and channels could serve the role of sensory receptors by allowing to take samples about chemical environment. One cannot exclude the possibility that proteins act as pumps and channels in sol phase if magnetic flux tubes are absent in this phase since also in TGD Universe homeostasis and its control at the level of visible matter in sol phase might requires them. The metabolic energy needed for this purpose would be however dramatically smaller and a reliable estimate for this would allow an estimate of the portion of dark matter in living systems.

4. Quantum criticality suggests that the phase transitions for the gel phase are induced by quantum phase transitions changing the value of Planck constant for magnetic flux tubes and inducing the change of the length of the flux tube. Macroscopic quantum coherence would explain the observed co-operativity aspect of the phase transitions. Concerning locomotion and transport mountain climbing using pickaxe and rope inspires a guess for a general mechanism. For instance, a packet of molecules moving along actin molecule or a molecule carrying a cargo along micro-tubule could repeat a simple basic step in which a magnetic flux tube with large $\hbar$ is shot along the direction of the electric field along micro-tubule and stuck to a rachet followed by a phase transition reducing the value of $\hbar$ and shortening the flux tube and forcing the cargo to move forward. The metabolic energy might be provided by the micro-tubule rather than molecular motor.

5. The reconnection of flux tubes would be a second phase transition of this kind. This phase transition could lead from a phase in phase proteins are unfolded with flux tubes connecting aminoacids to water molecules and thus possessing a large volume of layered water around them to a phase in which they become folded and flux tubes connect aminoacids to each other in the interior of protein. The phase transition could be associated with the contraction of connecting filaments of muscle cell. The phase transitions are also seen in "artificial protein" gels used for drug delivery applications, and are built from polymers arranged in alpha helices, beta sheets and common protein motifs [33]. If wormhole magnetic flux are taken are taken as a basic prerequisite of life, one must ask whether these "artificial proteins" represent artificial life.

6. The fact that cytoskeleton rather than only cell membrane is involved with the generation of action potential conforms with the idea that nerve pulse propagating along axon involves also axonal micro-tubules and that Josephson currents between axon and micro-tubules are involved in the process.

7. Di-valent ions ($Ca^{++}$ ions according to Pollack) serve as cross links in the peripheral cytoskeleton. The influx of monovalent ions from the exterior of axon induces gel-sol phase transition replacing di-valent ions with monovalent ions. One can consider two models.

   i) The minimal assumption is that this phase transition is induced $\hbar$ increasing phase transition the flow of the monovalent ions like $Na^+$ from the cell exterior along the magnetic flux tubes connecting axonal interior and interior. Suppose that in the original situation the flux tubes end to axonal membrane (this is not the only possibility, they could also end to $Ca^{++}$ ions). The flux tubes extending to the axonal exterior could result by $\hbar$ increasing phase transition increasing the length of the flux tubes connecting peripheral cytoskeleton to the axonal membrane so that they extend to the exterior of axon. This option is rather elegant since gel-sol phase transition itself can be understood in terms of "standard chemistry". In this model the very slow diffusion rate of the ions to gel phase would have explanation in terms of new physics involving dark matter and (wormhole) magnetic flux tubes.

ii) One can consider also an option in which divalent ions such as $Ca^{++}$ or $Mg^{++}$ are connected by two flux tubes to amino-acids of two negatively charged proteins whereas monovalent biological ions like $Na^+$ would have single flux tube of this kind and could not act as cross links. In the phase transitions removing the cross links the replacement of divalent ion with two monovalent positively charged ions would take place. If one believes in standard chemistry, $Na^+$ ions would flow in automatically. First the increase of Planck constant would induce the lengthening of the magnetic flux tubes and thus the expansion of the gel phase making possible the influx of monovalent ions. If $Na^+$ ions are dark, flux tubes connecting peripheral cytoskeleton to the axonal exterior are required and the mechanism of option i) is also needed.

8. The mechanisms i) and ii) could be fused to a single one. The hint comes from the presence of $Ca^{++}$ ions in the exterior of axon is necessary for the generation of action potential. The simplest possibility is that the flux tubes connecting proteins to intracellular $Ca^{++}$ cross links in gel phase connects them after the length increasing phase transition to extracellular $Ca^{++}$ ions and $Na^+$ ions flow along these flux tubes.

9. The increase of the Planck constant would induce the expansion of the peripheral cytoskeleton making possible the inflow of $Na^+$ ions, and divalent ions binding negatively charged actin molecules to a network would be replaced with inflowing $Na^+$ ions. After this a reverse phase transition would occur. Both phase transitions could be induced by a quantal control signal (Josephson current) inducing quantum criticality and a change of Planck constant.

10. A propagating $Ca^{++}$ wave inducing the gel-sol-gel phase transition of peripheral cytoskeleton would accompany nerve pulse. Quite generally, $Ca^{++}$ waves are known to play a fundamental role in living matter as kind of biological rhythms. Irrespective of whether one believes option i) or ii), this might relate to the cross-linking by flux tubes and gel-sol-gel phase transitions induce by phase transitions increasing Planck constant temporarily. The velocities and oscillation periods of $Ca^{++}$ waves vary in an extremely wide range: this can be understood if the flux tubes involved correspond to a very wide spectrum of Planck constant.

To sum up, the strange discoveries about the behavior of cell membrane provide direct experimental evidence for the presence of dark matter in living systems, for the prediction that it interacts with ordinary matter via classical electromagnetic fields, and for the assumption that it does not dissipate appreciably and could therefore have large value of $\hbar$ and form macroscopic quantum phases.

## 2.3 Further experimental findings

In this section I discuss further experimental findings giving support for the TGD based vision about living cell.

### 2.3.1 Genes and water memory

After long time I had opportunity to read a beautiful experimental article about experimental biology. Yolene Thomas, who worked with Benveniste, kindly sent the article to me. The freely loadable article is *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences* by Luc Montagnier, Jamal Aissa, Stphane Ferris, Jean-Luc Montagnier, and Claude Lavalle published in the journal Interdiscip. Sci. Comput. Life Sci. (2009) [50].

#### Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

1. Certain pathogenic micro-organisms are objects of the study. The bacteria Mycoplasma Pirum and E. Choli belong to the targets of the study. The motivating observation was that some procedures aimed at sterilizing biological fluids can yield under some conditions the infectious micro-organism which was present before the filtration and absent immediately after it. For instance, one filtrates a culture of human lymphocytes infected by M. Pirum, which has infected human lymphocytes to make it sterile. The filters used have 100 nm and 20 nm porosities.

M. Pirum has size of 300 nm so that apparently sterile fluids results. However if this fluid is incubated with a mycoplasma negative culture of human lymphocytes, mycoplasma re-appears within 2 or 3 weeks! This sounds mysterious. Same happens as 20 nm filtration is applied to a a minor infective fraction of HIV, whose viral particles have size in the range 100-120 nm.

2. These findings motivated a study of the filtrates and it was discovered that they have a capacity to produce low frequency electromagnetic waves with frequencies in good approximation coming as the first three harmonics of kHz frequency, which by the way plays also a central role in neural synchrony. What sounds mysterious is that the effect appeared after appropriate dilutions with water: positive dilution fraction varied between $10^{-7}$ and $10^{-12}$. The uninfected eukaryotic cells used as controls did not show the emission. These signals appeared for both M. Pirum and E. Choli but for M. Pirum a filtration using 20 nm filter canceled the effect. Hence it seems that the nano-structures in question have size between 20 and 100 nm in this case.

   A resonance phenomenon depending on excitation by the electromagnetic waves is suggested as an underlying mechanism. Stochastic resonance familiar to physicists suggests itself and also I have discussed it while developing ideas about quantum brain [M5]. The proposed explanation for the necessity of the dilution could be kind of self-inhibition. Maybe a gel like phase which does not emit radiation is present in sufficiently low dilution but is destroyed in high dilutions after which emission begins. Note that the gel phase would not be present in healthy tissue. Also a destructive interference of radiation emitted by several sources can be imagined.

3. Also a cross talk between dilutions was discovered. The experiment involved two tubes. Donor tube was at a low dilution of E. Choli and "silent" (and carrying gel like phase if the above conjecture is right). Receiver tube was in high dilution (dilution fraction $10^{-9}$) and "loud". Both tubes were placed in mu-metal box for 24 hours at room temperature. Both tubes were silent after his. After a further dilution made for the receiver tube it became loud again. This could be understood in terms of the formation of gel like phase in which the radiation does not take place. The effect disappeared when one interposed a sheath of mu-metal between the tubes. Emission of similar signals was observed for many other bacterial specials, all pathogenic. The transfer occurred only between identical bacterial species which suggests that the signals and possibly also frequencies are characteristic for the species and possibly code for DNA sequences characterizing the species.

4. A further surprising finding was that the signal appeared in dilution which was always the same irrespective of what was the original dilution.

#### Experimentation at gene level

The next step in experimentation was performed at gene level.

1. The killing of bacteria did not cancel the emission in appropriate dilutions unless the genetic material was destroyed. It turned out that the genetic material extracted from the bacteria filtered and diluted with water produced also an emission for sufficiently high dilutions.

2. The filtration step was essential for the emission also now. The filtration for 100 nm did not retain DNA which was indeed present in the filtrate. That effect occurred suggests that filtration destroyed a gel like structure inhibiting the effect. When 20 nm filtration was used the effect disappeared which suggests that the size of the structure was in the range 20-100 nm.

3. After the treatment by DNAse enzyme inducing splitting of DNA to pieces the emission was absent. The treatment of DNA solution by restriction enzyme acting on many sites of DNA did not suppress the emission suggesting that the emission is linked with rather short sequences or with rare sequences.

4. The fact that pathogenic bacteria produce the emission but not "good" bacteria suggests that effect is caused by some specific gene. It was found that single gene - adhesin responsible for the adhesion of mycoplasma to human cells- was responsible for the effect. When the cloned gene was attached to two plasmids and the E. Choli DNA was transformed with the either plasmid, the emission was produced.

### Some consequences

The findings could have rather interesting consequences.

1. The refinement of the analysis could make possible diagnostics of various diseases and suggests bacterial origin of diseases like Alzheimer disease, Parkinson disease, Multiple Sclerosis and Rheumatoid Arthritis since the emission signal could serve as a signature of the gene causing the disease. The signal can be detected also from RNA viruses such as HIV, influenza virus A, and Hepatitis C virus.

2. Emission could also play key role in the mechanism of adhesion to human cells making possible the infection perhaps acting as a kind of password.

The results are rather impressive. Some strongly conditioned skeptic might have already stopped reading after encountering the word "dilution" and associating it with a word which no skeptic scientist in his right mind should not say aloud: "homeopathy"! By reading carefully what I wrote above, it is easy to discover that the experimenters unashamedly manufactured a homeopathic remedy out of the filtrate! And the motivating finding was that although filtrate should not have contained the bacteria, they (according to authors), or at least the effects caused by them, appeared within weeks to it! This is of course impossible in the word of skeptic.

The next reaction of the skeptic is of course that this is fraud or the experimenters are miserable crackpots. Amusingly, one of the miserable crackpots is Nobelist Luc Montagnier, whose research group discovered AIDS virus.

### How TGD could explain the findings?

Let us leave the raging skeptics for a moment and sketch possible explanations in TGD framework.

1. Skeptic would argue that the filtration allowed a small portion of infected cells to leak through the filter. Many-sheeted space-time suggests a science fictive variant of this explanation. During filtration part of the infected cells is "dropped" to large space-time sheets and diffused back to the original space-time sheets during the next week. This would explain why the micro-organisms were regenerated within few weeks. Same mechanism could work for ordinary molecules and explain homeopathy. This can be tested: look whether the molecules return back to the the diluted solution in the case of a homeopathic remedy.

2. If no cells remain in the filtrate, something really miraculous looking events are required to make possible the regeneration of the effects serving as the presence of cells. This even in the case that DNA fragments remain in the filtrate.

   (a) The minimum option is that the presence of these structures contained only the relevant information about the infecting bacteria and this information coded in terms of frequencies was enough to induce the signatures of the infection as a kind of molecular conditioning. Experimentalists can probably immediately answer whether this can be the case.

   (b) The most radical option is that the infecting bacteria were actually regenerated as experimenters claim! The information about their DNA was in some form present and was transcribed to DNA and/or RNA, which in turn transformed to proteins. Maybe the small fragment of DNA (adhesin) and this information should have been enough to regenerate the DNA of the bacterium and bacterium itself. A test for this hypothesis is whether the mere nanoparticles left from the DNA preparation to the filtrate can induce the regeneration of infecting molecules.

The notion of magnetic body carrying dark matter quantum controlling living matter forms the basic element of TGD inspired model of quantum biology and suggests a more concrete model. The discovery of nanotubes connecting cells with distance up to 300 $\mu$ [51] provides experimental support for the notion .

1. If the matter at given layer of the onion-like structure formed by magnetic bodies has large $\hbar$, one can argue that the layer corresponds to a higher evolutionary level than ordinary matter

with longer time scale of memory and planned action. Hence it would not be surprising if the magnetic bodies were able to replicate and use ordinary molecules as kind of sensory receptors and motor organs. Perhaps the replication of magnetic bodies preceded the replication at DNA level and genetic code is realized already at this more fundamental level somehow. Perhaps the replication of magnetic bodies induces the replication of DNA as I have suggested.

2. The magnetic body of DNA could make DNA a topological quantum computer [O4]. DNA itself would represent the hardware and magnetic bodies would carry the evolving quantum computer programs realized in terms of braidings of magnetic flux tubes. The natural communication and control tool would be cyclotron radiation besides Josephson radiation associated with cell membranes acting as Josephson junctions. Cyclotron frequencies are indeed the only natural frequencies that one can assign to molecules in kHz range. There would be an entire fractal hierarchy of analogs of EEG making possible the communication with and control by magnetic bodies.

3. The values of Planck constant would define a hierarchy of magnetic bodies which corresponds to evolutionary hierarchy and the emergence of a new level would mean jump in evolution. Gel like phases could serve as a correlate for the presence of the magnetic body. The phase transitions changing the value of Planck constant and scale up or down the size of the magnetic flux tubes. They are proposed to serve as a basic control mechanism making possible to understand the properties and the dynamics of the gel phases and how biomolecules can find each other in the thick molecular soup via a phase transition reducing the length of flux tubes connecting the biomolecules in question and thus forcing them to the vicinity of each other.

Consider now how this model could explain the findings.

1. Minimal option is that the the flux tubes correspond to "larger space-time sheets" and the infected cells managed to flow into the filtrate along magnetic flux tubes from the filter. This kind of transfer of DNA might be made possible by the recently discovered nanotubes already mentioned.

2. Maybe the radiation resulted as dark photons invisible for ordinary instruments transformed to ordinary photons as the gel phase assignable with the dark matter at magnetic flux tube network associated with the infected cells and corresponding DNA was destroyed in the filtration.

   This is not the only possible guess. A phase conjugate cyclotron radiation with a large value of Planck constant could also allow for the nanostructures in dilute solute to gain metabolic energy by sending negative energy quanta to a system able to receive them. Indeed the presence of ambient radiation was necessary for the emission. Maybe that for sufficiently dilute solute this mechanism allows to the nanostructures to get metabolic energy from the ambient radiation whereas for the gel phase the metabolic needs are not so demanding. In the similar manner bacteria form colonies when metabolically deprived. This sucking of energy might be also part of the mechanism of disease.

3. What could be the magnetic field inducing the kHz radiation as a synchrotron radiation?

   (a) For instance, kHz frequency and its harmonics could correspond to the cyclotron frequencies of proton in magnetic field which field strength slightly above that for Earth's magnetic field (750 Hz frequency corresponds to field strength of $B_E$, where $B_E = .5$ Gauss, the nominal strength of Earth's magnetic field). A possible problem is that the thickness of the flux tubes would be about cell size for Earth's magnetic field from flux quantization and even larger for dark matter with a large value of Planck constant. Of course, the flux tubes could make themselves thinner temporarily and leak through the pores.

   (b) If the flux tube is assumed to have thickness of order 20-100 nm, the magnetic field for ordinary value of $\hbar$ would be of order .1 Tesla from flux quantization and in the case of DNA the cyclotron frequencies would not depend much on the length of DNA fragment since the it carries a constant charge density. Magnetic field of order .2 Tesla would give cyclotron frequency of order kHZ from the fact that the field strength of .2 Gauss gives frequency of about .1 Hz. This correspond to a magnetic field with flux tube thickness $\sim 125$ nm, which happens to be the upper limit for the porosity. Dark magnetic flux tubes with large $\hbar$ are however thicker and the leakage might involve a temporary phase transition to a phase with ordinary value of $\hbar$ reducing the thickness of the flux tube. Perhaps some genes (adhesin) plus corresponding magnetic bodies representing DNA in terms of cyclotron frequencies depending slightly on precise weight of the DNA sequence and thus coding it correspond to the frequency of cyclotron radiation are the sought for nano-structures.

4. While developing a model for homeopathy based on dark matter I ended up with the idea that dark matter consisting of nuclear strings of neutrons and protons with a large value of $\hbar$ and having thus a zoomed up size of nucleon could be involved. The really amazing finding was that nucleons as three quark systems allow to realize vertebrate code in terms of states formed from entangled quarks [F9] described also in this chapter! One cannot decompose codons to letters as in the case of the ordinary genetic code but codons are analogous to symbols representing entire words in Chinese. The counterparts of DNA, RNA, and aminoacids emerge and genetic code has a concrete meaning as a map between quantum states.

   Without any exaggeration this connection between dark hadronic physics and biology has been one of the greatest surprises of my professional life. It suggests that dark matter in macroscopic quantum phase realizes genetic code at the level of nuclear physics and biology only provides one particular (or probably very many as I have proposed) representations of it. If one takes this seriously one can imagine that genetic information is represented by these dark nuclear strings of nanoscopic size and that there exists a mechanism translating the dark nuclei to ordinary DNA and RNA sequences and thus to biological matter. This would explain the claimed regeneration of the infected cells.

5. Genetic code at dark matter level would have far reaching implications. For instance, living matter - or rather, the magnetic bodies controlling it - could purposefully perform genetic engineering. This forces me to spit out another really dirty word, "Lamarckism"! We have of course learned that mutations are random. The basic objection against Lamarckism is that there is no known mechanism which would transfer the mutations to germ cells. In the homeopathic Universe of TGD the mutations could be however performed first for the dark nucleon sequences. After this these sequences would diffuse to germ cells just like homeopathic remedies do, and after this are translated to DNA or RNA and attach to DNA.

### 2.3.2 Water electric as protocell

Ulla Matfolk sent to me some interesting material at the web page of Dr. Mae-Wan Ho which provides further insights into the model of cell. The articles are "Water electric" [53] and "Making Fuel from Water" [54]. The articles summarize an experimental discovery which could be called Pollack-Zheng effect [58, 59]. Both articles relate closely to what might be called the holy grail of artificial photosynthesis. The unreasonable effectiveness of photosynthesis in the sense that the waste of energy during the process is extremely small, makes artificial photosynthesis an excellent candidate for the final solution of energy problems as far energy sources and minimization of wastes are considered. In the following I comment only the first paper in detail from TGD viewpoint.

How photosynthesis manages to be so effective is one of the mysteries of biology. TGD based view about metabolic energy involves two ideas.

1. TGD predicts a hierarchy of metabolic energy quanta [J7, K6]. The basic quanta come as $E(k) = 2^k E_0$, where k is positive or negative integer and $E_0 \simeq .5$ eV holds true. For instance, 2 eV metabolic energy quantum corresponding to red light corresponds to $k = 3$. This is actually oversimplification since there is a cascade of quanta $E(k,n) = (1-2 < sup > -n < /sup >)E(k)$ converging to $E(k)$ for each p-adic length scale. These energies correspond to energies liberated when electron or proton drops to a larger space-time sheet at the limit when second space-time becomes very large and the particle starts from rest and remains to rest: this is second idealization as also the particle in a box geometry. The idea is that these universal metabolic energy quanta preceded the metabolism based on chemical storage of energy and that the primary step in photosynthesis is kicking of proton or electron to a smaller space-time sheet.

2. Second idea relies on the hierarchy of Planck constants.

(a) The rate of dissipation - that this the energy wasted per unit time - is inversely proportional to $\hbar$ in the first naive guess and means that macroscopically quantum coherent dark matter dissipates very little. Could photon kick charged dark particles to smaller space-time sheet where they dissipate very little? Or could photosynthesis capture ordinary or dark photons of sunlight to some layer of the onion like structure formed by the magnetic body of the organism, where it kicks particles to smaller space-time sheets. This light could correspond to bio-photons liberated as the biological body of the organism dies.

(b) Could this storage of photons have preceded chemical storage of energy in living matter? And could this energy reserve explain some rather mysterious findings about the ability of some people to survive without ordinary metabolic energy feed (usually saints and this kind of people telling that light is enough for them to survive;-). Also animals are capable to these metabolic miracles [61]: see the article "Researchers Seek to Demystify the Metabolic Magic of Sled Dogs" in Science. Of course, the storage of energy to that of dark matter or dark photons confined to the net defined by magnetic flux tubes could be the eventual manner to avoid energy waste and associated entropy growth inducing environmental problems. Hierarchy of Planck constants would allow the storage in arbitrary long length scales for given energy of photon so that even a community of organisms could have collective metabolic energy resources: maybe synergy has something to do with this.

The first article summarizing the Pollack-Zheng effect gives quantitative support for this picture. I have formatted the text as comments to the summary represented in the article of Mae-Wan Ho [53].

### Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [58, 59]. As a matter fact, the fascinating findings described in detail by Gerald Pollack in his book were absolutely crucial for the recent TGD based view about quantum biology in which dark matter plays key role.

1. Pollack and his student discovered that suspensions of colloids and dissolved substances are excluded from a region extending some hundreds of micrometres from the surfaces of hydrophilic gels. An exclusion zone (EZ) of this magnitude conflicts the belief that interfacial water forming at liquid-solid, or liquid-air interfaces can be no more than a few layers of molecules thick. Whats observed is a million layers or more! 'Exclusion' means that the water suspension of micro-spheres moved away from the surface of gel with constant velocity and behaving like single structural unit.

   **Comment**: The sizes of cells vary up to hundreds of micrometers and cells are by definition structures which are isolated from the environment. Maybe EZs represent protocells or their predecessors. Pollack and coauthors have indeed proposed that their finding might relate to the origin of life [59]. That the surface was that of gel might be important. In TGD based model of living matter gels have magnetic bodies and their presence might relate to the formation of the thick water layer in non-standard phase.

2. Similar exclusion zones were found next to any hydrophilic surface including surfaces coated with a monolayer of hydrophilic molecules, and around ion exchange resin beads. Electric charge appears to be important, as EZ failed to form around charge-exhausted resin beads. Although EZ can form in pure water, it is enhanced and stabilized by low concentrations of buffer (2 to 10 mM at pH 7).

   **Comment**: Hydrophily could correspond to the formation of magnetic flux tubes connecting the hydrophilic surface to water molecules as assumed in the model of protein folding and bio-catalysis [L9].

3. The EZ phase is very different from the bulk water. An unusually ordered crystalline phase where the molecules are less free to move is suggestive. The UV and visible absorption spectrum gave a single absorption peak at $\lambda \simeq 270$ nm in the UV region completely absent in the bulk phase. The infrared emission record showed that the EZ radiates very little compared with bulk water, as would be expected on account of the reduced mobility of water molecules. The

magnetic resonance imaging mapping similarly gave a transverse relaxation time (T2) of 25.4 + 1 ms, which is shorter than the 27.1 + 0.4 ms recorded for the bulk water phase, again indicative of restricted motion.

**Comment**: The reduced radiation might mean that part of photons are dark and bound inside magnetic flux tubes defining a structure responsible for the formation of gel like phases inside cell and perhaps also inside EZ. The interpretation as bio-photons is suggestive. This phase of water could be predecessor of the water in cell interior since in the crystalline phase long bio polymers like DNA and aminoacid sequences would be stable against hydration.

4. EZ had a different electrical potential from the bulk phase, by as much as 100  200 mV, depending on the hydrophilic surface. With a negatively charged surface such as polyacrylic acid or Nafion (widely used as a proton exchange membrane), the potential is negative compared with the bulk water away from the EZ. Simultaneously, the hydrogen ion (proton, $H^+$) concentration is high just outside the EZ, decreasing in a gradient away from it. This indicates that the formation of the EZ is accompanied by a separation of positive and negative electrical charges, which led to the build up of electrical potential between the EZ and the bulk water. In effect, the water has become an electrical battery, and can provide electricity through an external circuit.

   **Comment**: Cell membrane is also a battery and the potential is around 50-80 mV to be compared with 100  200 mV, and the size scale of cell varies from 5 micrometer to hundreds of micrometers so that EZs could be involved with the formation of cell and cell membranes. The kicking of electrons or protons to smaller space-time sheet could be the mechanism inducing electric potential at a given space-time sheet. The formation of battery would mean that water could some day used to store very effectively the energy of solar radiation.

### A connection with photosynthesis

Separating $H^+$ from $e^-$ (electron) is the first step of photosynthesis in green plants which provides energy for most of the biosphere. In this case the energy comes from solar radiation. The separation of charges requires energy also in the case of EZ and the question is where this energy comes from in the case of EZ.

1. A clue came after having inadvertently left the experimental chamber with the EZ on the microscope overnight. Next morning, the EZ had shrunk considerably. But after turning on the microscope lamp, it began to immediately grow again, restoring itself within minutes to its former size. The energy for EZ formation comes from light, as in photosynthesis, but it can use the low energy part of the solar spectrum that photosynthesis cannot.

   **Comment**: Could one consider the possibility that photosynthesis involves unknown step and this step is just the kicking of electrons or protons to a smaller space-time sheet. This step would also induce the separation of charges and the generation of electric potential.

2. Although the entire spectrum of visible light appeared effective in making the EZ grow, the most effective part is in the infrared region, peaking at $\lambda \simeq 3100$ nm. A 10 minute exposure at that wavelength expanded the width of an EZ 3.7 times, and after an hour of exposure, the expansion was more than 6 times. After the light was turned off, the EZ remained constant for about 30 minutes before beginning to shrink, reaching halfway to its baseline level in about 15 minutes.

   **Comment**: $\lambda = 3100$ nm corresponds to .4 eV. The nominal value of the fundamental metabolic energy quantum is around $E_0 = .5$ eV and one has $E(k = 0, n = 3) = 0.4375$ eV for this value of $E_0$. Perhaps the photons indeed kick electrons or protons to a smaller space-time sheet.

   (a) In the case of protons the smaller space-time sheet would correspond to atomic space-time sheets characterized by $p \simeq 2^{137}$: the larger one would correspond to to $k = 141$.

   (b) For electrons the size of the smaller space-time sheet would be by a factor $m_p/m_e = 940/.5 = 1880 \simeq 2^{11}$ larger and would correspond to $k = 137 + 11 = 148$. This is one half of the thickness of the lipid layer of cell membrane. The larger space-time sheet would correspond to cell membrane thickness $L(151) = 10$ nm and perhaps the dark space-time sheet serving as a template for the formation of the cell membrane! If $E = .4$ eV corresponds to electron, then proton would correspond to $E(0,3) = .44$ eV giving for the metabolic energy quantum the value $E_0(p) = 0.5029$ eV in the case of proton and $E_0(e) = 0.4616$ eV in the case of electron.

3. When the UV and visible range was tested, a peak in the degree of EZ expansion was detected at $\lambda = 270$ nm in the UV region, corresponding to the characteristic absorption peak of EZ that was identified before. However, as the optical power used in the UV and visible region was 600 times that in the IR, the most profound effect was identified in the IR region, particularly at 3 100 nm.

   **Comment**: $\lambda = 270$ nm corresponds to the energy 4.5926 eV. E=4 eV is the nearest metabolic energy quantum. This energy does not correspond directly to any metabolic energy quantum assignable to .4 eV or .43 eV. One must be however cautious with conclusions since the model is very rough.

4. The mechanism of EZ formation is still unknown. But the two wavelengths that expand the EZ most effectively may offer some hint. The UV wavelength 270 nm is close to the 250 nm ($\simeq 5$ eV) required to ionize water under standard state conditions and taking into account the hydration of the resulting ions. The 3 100 nm peak, on the other hand is close to the OH stretch of the ring hexamer identified as the most abundant species in infrared predissociation spectroscopy of large water clusters, and also in neon matrices by infrared spectroscopy. These results suggest that photoexcitation of ring hexamers and photoionisation followed by ejection of protons play synergistic roles in the assembly of the EZ phase. Pollack and colleagues believe that the infrared radiation, though normally insufficient to break OH bonds, can nevertheless work via resonance induced dissociation of large hydrogen-bonded networks.

   **Comment**: Ring hexamers bring in mind the crucial role of aromatic cycles in TGD inspired model of DNA as topological quantum computer which leads also to a model of ADP$\leftrightarrow$ ATP transition involving reconnection of magnetic flux tubes and having also information theoretic interpretation as a change of the topology of the braid structure defining topological quantum computer program [O4]. Magnetic flux tubes carrying dark electrons begin from these and can end up to other bio-molecules or water. Just a guess: could they end on ring hexamers?

#### Summary

The findings suggest additional details to the TGD based view about living matter.

1. The kicking of electrons or protons or both of them to a larger space-time sheet would be the first step in photosynthesis as I indeed suggested for years ago. The energy of 3100 nm photons indeed corresponds to that for the fundamental metabolic energy quantum. I have also proposed this process to be a fundamental step also in bio-catalysis: the temporary dropping of electron or proton of the catalyst molecule could provide the energy helping the reacting molecules to overcome the potential wall preventing the reaction from running. This metabolic coin could be returned to catalyst with high enough probability or the photons exchanged could be virtual.

2. The findings suggest also a mechanism for how solar radiation generates proto cells or their predecessors. The resulting phases of water have size extending to those for largest cells and the water could involve a gel like phase in which magnetic flux tubes containing dark matter could play a key role and eventually lead to quantum computer like behavior [O4]. The kicking of electrons (or protons) to smaller space-time sheet would induce ionization at given space-time sheet so that electric potential difference would result. The magnitude of the potential difference is of a correct order of magnitude. Cell membrane scale is present as a p-adic length scale for the space-time sheet of electrons before the kicking to the smaller space-time sheet and these space-time sheets could act as templates for the formation of cell membrane.

3. Interestingly, TGD based model of high $T_c$ super conductivity predicts that both cell membrane length scale and size scale of cell are involved with the super-conductivity [J1]. Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

### 2.3.3 A model for chiral selection

Chiral selection of bio-molecules is one of the basic mysteries of biology and it is interesting to see whether the existing bits of data combined with vision about quantum TGD could help to build a coherent picture about the situation. Let us first try to identify the most important pieces of the puzzle.

1. Chiral selection requires parity breaking in the scale of biomolecules. Standard model predicts parity breaking interactions but the effects are extremely small above intermediate boson length scale which is by a factor $10^{-7}$ shorter than atomic length scale. The proposed solution of the problem is that dark variants of intermediate gauge bosons are in question so that the Compton lengths of intermediate gauge bosons are scaled up by a factor $r = \hbar/\hbar_0$. Below the dark Compton length weak gauge bosons would be effectively massless and above it possess ordinary masses. Large parity breaking effects induced by dark intermediate gauge bosons would be possible.

2. For instance, for $r = 2^{44}$ for which EEG photons have energies just above thermal threshold at room temperature, the effective p-adic length scale would correspond to $L(k)$, $k = 89+44 = 133$ of about .2 Angstrom. This scale in turn would scale up to $L(133+44 = 177)$. Secondary p-adic length scale assignable to $k = 89$ which is important in zero energy ontology would correspond to $k = 2 \times 89 = 178$ which corresponds to about $L(178) \simeq 100$ $\mu$m, the length scale assignable to large cells and the thickness of water layers in the experiment of Pollack.

3. Parity breaking interaction is associated with spin and the interaction energy of form $ks \cdot E_Z$, where $s$ is the spin of particle and $E_Z$ is $Z^0$ electric field. Classical induced gauge fields are very strongly correlated in TGD since they are expressible in terms of four $CP_2$ coordinates and their gradients. Hence classical electromagnetic field $E$ is in the generic case accompanied by classical $Z^0$ field $E_Z = aE$. This means that if there is classical electromagnetic field and charge density at the dark space-time sheet, large parity breaking effect is possible at the level of spin. The induced $Z^0$ electric field could force the spins to become parallel and in this manner induce also magnetization.

The crucial finding about which I learned three years ago is that L glutamate is more stable than R glutamate in water and that heavy water does not induce this effect [62]. This suggests a connection with Pollack-Zheng effect [58]. Heavy water nuclei have vanishing spin whereas hydrogen nuclei have spin 1/2 so that $H_2$ in water molecules can be in spin singlet or triplet states (para and orto configurations). Could the nuclear spin of water molecules somehow induce parity breaking and the magnetic interaction distinguishing between these molecules?

1. Suppose that bio-molecules in question have magnetic moment and water carries magnetic field, most naturally at dark magnetic flux tubes. The parity breaking interaction energy $-p \cdot E$ with dark electric field remains invariant under reflection and rotation of $\pi$ changing the orientation of the mirror image of the molecule with respect to electric field. The interaction energy with magnetic field however changes its sign since magnetic moment is not affected by the reflection but changes direction under rotation. The angular momentum of the molecule responsible for the magnetic moment can of course change sign but since the transformation involves acts on angular momenta only, it is not a symmetry of entire system. Indeed, if there is interaction between angular momentum degrees of freedom and geometric degrees of freedom the magnetic interaction energy for the mirror image is different. Suppose that the breaking of reflection symmetry induced by the chirality of the molecule induces internal electric field $E_{int}$. The parity breaking interaction energy $ks \cdot E_{int}$ would indeed break the symmetry in the transformation changing the directions of angular momenta and spins.

2. It deserves to be emphasize that the parity breaking of the molecule itself would induce the symmetry breaking if molecule possesses dark magnetic body. One can actually imagine a cascade of parity breakings proceeding from shorter to longer length scales in this manner.

3. The mechanism creating electric field could be the charging of water, perhaps by the Pollack-Zheng mechanism and having in TGD framework an interpretation as a basic mechanism storing

the energy of sunlight to metabolic energy (kicking of electrons and/or protons to a smaller space-time sheet so that oppositely charge space-time sheets emerge as a consequence). A direct connection with metabolism would be admittedly a highly satisfactory feature of the mechanism.

4. Parity breaking energy $ks \cdot E$ for say dark protons assignable to hydrogen nuclei of bio-molecules in the internal electric field of the molecule or dark protons of water molecules in the electric field induced by Pollack-Zheng effect [58] does not change sign under the reflection of the molecule so that spin polarization independent of chirality could result form both water molecules in crystal like phase and for bio-molecules possessing dark protons (and dark hydrogen atoms). This could in turn serve as a seed for magnetization essential for the existence of dark magnetic flux tubes.

If water is replaced with heavy water there is no difference between L and R. What distinction $H$ and $D$ could explain this difference?

1. The basic difference between water and heavy water nuclei is that for water nucleus is just proton having spin 1/2 so that $H_2$ in water molecule can be in spin triplet and singlet states. Fractions of the two states are 3/4 and 1/4 in the absence of external magnetic field.

2. On the other hand, in attosecond time scale (corresponding length scale is 3 Angstroms) water is known to behave effectively as $H_{1.5}O$. A possible explanation is that 1/4:th of $H$ nuclei/atoms are effectively dark having large Planck constant. The dark protons cannot correspond to $H_2$ in spin singlet state since the interaction energy $ks \cdot E$ would be small in this case. Dark spin triplet states of $H_2$ could however induce parity breaking in water and make crystal like water phase both electret and magnet. If the spin $s_z = 1$ with negative interaction energy with $E$ becomes dark then 1/4 of hydrogen atoms would be dark and $H_{1.5}O$ formula would hold true. For $D_2O$ this mechanism would not work.

3. The model for homeopathy led to the idea that dark nuclei consisting of scale up variants of nucleons possibly having size of order atomic length scale could be crucial for understanding living matter. The states of nucleons correspond naturally to those DNA, RNA, and aminocids and vertebrate genetic code emerges naturally with DNA code word replaced with 3 quark state with entanglement between the quarks representing the information. Could it be that dark protons of water combine to form dark nuclei providing a fundamental representation of the genetic code and could the spin of protons induce electro-weak chiral symmetry breaking. Also now this mechanism fails for $D_2O$.

### 2.3.4 Burning water and photosynthesis

For a physicist liberated from the blind belief in reductionism, biology transforms to a single gigantic anomaly about which recent day physics cannot say much. During years I have constructed several models for these anomalies helping to develop a more detailed view about how the new physics predicted by quantum TGD could allow to understand biology and consciousness.

The basic problem is of course the absence of systematic experimentation so that it is possible to imagine many new physics scenarios. For this reason the article series of Mae-Wan Ho [53, 54, 55, 56] in ISIS was a very pleasant surprise, and already now has helped considerably in the attempts to develop the ideas further.

The first article "Water electric" [53] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [58]. The zones were in potential of about 100 meV with respect to surroundings (same order of magnitude as membrane potential) and had thickness ranging to hundreds of micrometers (the size of a large cell): the standard physics would suggests only few molecular layers instead of millions. Sunlight induced the effect. This finding allow to develop TGD based vision about how proto cells emerged and also the model for chiral selection in living matter by combining the finding with the anomalies of water about which I had learned earlier.

The article "Can water burn?" [55] tells about the discovery of John Kanzius -a retired broadcast engineer and inventor. Kanzius found that water literally burns if subjected to a radio frequency radiation at frequency of 13.56 MHz [60]. The mystery is of course how so low frequency can induce burning. The article "The body does burn water" [56] notices that plant cells burn water routinely in photosynthesis and that also animal cells burn water but the purpose is now to generate hydrogen peroxide which kills bacteria (some readers might recall from childhood how hydrogen peroxide was used to sterilize wounds!). Hence the understanding of how water burns is very relevant for the understanding of photosynthesis and even workings of the immune system.

### Living matter burns water routinely

Photosynthesis burns water by decomposing water to hydrogen and oxygen and liberating oxygen. Oxygen from $CO_2$ in atmosphere combines with the oxygen of $H_2O$ to form $O_2$ molecules whereas $H$ from $H_2O$ combines with carbon to form hydrocarbons serving as energy sources for animals which in turn produce $CO_2$. This process is fundamental for aerobic life. There is also a simpler variant of photosynthesis in which oxygen is not produced and applied by an-aerobic life forms. The article "Living with Oxygen" by Mae-Wan Ho gives a nice overall view about the role of oxygen [57]. As a matter fact, also animals burn water but they do this to produce hydrogen peroxide $H_2O_2$ which kills very effectively bacteria.

Burning of water has been studied as a potential solution for how to utilize the solar energy to produce hydrogen serving as a natural fuel [54]. The reaction $O_2 + H_2 \rightarrow 2H_2O$ occurs spontaneously and liberates energy of about 1.23 eV. The reverse process $2H_2 \rightarrow H_2O_2 + H_2$ in the presence of sunlight means burning of water, and could provide the manner to store solar energy. The basic reaction $2H_2O + 4h\nu \leftrightarrow H_2O_2 + H_2$ stores the energy of four photons. What really happens in this process is far from being completely understood. Quite generally, the mechanisms making possible extreme efficiency of bio-catalysis remain poorly understood. Here new physics might be involved. I have discussed models for photosynthesis and $ADP \leftrightarrow ATP$ process involved with the utilization of the biochemical energy already earlier [K6].

### How water could burn in TGD Universe?

The new results could help to develop a more detailed model about what happens in photosynthesis. The simplest TGD inspired sketch for what might happen in the burning of water goes as follows.

1. Assume that 1/4 of water molecules are partially dark (in sense of nonstandard value of Planck constant) or at least at larger space-time sheets in atto-second scale [75, 76, 77, 78]. This would explain the $H_{1.5}O$ formula explaining the results of neutron diffraction and electron scattering.

2. The question is what this exotic fraction of water precisely is. The models for water electret, exclusion zones and chiral selection lead to concrete ideas about this. Electrons assignable to the $H$ atoms of (partially) dark $H_2O$ reside at space-time sheet $k_e = 151$ (this p-adic length scale corresponds to 10 nm, the thickness of cell membrane). At least the hydrogen atom for this fraction of water molecules is exotic and findings from neutron and electron scattering suggest that both proton and electron are at non-standard space-time sheets but not necessarily at the same space-time sheet. The model for the burning requires that electron and proton are at different space-time sheets in the initial situation.

3. Suppose all four electrons are kicked to the space-time sheet of protons of the exotic hydrogen atoms labeled by $k_p$. This requires the energy $E_\gamma = (1-2^{-n})E_0(k_p)$ (the formula involves idealizations). At this space-time sheet protons and electrons are assumed to combine spontaneously to form two $H_2$ atoms. Oxygen atoms in turn are assumed to combine spontaneously to form $O_2$.

4. For $k_f = 148$ and $n = 3$ minimum energy needed would be $4E_\gamma = 4 \times .4 = 1.6$ eV. For $k_p = 149$ (thickness of lipid layer) and $n = 2$ one would have $4E_\gamma = 4 \times .3462 = 1.385$ eV whereas $H_2O_2 + H_2 \rightarrow 2H_2O$ liberates energy 1.23 eV. Therefore the model in which electrons are at cell membrane space-time sheet and protons at the space-time sheet assignable to single lipid layer of cell membrane suggests itself. This would also mean that the basic length scales of cell are already present in the structure of water. Notice that there is no need to assume that Planck constant differs from its standard value.

There is no need to add, that the model is an unashamed oversimplification of the reality. It might however catch the core mechanism of photosynthesis.

### Burning of salt water induced by RF radiation

Mae-Wan Ho's article "Can water Burn?" [55] provides new information about burning salt water [60], in particular reports that the experiments have been replicated. The water is irradiated using polarized radio frequency light at frequency 13.56 MHz. The energy of radio frequency quantum is $E_{rf} = .561 \times 10^{-7}$ eV and provides only a minor fraction $E_{rf}/E = .436 \times 10^{-7}$ of the needed energy which is $E = 1.23$ eV for single $2H_2O \rightarrow H_2O_2 + H_2$ event. The structure of water has been found to change, in particular something happens to O-H bonds. The Raman spectrum of the water has changed in the energy range $[0.37, 0.43]$ eV. Recall that the range of metabolic energy quanta $E(k,n) = (1-2^-n)E_0(k)$ varies for electron in the range $[.35, .46]$ eV in the model for the formation of exclusion zone induced by light. Therefore the photons assigned to changes in Raman spectrum might be associated with the transfer of electrons between space-time sheets.

My original proposal [F9] was that some fraction of radio wave photons are dark or transform to dark photons with large Planck constant $\hbar$. At that time I did not realize the connection with photosynthesis and actual burning of water. The recent experimental findings suggest that dark radio frequency photons transform to photons inducing splitting of water as in photosynthesis so that that one should have $r = \hbar/\hbar_0 = E_{rf}/4E$. One could say that large number of radio wave photons combine to form a single bundle of photons forming a structure analogous to what mathematician calls covering space. In the burning event the dark photon would transform to ordinary photon with the same energy. This process would thus transform low energy photons to high energy protons with the ratio $r = \hbar/\hbar_0$.

Therefore the mechanism for the burning of water in the experiment of Kanzius could be a simple modification of the mechanism behind burning of water in photosynthesis.

1. Some fraction of dark radio frequency photons are dark or are transformed to dark photons in water and have energies around the energy needed to kick electrons to smaller space-time sheets .4 eV. After this they are transformed to ordinary photons and induce the above process. Their in-elastic scattering from molecules (that is Raman scattering) explains the observation of Raman scattered photons. For a fixed value of $\hbar$ the process would occur in resonant manner since only few metabolic quanta are allowed.

2. How dark radio frequency photons could be present or could be produced in water? Cyclotron radiation assignable to say electrons in magnetic field comes in mind. If the cyclotron radiation is associated with electrons it requires a magnetic field of 4.8 Gauss the cyclotron frequency is 13.56 MHz. This is roughly ten times the nominal value $B_E = .5$ Gauss of the Earth's magnetic field and 24 times the value of dark magnetic field $B_d = .4B_E = .2$ Gauss needed to explain the effects of ELF em fields on vertebrate brain. Maybe dark matter at flux tubes of Earth's magnetic field with Planck constant equal to $\hbar/\hbar_0 = \frac{1}{4}\frac{E}{E_{rf}}$ transforms radio frequency photons to dark photons or induces resonantly the generation of cyclotron photons, which in turn leak out from magnetic flux tubes and form ordinary photons inducing the burning of water. $E_\gamma = .4$ eV would give $\hbar/\hbar_0 == 1.063 \times 2^{21}$ and $E_\gamma = .36$ eV would give $\hbar/\hbar_0 = .920 \times 2^{21}$.

3. Magnetic fields of magnitude .2 Gauss are in central role in TGD based model of living matter and there are excellent reasons to expect that this mechanism could be involved also with processes involved with living matter. There is indeed evidence for this. The experiments of Gariaev demonstrated that the irradiation of DNA with 2 eV laser photons (which correspond to one particular metabolic energy quantum) induced generation of radio wave photons having unexpected effects on living matter (enhanced metabolic activity) [64], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K4, L8] identifies radio-wave photons as dark photons with same energy as possessed by incoming visible photons so that a transformation of ordinary photons to dark photons would have been in question. The model assumed hierarchy of values of magnetic fields in accordance with the idea about onion like structure of the magnetic body.

An interesting question concerns the role of salt in the process (and in cells). Is there some trivial explanation for why it must be present or is new physics involved also here? In the experimental arrangement leading to the generation of exclusion zones the pH of water was important control factor, and it might be that the presence of salt has an analogous role to that of protons.

### Free radicals, expanding Earth, water memory, and Cambrian revolution

The title is intentionally chosen to involve notions which one would expect to have absolutely nothing in common. The purpose is to show that this expectation might be wrong. Consider first the free radical theory [52]. The theory states that free radical produced in mitochondria are responsible for the ageing since they are highly reactive and cause damage for the DNA. One can however wonder what is the mechanism causing the generation of the free radicals.

A TGD based justification for the free radical theory came as unexpected application of the quantum model for how metabolic batteries are loaded in many-sheeted space-time. The kicking of electrons to smaller space-time sheet loads metabolic batteries in TGD Universe. The dropping of electrons back liberates metabolic energy. These processes occur all the time in ADP↔ATP "Karma's" cycle. The quantitative model for the burning of water producing hydrogen peroxide and hydrogen (this process could provide a mechanism of storing solar energy by a mechanism analogous to photosynthesis) as already discussed.

### Burning water, photo synthesis, and water memory

The burning of water, photons synthesis and water memory are closely interrelated phenomena in TGD Universe. Recall first what was observed in the experiments carried out by the group led by Luc Montagnie.

1. What was done was filtration of human cells infected by bacteria in sterilization purpose to eliminate the infected cells. Human cells were added to the filtrate. Rather magically, the infection returned to the filtrate within few weeks. Something having size of order of nanoscale leaked through. It was also found that when the filtrate was diluted by water to produce an analog of homeopathic remedy, it produced at multiples of kHz if the dilution factor was in the range $10^{-7} - 10^{-12}$.

2. The second discovery was that if you have two bottles containing a solute of nanostructures such that for the first one dilution factor is small and for the second in the critical range so that it radiates at kHz frequencies. What was found that in the final situation neither radiates but only if the dilutions correspond to the same bacterial species! I proposed two interpretations. The first one was that the nanoscale systems in the highly diluted system are starving and gain metabolic energy by sending negative energy photons to the low dilution system and this makes them possible to replicate and achieve higher dilution after which the process stops.

3. One of the most fascinating possibilities suggested by the discovery is that the nanoscale structures identified as certain gene of the bacteria plus possibly something else (the magnetic body of gene in TGD context) might have been able to regenerate the bacteria themselves! This would require a non-chemical representation of genetic code and its translation to DNA or RNA. For about year ago I indeed discovered a realization of genetic code in terms of dark nuclei with states of nucleons representing the code words [F9].

These findings allow a more detailed interpretation of the findings of the experiments of the group of Luc Montagnie.

1. The mysterious burning of water induced by radiowaves in GHz range and interpreted in terms of a decomposition of water molecules to hydrogen peroxide and hydrogen: $2H_2 \rightarrow H_2O_2 + H_2$ is closely related to the splitting of water to hydrogen and oxygen occurs also in photosynthesis. The interpretation was that radiowaves are resonantly transformed to dark photons with same frequency but with very large value of Planck constant and hence of energy followed by a transformation to ordinary IR photons with much higher frequency but same energy energy around .4 eV. The finding that Raman scattering (non-elastic scattering of photons on molecules) around this energy occurs in the burning water supports this view. The natural guess is that also in the recent case something similar occurs.

2. This kind of frequency scaling is one of the basic mechanisms of water memory as I learned for the first time from the lecture of Cyril Smith in CASYS conference many years ago. One of the basic findings was that there is an unknown mechanism transforming low frequencies to high

ones and vice versa. The low frequencies are scaled up by a factor which has a preferred value $r \simeq 2 \times 10^{11}$ interpreted in TGD framework as the ratio of the dark matter Planck constant to the ordinary one. I christened this correlation as a scaling law of homeopathy.

3. It is interesting to apply the law to kHz frequency. In this case the law would give frequency $f = 2\times 10^{14} >$ Hz. The corresponding energy is .826 eV, which is essentially twice the energy quantum associated with burning water and thus has interpretation as a p-adically scaled up frequency (by one octave). Interestingly, Mae-Wan Ho states in [57] that *"to use water as electron-donor, and hence to produce oxygen, requires the creation of the chlorophyll-a in cyanobacteria and green plants that can be boosted to a higher electrochemical potential of 0.82 V"*. Hence .83 eV is very near to a metabolically interesting energy.

4. This finding supports the view that kHz radiation produced by nano-structures corresponds to dark phase conjugate photons with energy equal to a metabolic energy quantum. The interpretation would be that the unidentified nanoscale systems in the highly diluted system are starving and get metabolic energy by sending negative energy quanta in the hope that there are metabolic energy reservoirs around able to absorb them. If biophotons are Bose Einstein condensates of dark cyclotron photons at the flux tubes of magnetic body acting like population reversed lasers, they could serve as metabolic energy reservoir as suggested in on basis of the discovery described by Mae-Wan Ho in [53].

5. A continual fight for metabolic resources is raging everywhere in Nature, presumably also at the monocellular level. It would not be surprising if harmful bacteria would try to steal the metabolic energy of other organisms stored (say) as biophotons by sending phase conjugate light to the biophoton resources of multicellular organisms. Nor it would be surprising if living organisms would have developed manners to prevent this. The fine tuning of the metabolic frequencies so that only the members of the same species can share the energy could guarantee this. Also password like protocols might have developed and either or both of them might be involved.

   In the two-bottle experiments the nanoscale systems in the highly diluted system would gain metabolic energy by sending negative energy photons received by the low dilution system. The gain of metabolic energy would make possible for the nanosystems to replicate and achieve higher dilution after which the process would stop as was indeed observed. That this took place only for the bacteria of same species supports the interpretation that frequency tuning or password mechanism was involved. This metabolic mechanism (quantum credit card as I have called it) could be a completely general mechanism energy sharing mechanism for cells of the same multicellular organism and perhaps even same species in TGD Universe.

## 2.4 TGD based model for the generation of nerve pulse and EEG

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

The TGD based view about dark matter hierarchy involving a hierarchy of values of Planck constant provides a justification for this picture. Dark matter hierarchy corresponds to the hierarchy of moments of consciousness with increasingly long duration with respect to geometric time and defines a hierarchy of conscious entities and reflective levels of consciousness.

Dark matter hierarchy provides a mechanism for the formation of macroscopic and macro-temporal quantum phases in all length scales. The earlier assumption about thermal isolation of space-time sheets corresponding to different p-adic length scales can be given up and thermal stability condition becomes an additional strong constraint allowing to eliminate various options very effectively. Since cyclotron energies scale like $\hbar$, thermal stability is possible to achieve for them.

In this section TGD based model of nerve pulse and EEG inspired by the soliton model of Danish researchers and the model of Pollack is discussed. Also a model for the action of anesthetics is proposed.

### 2.4.1 Soliton model of nerve pulse

Let us first briefly summarize soliton model of nerve pulse proposed by Danish researchers [107, 108, 109, 110].

1. The temperature of the axon is slightly above the critical temperature $T_c$ for the phase transition leading from crystal like state of the lipid layers to a liquid crystal state. Near criticality the elastic constants and heat capacity of the membrane vary strongly and have maxima at criticality so that also sound velocity varies strongly near criticality. Also the relaxation times are long. There is also dispersion present meaning that the frequency of sound wave depends nonlinearly on wave vector. Non-linearity and dispersion are prerequisites for the presence of solitons which by definition do not dissipate energy.

2. Variations of temperature, volume, area, and thickness and also other mechanical effects are known to accompany nerve pulse propagation. It is also known that the heat density and temperature of the cell membrane increases slightly first and is then reduced. This suggests adiabaticity in average sense. These findings motivate the assumption that nerve pulse actually corresponds to acoustic soliton [108, 109].

3. Soliton model reproduces correctly the velocity of nerve pulse inside myelin sheaths but it is not clear to me how well the much lower conduction velocity in non-myelin sheathed regions is reproduced. It is not clear how the lower values of the conduction velocity and its proportionality to the axonal radius in non-myelinated regions can be understood. Intuitively it however seems clear that the lower velocity is due to the feedback from the interaction of ions with the region exterior to cell membrane. In the case of myelin sheaths the conduction of nerve pulse is usually believed to take place via saltation [111]: the depolarization induced at Ranvier node is believed to be enough to take the membrane potential below critical value in the next node so that nerve pulse hops between the nodes. Insulation would improve the insulation and make this process possible. The reversible heat transfer process is however known to be present also in the myelinated portions of axon so that there must be a pulse propagating also in these regions [109]. It is not clear how the myelin sheet can increase the velocity in the soliton model but the reduction of the feedback inducing friction suggests itself.

4. Soliton property predicts adiabaticity. Ordinary ionic currents however dissipate so that adiabaticity assumption is questionable in standard physics context. The model does not predict the growth of entropy followed by its reduction. This behavior is consistent with adiabaticity in a time resolution of order millisecond.

5. The estimate for the capacitor energy density during the nerve pulse is considerably smaller than the energy density is many times magnitude smaller than that of the acoustic wave. This might allow to demonstrate that Hodgkin-Huxley model is not a complete description of the situation.

6. Authors notice [108, 109] that the shapes curves representing solitonic energy density and the capacitor energy density as a function of time are essentially identical. Same applies to the experimentally deduced heat change release curve and capacitor energy density for garfish axon. Also heat release and the deviation of the membrane potential from its resting value are in exact phase. These similarities could reflect a control signal responsible for the nerve pulse originating somewhere else, perhaps at micro-tubules. This could explain why secondary nerve pulse is not generated immediately after the first one although the temperature is slightly lower after

the pulse than before it. This could of course be also due to the exhaustion of the metabolic resources.

### 2.4.2 TGD based model of nerve pulse

The model of nerve pulse described below can be motivated by the observed adiabaticity of the nerve pulse and by the strange findings about ionic currents associated with the cell membrane and by the model of Danish researchers for the nerve pulse [106, 107, 108, 109]. The model involves also a fusion of various ideas of earlier models. In particular, Josephson currents and solitons are in a key role in the model but with the necessary flexibility brought in by the hierarchy of Planck constants. The model of nerve pulse by Pollack [33] discussed at the end of previous section allows to understand the behavior of ionic currents quantitatively.

#### Consistency with the absence of dissipative currents through the axonal membrane

The basic inputs of the TGD based model are following.

1. The presence of acoustic soliton or density pulse proposed by Danish researchers [109] looks plausible but a a more fundamental quantum control mechanism inducing the acoustic soliton cannot be excluded. Among other things this should explain why acoustic solitons propagate always in the same direction. In particular, one can consider a soliton like excitation (say breather for Sine-Gordon equation) associated with the electronic or ionic Josephson currents running along magnetic flux tubes. The strange effects associated with the ionic currents through the cell membrane suggest quite generally that at least weak ionic currents through normal cell membrane are non-dissipative quantal currents. The adiabaticity of the nerve pulse suggests that also strong ionic currents are quantal.

2. Strong ionic currents generating nerve pulse through axonal membrane are absent in the resting state. The naive explanation is simple: the life time of the magnetic flux tubes connecting the axonal interior to the exterior is short or the flux tubes are altogether absent. The observation that Josephson currents in constant voltage are automatically periodic suggests a less naive explanation allowing the flux tubes to be present all the time. The presence of ionic Josephson currents predicts a small amplitude oscillation of membrane potential for which 1 kHz synchronous oscillation is a natural identification. Josephson oscillation correspond naturally to propagating soliton sequences for Sine-Gordon equation. The dynamics of the simplest modes is equivalent to the rotational motion of gravitational pendulum: the oscillation of membrane potential corresponds to the variation of $d\Phi/dt \propto V$. Note that if axon is above the melting temperature, the lipid layer is in gel phase and fluid motion is impossible. The surface density of lipids is dramatically reduced at criticality so that lipid layers behave like fluids [109]. This means that tqc is not possible by the braiding of lipids.

3. Nerve pulse is generated when the magnitude of the negative membrane potential is reduced below the critical value. Generation of the nerve pulse is like a kick to a rotating gravitational pendulum changing the sign of $\Omega = d\Phi/dt$ so that rotational motion is transformed to oscillatory motion lasting for about the period of rotation. An opposite but slightly stronger kick must reduce the situation to the original one but with a slightly higher value of $\Omega$. These kicks could correspond to voltage pulse between micro-tubules and inner lipid layer of cell membrane induced by the addition of small positive (negative) charge on lipid layer. This pulse would induce electronic DC Josephson current inducing the kick and thus reducing $V$. The exchange of scaled variants of $W$ bosons (assignable to $W$ MEs) could mediate the transfer of charge through the cell membrane and reduce the membrane potential below the critical value but one can consider also other mechanisms.

4. The conservative option would be that ordinary ionic currents take care of the rest and Hogkin-Huxley model applies. This was assumed in the earliest model in which soliton sequence for Josephson current was assumed to induce nerve pulse sequence: in the recent model this assumption does not make sense. The findings of Danish researchers do not however support the conservative option [109]. Nerve pulse could be due to dark ionic (possibly supra -) currents

with large $\hbar$ with a low dissipation rate. Their flow would be made possible by the presence of magnetic flux tubes connecting cell interior and exterior.

### The relationship with the model of Pollack

In the model of Pollack [33] for the action potential gel-sol-gel phase transition for the peripheral cytoskeleton accompanies the generation of the action potential. The model allows to understand reasonably well the behavior and the physical role of the ionic currents and explains various anomalies. Using pendulum analogy, the kick to the rotating pendulum representing Josephson junction would force it to an oscillatory motion inducing a gel-sol-gel phase transition propagating along the peripheral cytoskeleton.

The challenge is to understand how quantum criticality making possible the phase transition is induced.

1. The primary Josephson currents from the micro-tubuli to the axonal membrane would reduce the magnitude of the cell potential below the critical value (slowing down of the pendulum rotation). This should somehow take the peripheral cytoskeleton near to quantum criticality and induce the increase of Planck constant for the flux tubes connecting peripheral cytoskeleton to the axonal membrane and increasing their length so that they would extend to axonal exterior. This would make possible the flow of monovalent dark ions (say $Na^+$) from the axonal exterior replacing $Ca^{++}$ acting as cross links between negatively charged proteins and in this manner induce gel-sol phase transition. The reverse phase transition would reduce Planck constant. If ionic currents are non-dissipative they flow back automatically much like oscillating Josephson currents.

2. There are two forms of quantum criticality corresponding to critical sub-manifolds $M^2 \times CP_2$ and $M^4 \times S^2$, where $M^2 \subset M^4$ has interpretation as plane of non-physical polarizations and $S^2 \subset CP_2$ is a homologically trivial geodesic sphere of $CP_2$ with vanishing induced Kähler form (see the Appendix of [O4]). The latter kind of quantum criticality corresponds to very weak induced Kähler fields and thus to almost vacuum extremals. Given electromagnetic field can be imbedded as a 4-surface in many manners: as a vacuum extremal, as a surface maximizing Kähler electric energy, or something between them.

3. Quantum criticality suggests that em fields in the cell interior corresponds to nearly vanishing induced Kähler fields and that in the resting state the em fields at cell membrane and peripheral cytoskeleton correspond to strong Kähler fields. The magnitude of the cell potential in the absence of the membrane is about .05 V and slightly below the magnitude of the critical potential [33]. Hence the reduction of the magnitude of the em (-or more precisely- Kähler-) voltage between the inner boundary of the peripheral cytoskeleton and cell exterior to a small enough value could induce quantum criticality making $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axonal membrane possible. This framework also allows to understand the paradoxical fact that a reduction of the magnitude of the cell potential induces the action potential rather than its increase as the naive idea about di-electric breakdown would suggest.

4. The energy of the Josephson photon associated with cell membrane Josephson junction is about .05 eV at criticality for the generation of action potential. This is not too far from the value of the metabolic energy quantum liberated in the dropping of proton Cooper pair from $k = 139$ atomic space-time sheet or of electron Cooper pair from $k = 151$ cell membrane space-time sheet to a much larger space-time sheet. This leads to the idea that phase conjugate IR photons of Josephson radiation couple resonantly to the gel defined by the peripheral cytoskeleton and induce fast dropping of protons to larger space-time sheets and that this in turn induces the increase of Planck constant for magnetic flux tubes inducing gel-to-sol phase transition. This idea has been discussed already earlier and will reconsidered in the section where the relationship of the model with microtubular level is discussed.

5. A comment relating this picture to DNA as tqc model is in order. The basic difference between TGD and standard model is that color rotations leave invariant the induced Kähler field but affect electro-weak gauge fields. In particular, color rotations change the intensity of em field by

transforming em and $Z^0$ fluxes to each other. In the recent case color rotation cannot obviously reduce the value of the electric field. The most elegant variant of the model of DNA as tqc replaces qubit with qutrit (true/false/undefined) presented as color triplet of quarks associated with the (wormhole) magnetic flux tubes connecting nucleotides with lipids [O4]. Hence the color rotations representing basic 1-gates would not affect induced Kähler fields and cannot induce phase transitions although they would affect cell potential. For 2-gate represented by the basic braiding operation permuting the ends of the neighboring strands the situation is different. Quantum criticality would make possible the generation of braiding by taking cell membrane to liquid state. The discussion about the effects of anesthetics in the sequel forces however to conclude that in the liquid crystal state action potentials are not possible. Propagating action potentials could however represent tqc programs as time-like braidings if it is microtubular surface that suffer gel-sol-gel transition during the nerve pulse.

**What the replacement of Ohmic ionic currents with quantal currents means?**

Before the replacement of Hodgkin-Huxley model with a genuinely quantal model can be taken seriously, one must answer many difficult questions which also Hodgkin and Huxley must have faced as they developed their own model.

*1. Questions and answers*

*Q: In the resting state membrane potential is negative and cell has a negative net charge. What stabilizes the cell against the leakage of the negative charge if pumps and channels are not responsible for this?*

A: The findings about the strange behavior of cell membrane inspire TGD based answer. Cell membrane space-time sheet is its own quantum world and the flow of ions occurs only in the presence of magnetic flux tubes connecting it to the external world. These currents a however oscillatory Josephson currents if dissipation is absent. Hence there is no need to cut completely the connections to the external world.

*Q: How the resting state can result spontaneously if pumps are absent?*

A: If ionic currents are Josephson currents, they are automatically oscillating and the return to the original state is guaranteed. The flux tubes carrying the ionic currents will be assumed to connect axonal micro-tubules to the space-time sheet of the cell interior. Consider first the most obvious objections.

1. Dark ions cannot transform to ordinary ones in the exterior of the cell membrane. This might indeed kill the model.
2. The second objection is that all biologically important ions are not bosons and the model for high $T_c$ super-conductor in its recent form allows only electronic and protonic Cooper pairs at room temperature [J1]. TGD based nuclear physics however predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation.

The table below describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation $Mg_-^{++}$ tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.

$$\begin{array}{llll} Ion & f_c/Hz & Pseudo-ion & f_c/Hz \\ ^{23}Na^+ & 13.1 & ^{19}Ne_+ & 15.7 \\ ^{23}Na^+ & 13.1 & ^{24}Mg_-^{++} & 12.5 \\ ^{39}K^+ & 7.7 & ^{40}A_+ & 7.5 \\ ^{39}K^+ & 7.7 & ^{40}Ca_-^{++} & 7.5 \\ ^{35}Cl^- & 8.6 & ^{40}A_- & 7.5 \end{array} \quad (2.4.1)$$

$f_c(K+)$ and $f_c(Cl^-)$ are replaced with the frequency 7.5 Hz and one can do only using the cyclotron frequencies $f(Ca^{++})/2 = 7.5$ Hz, $f_c(Mg^{++}) = 12.5$ Hz, and $f(Ca^{++}) = 15$ Hz. The nominal values of the lowest Schumann frequencies are 7.8 Hz and 14.3 Hz. All ions with relevance for nerve pulse and EEG could be bosonic ions or bosonic pseudo-ions. I do not know how well the needed ionization mechanisms are understood in the standard framework.

For small oscillations the maximal charge transfer $\Delta Q$ generated by an oscillating ionic Josephson current during the cycle is proportional to $\hbar/f_J \propto \hbar^2$ and $\hbar/\Omega \propto \hbar$ for solitonic situation. $\Delta Q$ is very small for the ordinary value of $\hbar$: also the oscillation period is very small. For large values of $\hbar$ situation changes and large maximal ion transfers are possible. An $\hbar$ increasing phase transition could be involved with the generation of the nerve pulse. Quantum criticality during nerve pulse generation indeed suggest the presence of flux tubes with varying values of $\hbar$. The lifetimes of the connected flux tubes could be proportional to $\hbar$ at criticality. A fractal hierarchy of pulses and EEG like oscillations of the membrane potential corresponding to various values of $\hbar$ is suggestive.

*Q: Can one make this more quantitative?*

A: One can construct a model based on Sine-Gordon wave equation for the phase difference $\Phi$ between the superconductors connected by Josephson junction sequences defined by magnetic flux tubes and idealizable as a continuous Josephson junction.

1. For a Josephson junction idealizable as a hollow cylinder with radius $R$ and thickness $d$ the expression of the Josephson current reads as

$$J = J_0 sin(Ze\int Vdt/\hbar) \ .$$

   $J_0$ is in case of cell membrane given by

$$J_0 = \frac{Ze2\pi dR}{\Lambda^2}\frac{\hbar}{m} \ ,$$

   where $R$ and $d$ would be now the radius and thickness of the axon, $\Lambda$ is the magnetic peneration length, and $m$ is the mass of the charge carrier. Although this expression does not hold true as such when Josephson junctions are replaced by magnetic flux tubes connecting micro-tubules and axon, one can can safely make some qualitative conclusions. The amplitude of the Josephson current increases with $\hbar$. For electron the value of the amplitude is by a factor $x \simeq Am_p/m_e \simeq 2^{11}A$ larger than for ion with a mass number $A$. This gives for electron Cooper pairs a unique role as an initiator of the nerve pulse. Note that the amplitudes of the Josephson currents of electron and ions are quite near to each other if one has $\hbar(ion) = 2^{11}A\hbar e$: this might explain why the powers of $2^{11}$ for $\hbar$ seem to be favored.

2. Electronic Josephson current dominates and makes it ideal for the generation of nerve pulse (kick to gravitational pendulum). This is possible if the net amount of electronic charge is so small that it flows out during the generation of flux tubes. For ions this need not occur even if ion densities are of same order of magnitude. Constant voltage $V$ creates an oscillating current and no catastrophic leakage takes place and the resting state results automatically. The ionic Josephson currents assignable to the magnetic flux tubes connecting micro-tubules through the cell membrane to the external world could be responsible for the nerve pulse.

3. The mechanical analog for Sine-Gordon system [112] assignable to Josephson junction is rotating pendulum but one must be cautious in applying this analogy. There are two options concerning the modeling of the situation.

   i) Membrane potential represents an external voltage $V(t)$ and one has $\Phi_i = Z_ie\int Vdt/\hbar$, where $\Phi$ is the phase difference between Bose-Einstein condensates.

   ii) System is autonomous and membrane potential $V(t) = \hbar(d\Phi_i/dt)/Z_ie$ is completely determined by the dynamics of any phase $\Phi_i$. This option is highly predictive and discussed in the sequel.

4. The analogy with gravitational pendulum allows to identify the phase angle $\Phi$ as the counterpart of angle $\Theta$ characterizing angular position of mathematical pendulum (note that this analogy can be misleading since it implicitly brings in 3-D thinking).

i) In this picture rotating pendulum corresponds to a soliton sequence containing infinite number of solitons: both stationary and moving soliton sequences are obtained. The sign of $\Omega = d\Phi/dt$ is fixed and approximately constant for large values of $\Omega$. Resting potential could correspond to this kind of situation and $\Omega \simeq 2\pi$ kHz is suggested by kHz synchrony. A mechanism of this synchrony will be discussed below. For large values of $\hbar$ even values of $\Omega$ in EEG range could correspond to membrane potential. For large values of $\Omega$ one as $V \simeq \hbar\Omega_i/Z_ie$. If also EEG rhythms correspond to $\Omega$ they must correspond to different values of $\hbar$ and $f \propto 1/\hbar$ would hold true. Changes in the dominating EEG rhythm (40 Hz, 10 Hz, 5 Hz,..) could correspond to phase transitions changing $\hbar$ to given value for a large number of axons. The maximal charge transfer during single period is proportional to $\Delta Q \propto 1/\Omega$.

ii) Hyperpolarization/polarization would mean fastening/slowing down of the pendulum rotation and slowing down would make the system unstable. Near criticality against the generation of nerve pulse would mean that pendulum is rotating rather slowly ($\Omega \ll f_J$ ) so that a small kick can transform rotation to oscillation. The sign of $V \propto d\Phi/dt$ would change and large amplitude oscillatory motion would result for single period only after which a kick in opposite direction would lead back to the resting state. Membrane potential varies between the resting potential $V_0 = -75$ V and $V_1 = +40$ V during nerve pulse: $V_1 > |V_0|$ would have killed the model. Note that $V_1 = 40$ V is rather near to the critical potential about $V_1 = 50$ V: ideally these potentials should be identical.

iii) The so called breathers -both stationary and moving- correspond to soliton-antisoliton bound state (see the visualization in [112]). Breathers could be identified as large amplitude oscillations around $\Phi = 0$ ground state. Physical intuition suggests that breathers are possible also for a ground state corresponding to a rotating pendulum (representing moving or stationary waves). They would correspond to kicking of one pendulum in a sequence of pendulums along z-axis rotating in phase at the initial moment. The kick could correspond to a genuine external perturbation generated by a pair electronic supra current pulses of opposite sign giving constant velocity increments $\Delta\Omega$ initiating and halting the nerve pulse just like they would do in the case of tqc but in opposite time order. If the background corresponds to a propagating EEG wave, also nerve pulse is expected to propagate with same velocity. The propagation direction of EEG wave would also explain why nerve pulses propagate only in single direction.

5. For the ordinary value of $\hbar$, the frequency $\Omega$ of the Josephson current corresponds to that assignable to energy .07 eV being around $f = 1.6 \times 10^{13}$ Hz and quite high. For $x \equiv \hbar/\hbar_0 = 2^{44}$ the frequency would be near to cyclotron frequency of about 1 Hz assignable to DNA strands. For $x = 3 \times 2^{3\times 13}$ $f$ would be near to the fundamental 10 Hz frequency which is secondary p-adic time scale associated with electron and correspond to the temporal duration of negative energy space-time sheet assignable to electron. For $x = 3 \times 2^{3\times 11}$ one would obtain a 640 Hz frequency which corresponds to the time scale of nerve pulse. It seems clear that the original hypothesis that only powers of $2^{11}$ define the spectrum of Planck constant is too restrictive. The requirement that cyclotron frequencies and Josephson frequencies are proportional to each other for small oscillations would guarantee resonant behavior for common strength of the magnetic field would give $\hbar \propto A$. This would require that each ion species lives at its own flux tubes.

Q: What instabilizes the axon? Why the reduction rather than increase of the magnitude of the membrane potential induces the instability? Why the reduction of the resting potential below the critical value induces nerve pulse?

A: Large enough voltage pulse between micro-tubules and membrane could generate electronic DC supra current. The introduction of a small amount of positive charge to the inner lipid layer and staying there for some time would generate the voltage pulse between micro-tubules and lipid layer so that DC electronic supra current would be induced, and induce the reduction $\Delta V \simeq .02$ eV of the magnitude of the membrane potential. A similar introduction of negative charge would induce hyperpolarization and the direction of the current would be opposite if it is generated at all. The mechanism generating the small positive charge to the inner lipid layer could be based on the exchange of exotic $W$ bosons between pairs of exotic nuclei at opposite sides of the cell membrane so that the negative charge of the inner lipid layer would be reduced.

*Q: Can one understand the observed radial force, the increase of the radius of axons and the reduction of its thickness, and heating followed by cooling?*

A: The observed outward force acting on a test system might be due to the ionic Josephson currents to which the test system responds. During the second half of the pulse the sign of the ionic force is predicted to change. The pressure caused by the electronic Josephson current pulse might relate to the increase of the radius of the axonal membrane and with the reduction of its thickness as well as the slight increase of its temperature as being due to the electrons which heat the lipid layer as they collide with it. The ions return at the second half of the pulse and could transfer the heat away by convection.

1. This hypothesis gives the estimate for the force $f$ per unit area as

$$\begin{aligned} f_{2e}(t) &= \frac{dn(lipid)}{da} \times \frac{J(t)}{2e} \times \hbar k \\ &= \frac{dn}{da} \times U \times \frac{\hbar^2 k}{2m_e c} \times sin(\omega_J(2e)t) \ , \\ U &= \frac{2\pi A}{\Lambda^2} \ . \end{aligned} \tag{2.4.2}$$

   The parameter $A$ corresponds to the parameter $dR$ in the case that Josephson junctions have the thickness of axonal membrane, and is not relevant for order of magnitude estimate. $R$ corresponds to the distance between micro-tubules and cell exterior space-time sheet to which flux tubes end. $dn(lipid)/da$ is the 2-D density Josephson junctions equal to the density of lipids.

   $k \simeq 2\pi/R$ is the wave vector of electron Cooper pair at the magnetic flux tube. The 3-momentum of electron is enormous for the proposed value of $\hbar$, and the only possible interpretation is that the four-momentum of electron is virtual and space-like and corresponds to exchange of space-like virtual photon describing Coulomb interaction with lipid layer.

   $\Lambda^2$ satisfies in the first approximation the formula

$$\Lambda^{-2} = \frac{4\pi e^2 n_e}{m_e} + \sum_I \frac{4\pi e^2 n_I}{A m_I} = \alpha_{em} 16\pi^2 \times [\frac{\hbar_0 n_e}{m_e} + \sum_I \frac{\hbar_0 n_I}{A_I m_I}] \ . \tag{2.4.3}$$

   Note that there is no real dependence on $\hbar$. Above critical voltage electrons could dominate in the expression but during nerve pulse ions should give the dominating contributions. $U$ cannot be too far from unity.

2. From this one can integrate the total momentum of Cooper pairs transferred to the lipid layer before the flux tubes fuse together if one knows the value of time $t$ when this happens. $F \propto \hbar^2/m_e^2$ proportionality implies that for the required large value of $\hbar/\hbar_0 \simeq 3 \times 2^{33}$ the force is by a factor $6 \times 10^{20}$ stronger than for $\hbar_0$.

3. The force caused by ionic Josephson currents on piston is given by

$$f(t) = \sum_I \frac{2me}{m_I} \frac{2}{Z_I} \times f_{2e}(\frac{Z_I}{2} \frac{\Omega}{\omega_J} t) \ . \tag{2.4.4}$$

   The comparison with the observed force gives estimate for the value of magnetic penetration length and thus density of electrons at the flux tube.

4. According to [109] in one particular experiment the force on piston of area $S = .01\ \mathrm{cm}^2$ at the maximum of voltage ($t = 2\pi/\Omega$) is $F = 2$ nN. This gives a killer test for the model. One obtains an estimate for the parameter $U = \frac{\Lambda^2}{2\pi A}$ as

$$U \equiv \frac{\Lambda^2}{2\pi A} = \frac{dn}{da} S \times \frac{\hbar^2 k}{m_p c F} \times \sum_I \frac{2}{A_I Z_I} \quad . \tag{2.4.5}$$

The value of $U$ should not deviate too much from unity. One can use the estimates

$$\frac{\hbar}{\hbar_0} = 3 \times 2^{33} \quad , \quad k = \frac{2\pi}{R} \quad .$$

Note that the experimental arrangement forces to use this value of $k$. The actual value in normal situation could be smaller and depends on the distance of the boundary of cell exterior space-time sheet on micro-tubules. Using the values $d = 10$ nm and $R = 5\ \mu$m this gives

$$\begin{aligned} U &\simeq \sum_I \frac{2}{A_I Z_I} \times X \quad , \\ X &= 9 \times 2^{66} \times \frac{\hbar_0^2 2\pi}{m_p c F R} \times \frac{S}{S(lipid)} \quad . \end{aligned} \tag{2.4.6}$$

The factor $X = .9267$ is of order unity! Taking into account that $\hbar/\hbar_0$ is enormously large number it is difficult to believe that the result could be mere accident. Hence $U$ does not deviate too much from unity and there are good hopes that the model works.

For $n_I = x_I/a^3$, $a = 10^{-10}$ m, and $A = dR$ one obtains a direct estimate which combined with above estimate gives two conditions which should be consistent with each other:

$$\begin{array}{l} U = 76.1 \times \sum_I \frac{x_I}{A_I} \quad , \\ U = .93 \times \sum_I \frac{2}{A_I Z_I} \quad . \end{array} \tag{2.4.7}$$

These estimates are consistent for $x_I \sim 10^{-2}$, which makes sense.

*Q: Where the primary wave propagates: along axon or along micro-tubules?*

A: This question need not make sense if micro-tubules and axon are connected by magnetic flux tubes to form single quantum coherent system. That axonal micro-tubules have constant electric field which is always in same direction could explain why the background soliton sequences and nerve pulses propagate always in the same direction and suggests that the primary wave propagates along micro-tubules. On the other hand, if $W$ exchange between cell exterior and exterior reduces the negative charge of the inner lipid layer then axon could be seen as initiator. This could induce conformational or gel-sol phase transition propagating along micro-tubule and inducing the pair of voltage pulses in turn inducing the fusion of flux tubes at cell membrane which in turn would induce criticality of the axonal membrane. For this option axonal soliton would be a shadow of the micro-tubular soliton rather than completely independent dynamical process.

*Q: How nerve pulse velocities are determined?*

A: At first glance it seems nerve pulse velocity $v$ could be determined by boundary conditions guaranteing synchronization of neuronal activity rather than by dissipation as in Hodgkin-Huxley model. As a matter fact, dissipation turns out to affect also v just because it is determined by boundary conditions!

1. Hodgkin-Huxley model would suggest that nerve pulse velocity is dictated by frictional effects as an analog of a drift velocity. The rough order of magnitude estimates for the velocities of conformational waves along micro-tubuli are consistent with the velocities of nerve pulses. The proportionality $v \propto d$ of nerve pulse velocity to nerve axonal radius might be understood as resulting on the dependence on the length of flux tubes connecting axon and micro-tubules and mediating a frictional feedback interaction from axon. Feedback would be naturally reduced as $d$ increases. Feedback interaction could explain also the sensitivity of the thermal parameters of the axonal membrane to the proteins in its vicinity. If the frictional feedback is due to the environmental noise at the axon amplified at quantum criticality this is what one expects. Quite generally, quantum criticality would explain the high sensitivity of the thermal parameters on noise. Saltation cannot be responsible for the higher conduction velocity in myelin sheathed portions of axon. The insulation would reduce the environmental noise at the level of axons and thus reduce the frictional feedback from axon to the micro-tubules.

2. The introduction of friction is however problematic in the recent situation. In absence of boundary conditions Sine-Gordon equation predicts for the propagating soliton sequences a continuous velocity spectrum and friction should affect $\Omega$ and $V$ rather than phase velocity $v$ but it is not clear whether it can affect v.

   i) In this framework the boundary boundary conditions at the ends of the axon or some subunit of axon would dictate the values of $v$: $\gamma\Omega L/v = n2\pi$ corresponds to periodic boundary conditions (note that $\gamma = \sqrt{1-(v/c)^2} \simeq 1$ holds true). $v = \Omega L/n2\pi$ implies that friction indeed affects also $v$.

   ii) The relationship states that the time taken by the nerve pulse propagate through the axon is always $T = L/v = n2\pi/\Omega$: this would synchronize neurons and $\Omega \simeq 2\pi$ kHz is suggested by the well-known 1 kHz synchrony difficult to understand in the standard framework where $v$ would be determined by chemistry rather than geometry. Myelin shielding could in this picture guarantee that coherent wave propagation is possible over the entire axon so that boundary conditions can be applied.

   iii) This would give $v \simeq \Omega L/n2\pi < \Omega L/2\pi$. $\Omega = 2\pi$ kHz and $n = 1$ would give for $L \in$ [1 cm -10 cm] $v \in$ 10 m/s-100 m/s corresponding roughly to the observed range of values. For short axons velocity would be lower: for $L = 10$ $\mu$m one would have $v = .01$ m/s. For longer axons the value of $n$ could be higher or the axon would decompose into structural units for which periodic boundary conditions are satisfied. The sections between Ranvier nodes have length measured in millimeters as are also the lengths of axonal micro-tubules and 1 mm would correspond to a velocity of 1 m/s. The actual velocity for the myelinated sections varies between 18-100 m/s so that basic structural units should be longer. The proportionality of $v$ to the radius of axon would follow from the proportionality of the length of the axon or its basic sub-unit (not longer than $\sim$ 10 cm) to its radius: the simplest geometric explanation for this would be in terms of scaling invariance of the axonal geometry consistent with fractality of TGD Universe. In the standard framework this proportionality would be explained by the minimization of dissipative losses in the case of long axons: one cannot exclude some variant of this explanation also now since friction indeed reduces $v$.

   iv) There is an electric field associated with micro-tubules (always in same direction). Could this electric field play the role of external force feeding energy and momentum to the moving soliton sequence to compensate dissipation so that v would have interpretation as a drift velocity?

*Q: Can one understand EEG in this framework?*

A: Just like kHz waves also EEG generating waves could correspond to propagating soliton sequences. Since $V$ is not affected, the value of $\hbar$ must be much larger and one must have $\hbar \propto f$, where $f$ defines the EEG rhythm. It is known that EEG amplitudes associated with EEG rhythms behave roughly like $1/f$. This can be understood. By Maxwell's equation the divergence of electromagnetic field tensor is proportional to 4-current implying the amplitude of EEG identified as Josephson radiation is proportional $J_0/\Omega$ and therefore to $\hbar$. The propagation velocity $v = \Omega L/2\pi n$ of EEG generating waves is rather slow as compared to kHz waves: for $f = 10$ Hz one would have 10 cm long axon $v = 1$m /s. Synchronization results automatically from periodic boundary conditions at the ends of the axons.

Nerve pulses during EEG rhythms would have much slower velocity of propagation and the duration of nerve pulse would be much longer. The maximal charge transfer would be proportional to $1/\hbar$. It would thus seem that EEG and nerve pulse activity should exclude each other for a given axon. $\Omega$ is however smaller so that the generation of nerve pulse is easier unless also ion densities are lower so that $J_0$ (analogous to gravitational acceleration $g$ in pendulum analogy) is reduced. Perhaps this takes place. The consistency with the propagation velocity of micro-tubular conformational (or even gel-sol-gel) waves might pose additional constraints on $v$ and thus on frequencies $\Omega$ for which nerve pulses are possible. That ordinary EEG is not associated with ordinary cells might be due to the fact that $\hbar$ is much smaller: the fractal analog of EEG generating waves could be present but these EEG waves would correspond to faster oscillations in accordance with the view about evolution as an increase of $\hbar$.

### 2.4.3 Could micro-tubule-axon system perform topological quantum computation?

The proposed picture is consistent with the model of DNA as a topological quantum computer [O4] and with the idea that also micro-tubules could be involved with tqc. The model of DNA as tqc in its basic form assumes that DNA is connected to the nuclear membrane and cell membranes associated with the cell body by magnetic flux tubes such that each nucleotide is connected to single lipid. Tqc programs are coded to the temporal braiding patters of lipids. This requires that lipid layer is liquid crystal and thus below the critical temperature. The flux tube connecting DNA to inner lipid layer and that beginning from outer lipid layer can form single flux tube or be split. If they form single flux tube braiding and tqc are not possible. During tqc the braid strands going through cell membrane are split and the dance of lipids induced by water flow defining time like braiding (hydrophilic lipid ends are anchored to the cellular water) induces braiding of the magnetic flux tubes which write the tqc program to memory. Furthermore, the lifetimes of flux tubes in the connected state must be short enough to prevent the generation of a nerve pulse. This is the case if the temperature is sufficiently below the critical temperature. The ionic supra currents are identifiable as the observed quantal non-dissipative currents flowing through the cell membrane when tqc is not on.

Centrioles have their own genetic code realized in terms of RNA and they play key role during gene replication when DNA is out of the game. This encourages to think that micro-tubules make possible an independent tqc like process. The question is how micro-tubule-axon system could perform tqc assuming that the recent picture about DNA as tqc [O4] is roughly correct. The assumptions of the model relevant for the recent situation are following.

1. Flux tubes consists of pieces between standard plugs represented by hydrogen bond acceptors ($O =$, aromatic rings,...). For instance, $XYP$ molecules, $X = A, T, C, G$, $Y = M, D, T$ would represent standard plugs and that the transformation $XTP \rightarrow XDP + P_i$ represents the splitting of the flux tube and thus of braid strand. The XMPs associated with DNA would represent the ends of the braid strands. The formation of hydrogen bond between water molecule and $O =$ associated with phosphates at the hydrophilic ends of phospholipids would initiate tqc [O4].

2. In the model for protein folding [L9] free amino-acid corresponds to a codon $XYZ$ in the sense of wobble base pairing meaning that the third nucleotide corresponds to a quantum superposition of colors of nucleotides coding for the same amino-acid. Hydrogen bonds correspond flux tubes also and hydrogen bonds between $N - H$ and $O =$ groups in alpha helices and beta sheets mean a shortcut making it impossible to continue the flux tube from $O =$ further. Only the continuation of the flux tube through non-hydrogen bonded $O =$ acting as a plug is possible. $Y = Z$ rule holds true for the $O = -N - H$ hydrogen bonds and defines folding code. Inside proteins amino-acids correspond to code $YZ$ part of the codon $XYZ$ and inside alpha helices and beta sheets the flux tubes from DNA would end to amino-acids and for them one could have only braiding between DNA and tubulins. Only in the case of non-hydrogen bonded amino-acids the flux tube connection from DNA could continue to the lipid layer and only in this case one could have the generalization of DNA tqc with flux tubes connecting DNA via tubulins to the axonal lipid layer.

Taking this picture as a starting point one can consider several options. For two first options tubulins are basic units. For the third one DNA nucleotides and amino-acids would have this role.

Option I: Tubulins could be connected to the lipid layer of the axonal membrane by flux tubes and the melting of the axonal membrane would induce braiding during the propagation of nerve pulse. $\alpha$ tubulins are accompanied by stable GTPs analogous to single DNA nucleotide so that $\alpha$ tubulin could takes the role of DNA nucleotide with braid strands to lipids having only single color. Compared to DNA tqc this computation would represent much rougher resolution. $\beta$ tubulins are accompanied by unstable $GTP$s able to suffer a hydrolysis to $GDP$. Also this process would correspond to the splitting of flux tube but the connection to tqc remains unclear. One can imagine one/two connected flux tubes to lipid layer represents bit.

Option II: For some years ago I considered the possibility of a gel-sol-gel phase transition proceeding along the surface surface of the micro-tubuli, accompanying nerve pulse, perhaps inducing nerve pulse, and coding for long term sensory memories in terms of 13 13-bit sequences defined by the tubulin helices with bit represented as a conformation of micro-tubule. This hypothesis might be easily shown to be wrong on basis of the available experimental facts already now. Suppose however that this phase transition happens and that the braid strands do not continue from the micro-tubular surface to the cell nucleus. In this case the braiding could be induced by a gel-sol-gel transition accompanying and perhaps generating the nerve pulse at the micro-tubular level and inducing the disassembly of the microtubule to tubulins followed by re-assembly inducing the braiding. Also this braiding would contribute to tqc like process or at least to a memory storage by braiding and options I and II would provide the complete story.

Option III: What about the variant of DNA-membrane tqc for axons? In the model of DNA as tqc these flux tubes continue back to the nucleus or another nucleus: the flux tubes must be split at cell membrane during tqc and this splitting induces the required isolation from the external world during tqc. During nerve pulse the situation would be different and the flow of lipids in liquid phase could induce DNA-lipid layer braiding: the isolation could however fail now. Tqc would explain why the axon melts during nerve pulse.

There are objections against this option.

i) By previous argument only $Y$-codons of DNA and only non-hydrogen bonded $O=$s of aminoacids would contribute to the braid strands. This does not look nice.

ii) The idea about magnetic flux tubes emanating from DNA and flowing along micro-tubules interiors and radiating to the axonal membrane looks also ugly: in any case, this would not affect tqc and nerve pulse could be seen as a direct gene expression not conforming with the idea that microtubules define an independent computational system.

iii) One can wonder why also the magnetic flux tubes from DNA could not end to the space-time sheet of the cell exterior if they do so in the case of axon. The justification for 'No' (besides isolation) could be that also cell soma would possess standing soliton sequence like waves and standing nerve pulses in this kind of situation.

The following considerations do not depend on the option used.

1. What comes first in mind is that the braiding codes memories, with memories understood in TGD sense using the notion of 4-D brain: that is in terms of communications between brain geometrically now and brain in the geometric past. In standard neuroscience framework braiding of course cannot code for memories since it changes continually. Nerve pulse sequences would code for long term sensory memories in a time scale longer than millisecond and micro-tubular phase transition could have a fine structure coding for sensory data in time scales shorter than nerve pulse duration. The fact is that we are able to distinguish from each other stimuli whose temporal distance is much shorter than millisecond and this kind of coding could make this possible. Also the direct communication of the auditory (sensory) input using photons propagating along MEs parallel to axon could also explain this.

2. In the model of DNA as tqc nucleotides $A, T, C, G$ are coded into a 4-color of braid strand represented in terms of quarks $u, d$ and their antiquarks. An analogous coding need not be present also now: rather, all braid strands could have same color represented by $G$ of $GTP$. Tubulins could be seen as higher level modules consisting of order hundred 500 amino-acids. This corresponds to a DNA strand with length of about .5 $\mu$m corresponding to the p-adic length scale $L(163)$ which is one of the four magic p-adic length scales ($k = 151, 157, 163, 167$) which correspond to Gaussian Mersennes. This higher level language character of micro-tubular tqc programs would conform with the fact that only eukaryotes possess them.

3. Cellular cytoskeleton consists of micro-tubules. Could micro-tubular tqc -in either of the proposed forms- take place also at the cell soma level? Could DNA-nuclear membrane system define the primordial tqc and micro-tubular cytoskeleton-cell membrane system a higher level tqc that emerged together with the advent of the multicellulars? Is only the latter tqc performed at the multicellular level? The notions of super- and hypergenome encourage to think that both tqcs are performed in all length scales. One can imagine that ordinary cell membrane decomposes into regions above and below the critical point (the value of the critical temperature can be controlled. Those below it would be connected to DNA by flux tube bundles flowing inside the micro-tubular cylinders. Micro-tubular surfaces would in turn be connected to the regions above the critical point. One should also understand the role of $M_{13} = 2^{13} - 1$ 12-bit higher level "genetic code" assignable naturally to micro-tubules. For instance, could the bit of this code tell whether the module defined by the tubulin dimer strand bundle participates tqc or not?

#### Could Hodgkin-Huxley model provide a phenomenological description?

It is now clear that the physics behind Hodgkin-Huxley model is not consistent with the physics behind the TGD based model of nerve pulse. The cell as gel hypothesis excludes Hodkin-Huxley model even without any TGD based physics. If ionic currents were ordinary Ohmic currents as in the case of soliton model and Pollack's model, Hodgkin-Huxley model might be interpreted as a phenomenological description. In TGD framework the dark currents do not dissipate and the model can serve only a recipe to mimic the time evolution of the ionic currents by a judicious tailoring of the time dependence of ionic conductances.

The current associated with a given ion would be proportional to the sum of the electric forces experienced by the particle:

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

In the catastrophe theoretic variant of the Hodgkin-Huxley model [28], which assumes a wave ($Ca^{++}$ now) 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 vanishing of $g_{Na}$ at the resting value and down to the point, when nerve pulse is triggered, is assumed in Hodgkin-Huxley model and in the catastrophe theoretic model of the nerve pulse [28]. The vanishing of $g_{Na}$ codes for the absence of magnetic flux tubes in TGD framework.

### 2.4.4 Model for anesthetic action

The molecular mechanism of the anesthetic action is a fascinating unsolved problem of neurophysiology. Noble gases have very weak chemical interactions. Despite this many noble gas such as Xe, Kr, Ar but to my best knowledge not Ne and He, act as anaesthetics. Also chemically non-inert molecules have quite similar narcotic effect so that chemistry does not seem to matter as Hodgkin-Huxley model would predict.

#### Simplest model for the anesthetic action

It is known that the narcotic efficiency of anesthetics correlates with their solubility in lipids [45]. Anesthetics also reduce the melting temperature of the lipid layer. Strong pressure increases the melting temperature and it is known that high pressure brings consciousness back. Thus anesthetic molecules dissolved into the lipid membrane should hinder the generation of the nerve pulse somehow and liquid state of the axonal membrane could be the reason for this. The explanation of the soliton model for the anesthetic action [110, 109] is that the metabolic energy needed to generate an acoustic soliton becomes too high when axon is too high above the critical temperature.

To get a useful perspective note that also the problem why ordinary cell and neuronal soma outside axonal hillock do not allow action potentials is poorly understood. The obvious idea is that anesthetized axonal membrane (or at least axonal hillock) is just like the ordinary cell membrane. The model for DNA-cell membrane system as a topological quantum computer requires the liquid-crystal property of the lipid layers of the ordinary cell membrane and neuronal membrane outside axonal hillock. If this is the case, then liquid phase for axonal membrane implied by the anesthetic action would indeed make it more or less equivalent with the ordinary cell membrane. Therefore the question is why the liquid-crystal property of the ordinary cell membrane prevents the generation of the action potential.

1. Pollack's model [33] suggests that anesthetics could hinder the occurrence of the gel-sol phase transition for the peripheral cytoskeleton. Suppose that $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axon extends them to the axonal exterior and makes possible the influx of monovalent ions inducing gel-sol phase transition.

2. Suppose that the phase transition increasing $\hbar$ is induced by the reduction of the voltage over the axonal membrane (assume to be much smaller than cell potential) inducing almost vacuum property and quantum criticality. Somehow the presence of anesthetics would prevent this. Either the voltage over the membrane is increased in magnitude so that the flow of dark ionic currents to the membrane is not enough to induce quantum criticality or the flow of dark currents is completely prevented. The first option is more economical and could be tested by finding whether the voltage over the axonal membrane (membrane in a solid state) is considerably smaller than that over the ordinary cell membrane (membrane in liquid-crystal state). The first option also predicts that during sleep the increase of cell potential (hyperpolarization) actually corresponds to the increase of the membrane potential.

**Could cyclotron transitions of noble exotic ions in theta and delta bands induce lullaby effect?**

Just for fun can consider also more exotic explanation for the anesthetic action. If dark weak force is to have any biological role, the cellular environment should induce a generation of anomalous weak isospin due to the charged color bonds inside nuclei of noble gas. This would obviously relate closely to the anomalous properties of water explained in terms of dark matter hierarchy in [F9, J6]. The color bonds carry also em charge so that noble gas atom with single charged color bond would behave like an ion with nuclear charge Z+1 or Z-1 and electronically like ion with full electronic shell due to ionization (say $Cl^-$ or $K^+$ in the case of Argon). An important point is that the exotic ions are bosons and can form thermally stable Bose-Einstein cyclotron condensates at $k_d = 4$ flux sheets unlike ordinary ion with mass number differing by one unit.

An interesting question is whether some fraction of $Cl^-$ and $K^+$ ions are actually exotic Argon ions. Also the long ranged color force and dark weak force with range $L_w$=.2 $\mu$m associated with noble gas nuclei in dark phase could be part of the solution of the mystery.

EEG and ZEG bands above theta band correlate with consciousness. The cyclotron frequencies of ions of anaesthetic noble gases are in theta and delta band as are also EEG frequencies during various stages of sleep but for Ne and He this is not the case. This might not be a mere accident. For instance, one could imagine that the strong resonances in theta and delta bands in EEG induced by Xe, Kr, or A could steal the power otherwise going to higher EEG bands and induce a lullaby effect leading to anaesthesia. This effect of course does not exclude the proposed effect reducing the nerve pulse activity.

According to the general model of EEG [M3], the magnetic flux sheets traversing DNA double strands in cell nuclei come in two varieties corresponding to the two possible quantization of magnetic flux as $Z\int BdS = n\hbar(4)$. For $Z = 1$ the field strength is very near to $B_E$ and for $Z = 2$ to $B_E/2$, with $B_E = .2$ Gauss, the strength of endogenous magnetic field explaining the findings of Blackman and others. For instance, left and right brain hemispheres might correspond to $Z = 1$ and $Z = 2$ and the scale for cyclotron frequencies for right hemisphere would be half of that for left hemisphere. During sleep $Z = 2$ cyclotron frequencies are responsible for EEG via the interaction with Josephson junctions generating the satellites $f_c \pm f_J$ of these frequencies, $f_J = 5$ Hz for $Z = 2$ and $f_J = 2.5$ Hz for $Z = 1$.

The cyclotron frequencies of exotic ions $(Xe^+, Kr^+, Ar^+, Ne^+, He^+)$ are (2.15,3.57,7.5,15,75) Hz for $B = B_E$ and (1.08,1.78,3.75,7.5,37.5) Hz for $B = B_E/2$. It would be interesting to check whether EEG contains narrow bands around these frequencies during anesthesia. Also the satellites $f_\pm = f_c \pm f_J$, $f_J = 5$ Hz, could be present. For all noble gas anaesthetics Xe, Kr, and Ar both frequencies are below 7.5 Hz and thus in theta and delta bands. This would encourage to think that the presence of these bosonic exotic ions amplifies the EEG frequencies usually assigned with the theta and delta bands and in this manner induces anaesthesia.

If this is a correct interpretation then it would be essential that $K^+$ and $Cl^-$ are fermionic ions: otherwise a lullaby effect would result. Note that the exotic ions of Argon can mimic either $Cl^-$ and $K^+$. Besides producing the lullaby effect, this mimicry could change the effective concentrations of various ions so that large enough reduction of the resting potential could become impossible.

## 2.5 More speculative ideas about nerve pulse and EEG

In order to not frighten the reader I have collected the most speculative speculations about the possible role of charge entanglement and fractally scaled variants of weak interactions in the generation of nerve pulse to a this section. Reader has freedom decide whether to read it or skip to the next section.

### 2.5.1 Could scaled variants of weak bosons be key players in the model nerve pulse?

One of the basic predictions of classical TGD is the presence of long range weak and color forces. It took quite a long time to accept this and realize that TGD predicts fractal hierarchy of copies of weak and color physics and that these scaled variants might be crucial for the understanding of living matter and even nuclear and condensed matter physics.

I have done a considerable amount of work in trying to clarify whether this new physics might allow to understand the generation of nerve pulse. Nerve pulse is generated when the voltage over cell membrane is reduced from $\simeq .08$ V to a critical voltage $\simeq .05$ V. This means that Josephson frequency is also reduced. Josephson current generates EEG and ZEG patterns as coherent states or Bose-Einstein condensates of photons and $Z^0$ quanta. This raises the question whether the reduction of Josephson frequency characterizing these quanta could serve as a signal for cell nucleus to induce activities leading to the generation of nerve pulse so that nerve pulse would not be automatic response to the lowering of the resting potential below the critical level.

The basic problem is to understand how resting potential is reduced below the critical value .05 V. One can divide the mechanisms to three types depending on whether ordinary charge flow, reduction of charge entanglement, or exchange of virtual or real $W$ bosons is involved.

#### Both Em and $Z^0$ cyclotron BE condensates could be important

Besides em force also long ranged $Z^0$ and color fields generated by various levels of dark matter hierarchy could play an active role. Exotic weak bosons corresponding to p-adic length scale $k = 113$ and by a factor $2^{-12}$ lighter than ordinary weak bosons and their dark variants with same masses but Compton wave lengths $L_w(k_d)$ scaled up by a factor $\lambda^{k_d}$ are assumed to be present and explain besides the anomalous behavior of water also the large parity breaking effects such as chiral selection in living matter. $k_d = 1$ corresponds to $L_w(1) = 1$ Angstrom length scale and $k_d = 2$ corresponds to $L_w(2) = .2\ \mu$m.

The values of $k_d$ in weak sector and em sector are related by $k_d^W = k_d^{em} + 2$. This has important implications.

1. In a given length scale weak cyclotron time scale is by a factor $\lambda^2 \simeq 4 \times 10^6$ longer than corresponding em cyclotron time scale. Hence $Z^0$ cyclotron transitions are naturally involved with biological functions involving long time scales such as cognition whereas em cyclotron transitions are ideal for functions involving short time scales such as sensory perception which requires sharp time resolution.

   $k_d^{em} = 4$ would correspond to the length scale of magnetosphere and cyclotron frequencies in EEG range, most bosonic ions having them in alpha band. $k_d^W = 4$ corresponds to $L_w(4) = .8$ m, body length scale. ZEG is very similar to EEG. Thus em-$Z^0$ dichotomy would give additional support for the idea [N1] that magnetosphere and biological body have a rough fractal correspondence.

   $k_d^{em} = 4$ level corresponding to the length scale of Earth's magnetosphere. In this length scale $Z^0$ magnetic field $g_Z B_Z = eB$ would correspond to $k_d^W = 6$. The typical time scale .1 second for delta band of EEG would be scaled up by a factor $\lambda^2$ to a time scale of order year serving as a kind of drumbeat for the activities of everyday life.

2. $k_d^W = k_d^{em} + 2$ makes possible $Z^0$ cyclotron Bose-Einstein condensates in length scales shorter by a factor $\lambda^{-2}$ than in em case. Cooper pairs of exotic neutrinos coupling to $k = 113$ weak bosons are the most obvious candidates for bosons in question. Exotic nuclei obtained when some color bonds of nucleus containing quark and antiquark at its ends becomes charge $u\overline{d}$ or $d\overline{u}$ type bonds have both weak and em charge. Hence $Z^0$ cyclotron condensates could be of special importance for bio-control by structures having body length scale.

3. The requirement that the quantum model for hearing and memetic code is not lost, implies that exotic neutrinos correspond to $M_{127}$ and thus have mass near to that of electron. $k_d = 0$ cognitive neutrino pairs essential for the realization of memetic code can be realized as wormhole contacts with the light-like causal horizons associated with the throats of contact carrying quantum numbers of neutrino and antineutrino. The net energy of cognitive neutrino pairs can be very small or even vanish due to the strong $Z^0$ Coulombic interaction energy of the exotic neutrino with $Z^0$ charged exotic nuclei condensed at $k_d^W = 1$ level. The combined spin flips and cyclotron transitions of the cognitive neutrinos provide a possible mechanism to realize memetic code [J3, M6].

4. Dark $k_d = 1$ exotic neutrinos can topologically condense at the boundaries of $k_d = 2$ flux quanta of $Z^0$ magnetic field can give rise to neutrino boundary superconductivity by a mechanism similar to that of electronic high $T_c$ super-conductivity [J3]. In the interior of these flux quanta BCS type Cooper pairs are possible and the resulting two super-conductivities are competing at quantum criticality prevailing in some narrow temperature range for which 36-37 K is a good guess as in the case of also electronic high $T_c$ superconductivity.

   Exotic neutrino Cooper pairs (having possibly unit spin) condensed at $k_d = 2$ $Z^0$ magnetic flux sheets have for $k_d = 2$ cyclotron frequency $f_c \simeq 150$ Hz and cyclotron energy $E_c \sim 20eV$ for $Z^0$ magnetic field $g_Z B_Z = .1$ Tesla for which flux sheets would have thickness of 2.5 nm, thickness of DNA double strand if obtained by scaling down flux tubes of the endogenous magnetic field $B = .2$ Gauss Hence the cyclotron transitions of exotic neutrino Cooper pairs might be involved with biocontrol in time scale corresponding to 150 Hz.

   Josephson junctions would provide a realization of this control. Thermal stability predicts a minimal $Z^0$ Josephson voltage of about 86 mV very near to the resting voltage over cell membrane. Corresponding Josephson frequency for $k_d^W = 2$ would be in MHz range. Modulation of this MHz frequency amplitude by 150 Hz amplitude would give rise to $Z^0$ Josephson radiation and ZEG in MHz range with 150 Hz amplitude modulation.

**Generation of charge by a state function reduction of a charge entangled state**

MEs are ideal for control purposes since the field propagates with light velocity so that dispersion is absent and the field pattern is arbitrary as a function of time at a given point. Charged $W$ MEs make possible charge entanglement between Bose-Einstein condensate of ions at $(k_W, k_{em}) = (5, 3)$ magnetic body of neuron involving dark Josephson junction with thickness $40 + 40$ m and weak length scale $L_W(5) = 1.6$ km. Denote the charges of ions in their usual state by $Q_n$ and $Q_m$: the subscript refers to neuronal interior or magnetic body.

Charge entanglement means that cyclotron B-E condensates of ions with charges $Q_n$ and $Q_m$ develop exotic nuclear charges due to the transformation of $q\overline{q}$ color bonds to $u\overline{d}$ or $d\overline{u}$ type color bonds in the external $W$ field.

If only single charged color bond can be created, the entangled state is of form

$$|Q\rangle = a|Q_n\rangle|Q_m\rangle + b|Q_n + 1\rangle|Q_m - 1\rangle + c|Q_n - 1\rangle|Q_m + 1\rangle \qquad (2.5.1)$$

Since the classical $W$ field inducing the entanglement is real, one must have $|b|^2 = |c|^2$. One has $|b|^2 \propto |W|^2$ in the approximation that the transversal $W$ field associated with ME is constant inside neuron. $Ca^{++,+}$ and $Ca^{++,-}$ exotic ions are the most plausible option but their are also other options as Table 1 below shows. The reason for the preferred role of $Ca$ ions is that $Ca$ waves play a key role in bio-control in a wide range of time scales [20]. That they do not appear in the standard version of Hodgkin-Huxley model conforms with the assumption that they are in dark matter matter phase.

The quantum phase transition reducing the charged entanglement of the Bose-Einstein condensate leads with a probability $|b|^2$ to the state $|Q_n + 1\rangle|Q_m - 1\rangle$ so that the negative charge of the neuron interior is reduced. The rate for the state function reduction process is proportional to the intensity $|W|^2$ of $W$ boson field and $N^2$, $N$ the number of bosons in the condensate. The quantum randomness of the process is consistent with the randomness of nerve pulse emission.

If the resulting positive charge is large enough, membrane potential reduces below the value .05 V at which nerve pulse is generated. Only this option is consistent with the model allowing to understand how big leaps in evolution (molecular life, prokaryotes, eukaryotes, animal cells, neurons, EEG) correspond to the emergence of new levels in dark matter hierarchy.

#### Exchange of exotic $W$ bosons between cell interior and exterior

Exchange of exotic $k_d^W = 2$ $W^\pm$ with Compton length of $L_2 = .2$ meters allows charge exchange between charged particles at different sides of cell membrane. This charge transfer mechanism would be nonlocal and essentially quantal. Quite generally, the exchange of $W^\pm$ boson could provide a very general non-local mechanism of bio-control by inducing currents of em and weak currents through Josephson junctions. Em and $Z^0$ fields would in turn be associated with communication and coordination.

If Bose-Einstein condensates are in question the rate of this process is large due to its quantum coherence. There are several candidates for the Bose-Einstein condensates.

1. $k = 127$ exotic quarks inside nuclei couple to $k = 113$ $k_d^W = 1$ weak bosons and their dark variants associated with dark nuclei would couple to $k_d^W = 2$ W bosons. The problem is that the cyclotron energies of atoms are below the thermal threshold for $k_d^W = 2$ so that cyclotron Bose-Einstein condensates are not possible. One can of course consider the possibility that $k = 127$ quarks can appear as free particles in scaled up dark length hadron length scale and that also they or mesons formed by them form Cooper pair Bose-Einstein condensates.

2. $k_d^W = 2$ dark $k = 127$ neutrino Cooper pairs have cyclotron energies above thermal threshold for $g_Z B_Z = .05$ Tesla and are unique candidates in this respect. This transition would change exotic neutrinos to exotic (and dark) electrons coupling only to $k = 113$ weak bosons. Internal consistency suggests that they indeed exist and they might have essentially the same mass as ordinary electron. The decay widths of ordinary gauge bosons do not forbid a scenario in which all fundamental fermions exists as dark fermions with $k = 127$.

3. The exchange of exotic $W^\pm$ between $k_d = 2$ dark quarks of dark nuclei and exotic neutrino Cooper pairs ions or exotic electrons at different sides of cell membrane is one possibility. This mechanism induces exotic ionization and charging of nuclear or intramolecular color bonds. If the ions or molecules in question are bosons they can form Bose-Einstein condensates and this would allow the effect to occur coherently and thus increase its rate dramatically. It seems however that even for $g_Z B_Z = .05$ Tesla cyclotron states of exotic ions are thermally unstable for $k_d^W = 2$. This mechanism would however work at higher levels of dark matter hierarchy.

### 2.5.2 Some aspects of the model of nerve pulse based on charge entanglement

Charge entanglement induced by $W$ MEs seems to provide a highly plausible mechanism of quantum control with nerve pulse generation representing only a particular application of this mechanism. Therefore the following considerations are restricted to this case.

#### Quantum parallel dissipation and dissipative quantum computation

Already before the ideas about dark matter hierarchy the notion of self hierarchy led to the notion of hierarchy of quantum jumps with increasing average geometric durations assignable to quantum jumps [K1, K2]. Also the notion of quantum parallel dissipation occurring at levels below a given level of hierarchy emerged naturally. Dark matter hierarchy together with the p-adic hierarchy define naturally this kind of hierarchy. The descriptions of hadrons as quantum coherent systems on one hand, and in terms of quarks and gluons obeying dissipative dynamics governed by kinetic equations on the other hand, would represent one example of this hierarchy.

The charge entanglement generated by $W$ MEs during generation of nerve pulse would represent second example of quantum parallel dissipation. Ionic currents would flow already during the superposition of ordinary and exotically ionized Bose-Einstein condensates. These currents would correspond to the quantal currents discussed in the previous section made possible by the quantal generation of JABs (by Faraday law the voltage along space-time sheets at lower level of hierarchy is affected by the presence of exotic dark ions in the presence of JABs implying closed many-sheeted loops).

If this is the case, TGD would predict no deviations from Hodgkin-Huxley model except those brought by state function reduction and the fact that Ohmic currents are actually quantal currents. Ionic currents would start to flow in the geometric past and would be perceived only after the quantum jump reducing the state to an exotically ionized state would occur. Also ghostly nerve pulses and even patterns of them could be generated since state function reduction can also lead to the ordinary state. An interesting question is whether these ghostly nerve pulse patterns relate to imagination and whether they could make possible dissipative quantum computation (perhaps during sleep)[E9]. The naive expectation is that the probability that quantum jump does not occur during a given time interval decreases exponentially and that the dark time scale in question defines a typical duration for the entangled period.

### The role of $Ca^{+2}$ ions

$Ca^{+2}$ ions are perhaps the most important bosonic ions and their dark Bose-Einstein condensates are expected to be key actors in bio-control although also other bosonic ions are very probably involved (see Table 1 below). $Ca^{+2}$ waves are indeed central tool of bio-control and their velocities span a very wide range.

The model for nerve pulse led to a proposal that phase transitions increasing $\hbar$ and thus generating flux tubes between gel phase and its sol-like environment make possible the flow of mono-valent dark ions from the environment to the gel phase and induce gel-sol phase transition. The propagating gel-sol-gel phase transition would generate nerve pulse, and its fractally scaled variants corresponding to various values of $\hbar$ could generate $Ca^{++}$ waves accompanied by a periodic variation of em potentials. Also the miniature- and micro-potentials associated with the postsynaptic neuronal membrane could correspond to standing $Ca^{++}$ waves with an appropriate value of Planck constant.

A more speculative idea is that charge entanglement involving a periodically varying $W$ boson field could induce $Ca^{+2}$ waves by inducing the $\hbar$ increasing phase transition. The cautious prediction is that the most important time scales in question should come as $\lambda^k$, $\lambda = 2^{11}$ multiples of p-adic time scales. The propagation with a finite velocity could correspond to the motion of the second end of $W$ boson ME along tissue or to a phase of $W$ field varying in a direction transversal to the light-like wave vector assignable with $W$ ME.

| Ion | $f_1/Hz$ | $E_1/eV$ |
|---|---|---|
| $^6Li^+$ | 50.1 | 3.3 |
| $^{24}Mg^{2+}$ | 25.0 | 1.65 |
| $^{16}O^{2-}$ | 37.6 | 2.48 |
| $^{32}S^{2-}$ | 18.8 | 1.24 |
| $^{40}Ca^{2+}$ | 15.0 | .99 |
| $^{55}Mn^{2+}$ | 11.4 | .75 |
| $^{56}Fe^{2+}$ | 10.8 | .71 |
| $^{59}Co^{2+}$ | 10.0 | .66 |
| $^{64}Zn^{2+}$ | 9.4 | .62 |
| $^{80}Se^{2-}$ | 7.6 | .5 |

Table 1. The first columns give the cyclotron frequencies and cyclotron energies for biologically relevant bosonic ions in endogenous magnetic field assumed to have strength $.2 \times 10^{-4}$ Tesla. The third column gives cyclotron energy.

*1. Is nerve pulse conduction accompanied by the propagation of $Ca^{++}$ wave?*

Hodgkin-Huxley model introduces the velocity of conduction of nerve pulse in a rather ad hoc manner. To my limited knowledge the mechanism behind the finite velocity of conduction of nerve pulse remains poorly understood. In the catastrophe theoretic model of the nerve pulse [28] an unidentified wave triggering nerve pulse is assumed for purely mathematical reasons. $Ca^{++}$ waves as waves guiding the propagation of nerve pulse are a natural guess in this respect. $W$ MEs associated with nerve pulse transversal to axon could extend along its entire length and the variation of the phase of $W$ ME in transversal direction could induce $Ca^{++}$ wave in turn inducing the conduction of nerve pulse with a finite velocity.

One can of course wonder whether the observed $\mathrm{Ca}^{++}$ waves can really relate to entanglement oscillations of dark matter Bose-Einstein condensate. This depends on how direct the detection of the waves is: certainly the indirect detection of dark ions based on Faraday effect is possible. Note that $Ca^{+2}$ BE condensate behaves like dark matter is consistent with the fact that $Ca^{+2}$ conductance need not be taken account in the simplest variant of Hodgkin-Huxley model.

*2. $Ca^{++}$ waves and synaptic contact*

The action potential is known to trigger the transfer of $\mathrm{Ca}^{+2}$ ions into the presynaptic terminal and the presence of $\mathrm{Ca}^{+2}$ ions is essential for the emission of the neurotransmitters. The synaptic vesicles containing neuro-transmitters fuse with the presynaptic membrane and neurotransmitters are released. Neuro-transmitters bind to the postsynaptic proteins in the postsynaptic membrane changing their conformation, which in turns leads to ion flows and the generation of micro–potentials 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 [23].

The most natural interpretation for what happens in synaptic contact is that nerve pulse patterns are transformed to chemical qualia analogous to tastes and odors and that every synapse is specialized to generate particular kind of chemical qualia. These qualia need not be our chemical qualia which in TGD framework are assignable to the primary sensory organs. Neuronal sensory qualia could at our level of hierarchy give rise to emotions. These qualia are shared by the magnetic body ($(k_W, k_{em}) = (5, 3)$ level of dark matter hierarchy). Charge entanglement for subsystems is the TGD based manner to achieve the sharing of mental images and this bring in $Ca^{++}$ and $Ca^{++,\pm}$ B-E condensates.

*3. Other functions of $Ca^{++}$ waves*

$\mathrm{Ca}^{+2}$ currents are also related to the conformational changes of proteins, in particular microtubules, and are believed to be somehow involved with the delocalization of electrons. $\mathrm{Ca}^{+2}$ ions are also involved with GTP-GDP hydrolysis. Probably rather low level of dark matter hierarchy is in question in both cases.

Besides this $\mathrm{Ca}^{+2}$ ions are involved with 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 $\mathrm{Ca}^{+2}$ cyclotron frequency determine the rates and that the process is quantum controlled by EEG and WEG and corresponds to $k_W = 6$ level of dark matter hierarchy.

### 2.5.3 Could cognitive fermion pairs accompany the nerve pulse?

Cognitive neutrino pairs and memetic code words defined by them are the cornerstone of TGD based quantum model of hearing [M6] but the question whether this model really makes sense has remained without answer. Note however that if one accepts the role of exotic $W$ bosons, one cannot exclude cognitive neutrino pairs with interaction range longer than cell membrane thickness.

This highly speculative model whose history is as tortuous as that of nerve pulse model has several variants. Cognitive neutrino pairs could be actually replaced with any wormhole contact involving pair of fermion and antifermion. Only the large $Z^0$ interaction energy of neutrino wormhole throat making the net rest energy of the pair very small gives cognitive cognitive neutrino pair a preferred position.

An additional support for the notion of wormhole contact has emerged quite recently from the model of DNA as topological quantum computer [O4]. The wormhole contacts carrying quark and anti-quark at their throats and located at the ends of wormhole magnetic flux tubes are the key element in the model of DNA as topological quantum computer and lead to a large number of precise predictions about DNA itself (note that gauge bosons quite generally correspond to wormhole contact like structures).

The question which has remained without a satisfactory answer is whether and how nerve pulse generation could induce the generation of memetic code words as temporal sequences of zero energy cognitive neutrino (fermion) pairs. In this representation the existence of fermion would signify "yes" and its absence "no". For an alternative realization the spin of fermion signifies the two different truth values. The following argument suggests that the model of nerve pulse generation based on $W$ exchange might provide the answer.

The p-adic length scale associated with $k_d^W = 2$ space-time sheet must be shorter than $L_2(2) = .2$ $\mu$m. This leaves only $L(k = 157) = 80$ nm into consideration. If cell interior and exterior space-time sheets are disjoint, wormhole contacts mediating the em and weak gauge fluxes to other space-time sheets must be formed. Em gauge flux must be transferred to a larger space-time sheet.

Weak flux could be transferred also to a smaller space-time sheet, say $k_d^W = 1$ space-time sheet of $k = 113$ weak boson corresponding to $k(eff) = 135$. This flux is not conserved at this space-time sheet in length scales longer than $L(135)$. This wormhole contact would be identifiable as a fermion cognitive pair. The presence of kHz frequency assignable to .05 Tesla $Z^0$ gauge field at $k_d^W = 4$ and $k_d^{em} = 4$ levels would divide the time axis into bits. This would allow to realize memetic code in its original version in which the presence of fermion, say neutrino, corresponds to "yes" and its absence "no", and nerve pulse sequence would be automatically coded to a sequence of bits represented by the presence/absence of cognitive fermion pair.

## 2.6 Many-sheeted neuron

TGD approach allows to make educated guesses concerning the interpretation of various phenomena in neuronal level. This section has been written much before the input from DNA as tqc and the realization that microtubule-cell membrane braids could serve as quantal sensory memory storage based on the braiding of the magnetic flux tubes emanating from the aminoacids of tubulin molecules. This implies obvious updatings of the text of this section left to the reader.

### 2.6.1 Neuronal consciousness

The fractality of consciousness encourages the view that neurons and corresponding magnetic bodies 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 sub-self 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 pre-synaptic neurons. Postsynaptic receptors are analogs of ordinary sensory receptors and they determine the sensory qualia and primary sensory mental images of the neuron about external world (also ordinary cells have sensory receptors and sensory representations but only about nearby environment). Micro-tubuli 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 and hear at some wave length ranges and the micro-tubuli 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 micro-meter, one finds that frequencies involved are above $10^5$ Hz. $k_{em} = 3$ level of hierarchy of Josephson junctions would correspond to $10^4$ Hz frequency as Josephson frequency having 5 Hz frequency as EEG counterpart.

The counterpart for .5 Hz frequency scale of DNA sequences assigned to right hemisphere neuronal nuclei at $k_{em} = 4$ level of dark matter hierarchy would correspond to 1 kHz frequency at the level of neurons. Also neuronal membrane can give rise to sensory representations as probably does also 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.

### 2.6.2 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.

#### 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?

1. 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.

2. 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 mediated by $Z^0$ 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 output, 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 sub-self wakes up sub-self by nerve pulse patterns and is experienced by a higher level self as two subsequent mental images.

#### Could nerve pulse patterns realize the memetic code?

TGD based model of cognition allows to construct a model for memetic code in which sequences 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 [L1] 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 consciously 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 [L1, M6].

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

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

2. The prediction would be that high level linguistic cognition is everywhere in brain. Rather, higher level cognition should be associated with the neurons at multi-modal associative regions of cortex [L1] 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.

3. 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.

#### Generation of declarative long term memories at micro-tubular level

The TGD based model of declarative long term memories is based on the mirror mechanism with brain and body effectively serving as time like mirrors from which negative energy MEs are reflected as positive energy MEs. Long term memories are coded to subjecto-temporal changes of the micro-tubular conformations [K2] which allow a huge number of almost degenerate configurations, and the transitions between these configurations generate $Z^0$ MEs (or equivalently, gravitonic MEs) with ultra-low 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 micro-tubuli in the spin glass energy landscape. Nerve pulse could be also accompanied by a separate wave propagating along the axonal micro-tubuli 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 micro-tubuli is discussed in [H8]. 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 micro-tubular 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 micro-tubule would imply that the change of bit is replaced with a pattern of $b \rightarrow b+1 \rightarrow b$ transitions leading from the ground state to excited state and back to the ground state.

An interesting possibility is that micro-tubuli 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 micro-tubular conformation patterns could be coded to $2^{126}$ memetic codons represented by field patterns associated with MEs. The $64 \rightarrow 21$ correspondence for DNAs and aminoacids would be generalized to $2^{169}-1 \rightarrow 2^{127}-1$ 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 micro-tubular code.

### 2.6.3 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.

#### 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 neuro-modulation could indeed be carried out in much simpler manner?

1. 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.

2. When information molecules and receptors form a quantum bound state, macro-temporal quantum coherence is generated and this correspond at the level of conscious experience a multi-verse state of 'one-ness' and from the point of information processing a quantum computation like process [K2]. 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. Micro-tubuli indeed give rise to infrared vision in the case of bacterial cells.

3. This picture is consistent with the interpretation of neurotransmitter induced experiences as kind of chemical qualia analogous to tastes and odors and giving rise to emotions at our level of self hierarchy.

#### 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 [29]. 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 bio-control 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 paradoxical looking findings about the correlation of inhibition with the level of self control. The amount of inhibition increases and the behavior 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 consciousness 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 synesthetics 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 post-modern society.

## 2.7 A model for the effective electronic super-conductivity in axons

Also the following model for axonal electronic super-conductivity was constructed before the progress induced by the model of DNA as tqc and the inspiration coming from the model of nerve pulse by Danish researches [109] and is not completely consistent with the new model. I however decided to keep the text because it reflects the development of ideas and with a reasonable amount of work could be modified to the new situation.

Hafedh Abdelmelek and collaborators [67] have found evidence for effective super-conductivity 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 $\Delta T$, $\Delta T/T_c \sim .04$. 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 poikilotherms (say frog) to endotherms (say rabbit).

These findings seem to be consistent with the following view.

1. 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 [M4]. 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.

2. 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.

3. Poikilotherms 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.

The recent model for nerve pulse generation favors somewhat different view. The melting temperatures $T_m$ of the axon and microtubular surface and quantum critical temperature $T_c$ of high $T_c$ super-conductivity are the critical parameters. The generation of the nerve pulse is possible only if $T$ is slightly above $T_m$. $T_m$ can vary in a wide range and can be controlled genetically. Same could be true for $T_c$ since external perturbations amplified by quantum criticality are expected to affect it. This would explain different values of $T_c$ for poikilotherms and endotherms. The critical temperature for super-conductivity would pose only an upper bound for the temperatures at which organisms can survive whereas quantum criticality of various membranes would constrain this temperature to a narrow range.

### 2.7.1 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

$$L(k) = 2^{(k-151)/2} \times L(151) \ , \tag{2.7.1}$$

$L(151) \simeq 10$ 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

$$T(k) \ = \ n \times E_0(k) = n \times n_1 \times \frac{\pi^2}{2ML^2(k)} \ , \tag{2.7.2}$$

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.

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

The model for bio-superconductivity and its breaking relies on the following picture.

1. Magnetic flux tubes of Earth's magnetic field (in particular) characterized by $k = 169$ and having a minimal thickness about 5 $\mu$m correspond to tubular space-time sheets. The magnetic flux

tubes of endogenous magnetic field $B = .2$ with $n = 5$ characterizing the value of the scaled up Planck constant $\hbar = n\hbar_0$ [A9] and the unit $nh_0$ of magnetic field magnetic flux and $k = 169$ characterizing the p-adic length scale define second option consistent with the identification of 15 Hz as cyclotron frequency of $Ca^{++}$. In this case the value of magnetic flux is $2h_5$ and the scaled down magnetic field $B_{end}/2$ required by the sleep time EEG would correspond to single flux quantum. Flux tubes would have thickness of about 25 $\mu$m corresponding to a size of a large neuron.

In the absence of both larger and smaller space-time sheets, the flux quanta 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 $k = 167, 163, ...$ as especially interesting candidate since $k = 151, 157, 163, 167$ define Gaussian Mersennes $(1+i)^k-1$. 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.

2. 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 super-conductor in the sense that Cooper pairs are not destroyed in the breaking of super-conductivity 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

$$T > nE_0(k) \quad = \quad T(k) \ . \qquad (2.7.3)$$

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.

3. 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 $k = 169 \rightarrow 167 \rightarrow 163 \rightarrow 157 \rightarrow 151 \rightarrow ....$ The behavior 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 $\mu$m [J1, J2].

4. For a space-time sheet having $k = k_0$, the leakage of supra-current 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.

5. The strange findings indicating that DNA can behave like a super-conductor [31], an ohmic conductor [27], 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.

### 2.7.3 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

$$E_0(k) - E(k_>) < T < E_0(k_<) - E(k) \ ,$$
$$E_0(k) = n_1 \times \frac{\pi^2}{4m_eL^2(k)} \ , \qquad (2.7.4)$$

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: $k = 169 \rightarrow 167 \rightarrow 163 \rightarrow 157 \rightarrow 151 \rightarrow ....$ 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 $\Delta T$: $\Delta T/T \sim .04$.

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

$$\begin{aligned} F &= K(k)v \ , \\ K(k) &= \sum_{k_i>k} \kappa(k_i) = \kappa(k_>) + K(k_>) \ . \end{aligned} \qquad (2.7.5)$$

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

$$\frac{1}{\sigma(k)} = \frac{K(k)}{nq} = \frac{\kappa(k_>)}{nq} + \frac{1}{\sigma(k_>)} \ . \qquad (2.7.6)$$

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

$$K(k) \propto \frac{1}{L^\alpha(k)} \propto 2^{-\alpha k/2} \qquad (2.7.7)$$

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

$$\frac{\sigma(151)}{\sigma(157)} \simeq 1/8 - 1/64 \simeq .11 \qquad (2.7.8)$$

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.

### 2.7.4 Application at axonal level

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

#### 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. 2.7.4

$$E_0(k = 151) = n_1 \times 312.25 \ \text{K} \ . \tag{2.7.9}$$

$n_1$ 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 [M4] 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.

#### Predictions for the critical temperature and resistance

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

1. 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 [28]. 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.

2. The observation that DNA attached between carbon and rhenium electrodes becomes super-conducting below the critical temperature of about 1 K for rhenium [31] 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.

3. 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

$$\frac{L(frog)}{L(rabbit)} = \sqrt{\frac{T(rabbit)}{T(frog)}} = \sqrt{5/4} = 1.12 \tag{2.7.10}$$

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

4. A further prediction following from the fractal model for the conductance (Eq. 2.7.7) 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.

**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 [M4], 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.

1. 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.

2. 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. Note that the critical temperature in myelin sheathed regions could be higher than the physiological temperature. The endogenous magnetic field $B = .2$ Gauss suggested by the work of Blackman and others corresponds to a flux tube radius $L = sqrt5/2 \times L(169) \simeq 1.58L(169)$. $nL(167)$ with $n = F_0 = 3$ would give $L = 1.5L(169)$. $k = 167$ in turn corresponds to Gaussian Mersenne $(1+i)^k - 1$, $k = 167$. If one scales only in one direction then the scaling factor is $5/2$ and $5L(167)$ would give the correct result. $n = 5$ corresponds the minimum value of $n$ making possible topological quantum computation [E9].

It is interesting to notice that Evan Harris Walker [69] has developed a quantitative theory in which the tunnelling 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 tunnelling 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.

## 2.8 Relating the model of nerve pulse with the micro-tubular level

The relationship of the presumed quantum dynamics of the cell interior to the nerve pulse is the basic topic of quantum consciousness theories. Micro-tubular conformational dynamics; gel-sol phase transition of the cytoplasmic water inducing the depolymerization of the actin polymers; the parallelization of micro-tubuli 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 [70] 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 ions and Cooper pairs at various cold space-time sheets. The classical article of Nanopoulos summarizing basic facts and various ideas about micro-tubuli [63] has been a continual source of information and inspiration and is warmly recommended.

One important element are negative energy IR MEs having phase conjugate laser beams [19] as physical counterparts. First of all, they make possible intentional action at the micro-tubular level:

even the TGD based model of mRNA-protein translation involves intentional aspects. Negative energy MEs are crucial for the understanding of the macro-temporal 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 micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions and thus define fundamental micro-tubular representation of declarative long term memories.

The vision about dark matter hierarchy brings in perhaps the most decisive new elements.

1. Dark matter hierarchy leads to the identification of big leaps of evolution in terms of the emergence of new levels of dark matter hierarchy. Magnetic bodies are the intentional agents in this picture and it is possible to understand the control of logistics and declarative memory as basic functions associated with micro-tubules.

2. Synchronous neuron firing involves parallelization of microtubules. This coherent action can be understood in terms of macroscopic quantum coherence realized in terms of super-genes and the more general notion of multi-neuron with neurons organized to linear structures analogous to the lines of text on the pages of book defined by magnetic flux sheets.

3. $Ca^{++}$ and $Mg^{++}$ ions are known to be important for the depolymerization of microtubules and actin molecules occurring during nerve pulse. This conforms with the central role of the Bose-Einstein condensates of dark bosonic ions $Ca^{++}$ and $Mg^{++}$ and their exotically ionized counterparts in the generation of pulse in the proposed model, and more generally, in quantum bio-control based on charge entanglement between cell and magnetic body.

4. The ordered water associated with gel phase was earlier modelled in terms of dropping of protons to $k = 139$ space-time sheets. In the new framework this phase can be identified as a partially dark water. The response of cells to IR radiation is maximal at photon energy .1 eV. What makes bells ringing is that the model of high $T_c$ conductivity based on dark matter hierarchy leads to the identification of the cell membrane as a Josephson junction generating ordinary IR photons with energy $2eV = .1$ eV at the membrane potential corresponding to threshold for nerve pulse generation kicking protons to $k = 139$ space-time sheet associated with ordered water.

This section was written much before the breakthrough induced by the model of DNA as tqc and the inspiration coming from the model of nerve pulse as acoustic soliton by Danish researchers [109]. Hence a lot is lacking and the contents of section are not necessarily completely consistent with the new vision. For instance, the phase transitions changing the value of $\hbar$ and tqc using 4-colored braids provide a general explanation for the selectivity of the catalytic action [O4]. I have however decided to leave the section as it is.

### 2.8.1 Dark matter hierarchy and big leaps in evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

There are two hierarchies involved with the dark matter hierarchy. The dark levels associated with weak bosons for which $k_W = 1$ corresponds to the p-adic length scale about $L_W(1) \sim 1$ Angstrom with exotic weak bosons corresponding to $k = 113$ (rather than $k = 89$ as for ordinary weak bosons). There is also electromagnetic dark hierarchy and in a given length scale one has $k_W = k_{em} + 2$. In a given scale weak sector would be ahead in evolution by two units so that weak dark bosons can be associated with more abstract functions like cognition and planning whereas em level would be related to simpler functions.

Ordinary matter corresponds to $k_W = k_{em} = 0$ and ordinary value of $\hbar$ and higher levels correspond to scaled up values of $\hbar$ with scalings $\lambda^k$, $\lambda \sim 2^{11}$. This mean scaling up of various quantum length scales and also the sizes of space-time sheets by $\lambda$. It seems that magnetic flux quanta are the primary structures forming hierarchy of this kind and large $\hbar$ means that cyclotron energy scales expressible as $E = \hbar(k)eB/m \propto \lambda$ so that an arbitrarily weak magnetic field strength can in principle correspond to a cyclotron energy above thermal threshold at room temperature.

The appearance of space-time sheets zoomed up in size by a power of $\lambda$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of scaling of $\hbar$ by $\lambda$ and emergence of new large magnetic flux sheets satisfying magnetic flux quantization condition with the unit of flux scaled up by $\lambda$. This leap is quantum leap but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by $\lambda$ as the new level of dark matter hierarchy emerges.

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a detailed vision about big evolutionary leaps.

*1. Molecular life*

Magnetic body with $(k_W, k_{em}) = (1, 0)$ corresponds to the lowest level of hierarchy with the size of the basic structures corresponding to atomic length scale. The anomalous properties of water would be partly due to the presence of this level. At least the simplest bio-molecules regarded as living organisms would correspond to this level.

*2. The emergence of prokaryotes as simplest membrane bounded structures*

At $(k_W, k_{em}) = (2, 0)$ level high $T_c$ superconductivity predicting the basic length scales characterizing the double layered cell membrane, the size scale of the cell, and the weak length scale $L_w(2) \simeq .3$ $\mu$m. Prokaryotic cells (bacteria, archea) without cell nucleus and other cell organelles would correspond to this level. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes in this framework. Also viruses and nannobacteria could correspond to this level of hierarchy. Cell membrane is responsible for metabolic functions and genome is scattered around the cell at this stage.

*2. The emergence of cells having organelles*

The appearance of magnetic bodies with $(k_W, k_{em}) = (3, 1)$ correlate with the emergence of simple eukaryotic cells, in particular plant cells. Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles plus would form a symbiosis by topologically condensing to $(k_W, k_{em}) = (3, 1)$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. The interpretation would be that they are also life forms and magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Cntriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtubules. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. This means that there is no need for static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on coherent photons and weak bosons of generalized EEG associate with the level of dark matter hierarchy in question. The mysterious bio-photons could be decay products of dark photons resulting via de-coherence meaning that the size of the dark photons is reduced in stepwise manner by factor $1/\lambda$ in single step.

*3. The emergence of organs and animals*

The emergence of magnetic bodies with $(k_W, k_{em}) = (4, 2)$ leads to the formation of multicellular animals. Magnetic body at this level gives rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures formed from centrosomes and corresponding microtubules make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

*4. The emergence of nervous system*

$(k_W, k_{em}) = (5, 3)$ magnetic body makes possible nervous system. The period of Josephson oscillations associated with the scaled up variant of cell membrane is about 10 kHz and is consistent with the characteristic millisecond time scale of nerve pulse activity. Nerve pulse reception involves communication to the magnetic body via receptors of the neuronal membrane and the reaction of the magnetic body possibly generating a nerve pulse sequence. Charge entanglement made possible by $W$ MEs makes possible nerve pulse generation as a quantum coherent process.

The emergence of the new level means also the integration of axonal microtobuli to text lines at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

*5. The emergence of vertebrates and EEG*

$(k_W, k_{em}) = (6, 4)$ magnetic body would bring in EEG possessed by vertebrates and also ZEG and WEG. Magnetic body is now of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and basic building blocks of our sensory experience correspond to a fundamental period of .1 seconds.

*6. Cultural evolution*

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the genes involved. The development of speech faculty is certainly a necessary prerequisite for this breakthrough.

### 2.8.2 Some TGD inspired new ideas about biochemistry

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 pre-biotic evolution [L4]. 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.

### 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 pre-biotic evolution rather than as an outcome of a long molecular evolution [L4]. 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 process. 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 [70] is an interesting application of this notion.

1. 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 transformation involving the dropping of a proton to a larger space-time sheet.

2. The fact that F-actin polymerization does not require energy [70] 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.

3. 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. Micro-tubuli 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 super-conductivity 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 [32]. 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 micro-wave 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.

### Liquid crystal phase of water as a stabilizer of biopolymers

The second key element is the understanding of the role of the liquid crystal [22] water in the stabilization of various bio-polymers. 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 concentration, of reducing water activity have a stabilizing effect) are frozen to the liquid crystal. Thus the control at the level of bio-polymers 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.

### What distinguishes between sol and gel phases?

Sol-gel transition is crucial for the polymerization of actin molecules and micro-tubuli, 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 whose value varies roughly in the range .4-.5 eV). For protonic Cooper pairs the energy would be .05 eV. According to the findings of Albrecht-Buehler [46], the response of cells to IR radiation at .1 eV photon energy is maximal.

The presence of protonic Bose-Einstein condensate at $k = 139$ space-time sheet might thus distinguish between the liquid-crystalline gel phase from 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 proton would bind the water molecules to form this structure. Ordinary water would result when protons 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.

This phase could be interpreted in terms of the partially dark water whose existence is suggested by the empirical finding that the chemical formula of water seems to be $H_{1.5}O$ in attosecond scale in the sense that neutron diffraction and electron scattering see only 1.5 protons per oxygen molecule [75, 76, 77, 78]. As proposed in [F9], every fourth proton would be in $(k_W, k_{em}) = (1, 0)$ dark phase, the lowest dark matter phase and protons would form string like structure which could be regarded as scaled up nuclei consisting of protons (also ordinary nuclei correspond to nuclear strings in TGD framework and exotic $k = 127$ quarks play a key role in the model [F8]).

Attosecond suggests itself as the scale for the average time $T_d$ spent by proton in dark phase in this case. In ordered water the lifetime of this phase might be considerably longer. If a dark variant of $k = 139$ space-time sheet is in question, $T_d$ is scaled up by a factor $\lambda^n$, $\lambda \simeq 2^{11}$. Zero point kinetic energy and the energy of photons would remain invariant with photon wavelength scaled up by $\lambda^n$, making possible quantum coherent control in multi-neuron length scale.

### IR radiation as a stabilizer of gel phase?

The model for the effective electronic super-conductivity generalizes to the case protonic Cooper pairs and ionic 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 photons 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 photons 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.

Note that the gel-sol transition of the peripheral cytoskeleton assumed to occur during nerve pulse would rely on different different mechanism. $Ca^{++}$ ions act as cross links between actin molecules and the lengthening of the cytoskeleton-membrane flux tubes in $\hbar$ increasing phase transition makes possible the flow of dark monovalent ions from cell exterior to peripheral cytoskeleton and induces gel-sol phase transition. This phase transition is initiated with the voltage over membrane is reduced to very small value inducing quantum criticality. The proposal is that dark ionic currents from microtubules to axonal membrane induces this reduction.

One can of course ask whether the mere influx of monovalent ions is enough to induce the gel-sol phase transition in the required millisecond time scale. The reduction of cell potential to about .05 V, quite near to the value inducing action potential, implies that the photons of Josephson radiation have energy .05 eV. At this energy a resonant absorption of phase conjugate IR photons by the peripheral cytoskeleton inducing in turn the dropping protons to larger space-time sheet could induce the gel-sol transition.

### Cell membrane Josephson junction as a generator IR coherent light

What is then the mechanism generating IR MEs acting as space-time correlates for coherent IR photons? The crucial observation is that the Josephson energy $E_J = ZeV$ for $Z = 2$ for cell membrane Josephson junction is .1 eV at threshold $V = 50$ mV for nerve pulse generation. The value of the metabolic energy quantum varies in certain range and the value .13 eV for the resting potential 65 mV would correspond to .052 eV metabolic quantum. Hence Josephson radiation could take care of kicking protons back to $k = 139$ space-time sheet thus stabilizing gel phase above the threshold for nerve pulse generation. The IR photons generated by Josephson current tend to propagate parallel to the axon and axon could act as a waveguide. When nerve pulse is generated at axonal hillock the frequencies of Josephson radiation are reduced below the threshold allowing stability of gel phase in region near axonal hillock and gel-sol transition should occur.

During nerve pulse the Josephson frequency varies in a wide range and has also negative values during the period when membrane voltage is positive (below 35 meV). A possible interpretation is that a phase conjugate IR radiation with energies $|E| < .07$ eV is generated. These photons could draw protons to large space-time sheet but with kinetic energy $E_0 - E$ rather than at rest.

The scaled up variants of IR photons at higher levels of dark matter hierarchy de-cohering into ordinary IR photons could make possible coherent quantum control in length scales given by $\lambda^n \times \lambda_{IR}$. For instance, EEG photons with frequency of about 5 Hz would correspond to the large $\hbar$ variants of IR photons with the same energy.

### What happens in gel-sol phase transition?

The minimal model for the gel-sol transition could be following. When the membrane potential falls below the threshold value, Josephson radiation does not take anymore care of the stability of gel phase in the zone in the radiation zone directed parallel to the axon and gel-sol phase transition is generated in cellular water. The gel-sol transition occurs also at the level of micro-tubules and destabilizes them unless they take care of themselves by generating negative energy IR radiation received by cellular water. This might quite well occur.

### How $Ca^{+2}$ ions are involved with gel-sol phase transition?

Besides IR MEs also $Ca^{+2}$ ions are involved with the gel-sol transition and if these ions act as cross links between proteins in gel, their role can be understood. $Ca^{+2}$ waves are indeed known to be a fundamental cellular control mechanism. $Ca^{+2}$ ions are known to induce a depolymerization of micro-tubules even in micro-molar concentrations whereas $Mg^{+2}$ ions having much smaller ionic radius are known to favor the polymerization of the actin molecules [70]. $Ca^{+2}$ 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. 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 $k = 139$ space-time sheets by repelling the protons from $k = 139$ space-time sheets to larger space-time sheets. This could mean gel-sol phase transition and the transformation of ordered water to ordinary water and the increase in 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 depolymerization rate. 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.

Bose-Einstein condensates of bosonic ions are key element of the proposed quantum control mechanism involving charge entanglement induced by $W$ MEs connecting magnetic body and cell interior or exterior. The question is whether depolymerization involves the charge entanglement of $Ca^{++}$ and $Mg^{++}$ ions. One could argue whether the low amount of $Ca^{++}$ ($Mg^{++}$) in cell interior (exterior) actually means that most of $Ca^{++}$ ($Mg^{++}$) ions are in dark phase in cell interior (exterior). If so then at least sol-gel phase transition would be initiated by Josephson radiation and only at the later stages as $Ca^{++}$ rush into neuronal interior $Ca^{++}$ take the lead.

### 2.8.3 Nerve pulses and microtubules

As an application of above general view one can consider a model for what might happen during the nerve pulse inside axon and neuronal soma (this time interval can be as long as .5 seconds). The known pieces of information [70] indeed fit nicely with the above general principles and one ends up with the following scenario. Note again that this scenario has not been updated to correspond to the most recent view about nerve pulse.

#### Propagating sol-gel transitions as representations of declarative memories

The propagation of nerve pulse along axon means a propagation of gel-sol-gel phase transition along microtubule. Declarative long term memories could correspond to the temporal sequences of nerve pulses represented as propagating gel-sol-gel phase transitions. The representation of memories would be rather rough as compared to the capacity of microtubular conformations to represent bits: for a conduction velocity $v = 10$ m/s and duration of pulse about 1 ms single pulse would correspond to an axonal length of $10^{-5}$ meters meaning that $10^3$ conformational bits would lumped to single bit. Dark matter hierarchy suggests the existence of a more precise representation at $k_{em} = 2$ level: the duration of the scaled down nerve pulse would be about .5 $\mu$s which for $v = 5$ m/s would correspond to a length 10 nm giving the size scale of tubulin dimer.

#### What happens inside neuron soma as nerve pulse is generated?

Consider first what could happen inside neuronal soma as nerve pulse is generated.

1. The positive energy Josephson radiation at IR frequency generated by cell membrane Josephson junction ceases temporarily and induces gel-sol transition in cellular water. $Ca^{+2}$ ions flowing into the neuronal interior favor further the depolymerization of actin molecules. The microtubules of cytoskeleton receive the stabilizing IR radiation still from parts of neuronal membrane other than the throat of axon. They can also take care of themselves by sending phase conjugate IR radiation received by cellular ordered water.

2. The hydration of actin molecules in the vicinity of axonal hillock 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 micro-tubuli from the cell membrane. The micro-tubuli are now free to change their conformations and the micro-tubuli associated with different cells can arrange themselves in parallel configurations temporarily. Therefore they could act as quantum antennas generating 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. Also the return of membrane potential to the resting value brings back the IR radiation stabilizing the gel phase.

3. Gel phase is re-generated. Actin molecules re-polymerize and micro-tubuli 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.

4. 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 [70, 63]. 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 [H8] a micro-tubular spatial cognitive code based on $13 \times 13$ bits is discussed. Temporal pattern extends this code to $13 \times 13 \times 126$ bit code.

### 2.8.4 Magnetic bodies, MEs and microtubules

It would seem that magnetic bodies are the intentional agents and the most natural assumption is that micro-tubuli are used by the magnetic body of cell for logistic purposes as well as to represent memories. 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, one can argue that 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 [20].

Still an open question is whether laser beams actually correspond to dark photons having thus large value of $\hbar$ and scaled up wavelength. Scaled up wave lengths for .1 eV IR photons would be very natural concerning the control in length scales longer than that of single neuron and synchronous neuronal firing might involve the de-coherence of these dark photons to ordinary IR photons.

#### Could memes express themselves in terms of modulated IR radiation?

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 would be the language with which the cellular programs are written. Super-genes or at least hyper-genes would naturally correspond to the sequences of memetic codons.

Memes could express themselves as temporal patterns of IR radiation amplified by micro-tubuli 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 s, the basic time scale of the neuronal dynamics. Both the frequency for the occurrence of sol gel transition and the duration of memetic codon in turn corresponds to 10 Hz frequency in alpha band, which suggests that $k_{em} = 4$ hierarchy level of dark matter hierarchy is involved with the periodically occurring sol-gel phase transition. The general framework would suggest that this phase transition occurs with this frequency only in vertebrate neurons.

These patterns of IR radiation at $\sim .1$ eV energy 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 micro-tubulin conformations could represent long term declarative memories expressed in a universal language using memetic codons as basic units.

**Seesaw mechanism as a general manner to generate long term memories?**

Micro-tubuli can act as quantum antennae producing IR photons by the dropping of proton Cooper pairs and amplified resonantly, when the micro-tubule has a length of about 12.4 micrometers. The absorption of these photons would in turn re-establish the gel phase in receiving system. This energetic gel-sol seesaw would be obviously ideal for the minimization of the dissipative losses.

The seesaw mechanism for the cellular control by micro-tubuli means that sol-gel transition in tubulin induces a gel-sol transition in the controlled part of the cell. Thus it would automatically construct micro-tubular 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 macro-temporal quantum coherence.

## 2.9 Self hierarchy and hierarchy of weakly coupled super conductors

The realization that bio-systems are full of macroscopic quantum phases led to the general idea about the dynamical realization of the self-hierarchy as a master-slave hierarchy formed by weakly coupled super conductors. It is now clear that mere Josephson currents are not enough: the breaking of superconductivity due to leakage of supra currents from the super-conducting space-time sheets might also be an essential part of bio-control. A possible general conclusion is that Josephson currents are responsible for coordination whereas dissipative currents are related with the control aspect. The idea about charge entanglement made possible by $W$ MEs and generating the dissipative currents makes this vision more precise.

One of the great ideas was that soliton sequences associated with the Josephson currents underly nerve pulse sequences. This idea turned out be be wrong as such: as a matter, soliton sequences would correspond to kHz resonance frequency and also EEG in the recent model and nerve pulses could be understood as a perturbation of this sequences. Since homeostasis as a many-sheeted ionic flow equilibrium involves also Josephson currents in an essential manner, it would be however light hearted to assume that Josephson currents and the dynamics at the level of cell membrane were totally uncorrelated. The model for sol-gel phase transition indeed demonstrates that Josephson currents generate IR photons crucial for stabilizing gel phase.

The frequency of the possible Josephson currents associated with the atomic space-time sheets of the cell membrane (or some larger space-time sheets with the same potential difference by the average many-sheeted ir-rotationality of the cell membrane electric field) corresponds in the resting state to a potential energy difference of about 65 meV so that the frequency is about 16 THz. It seems that the Josephson currents associated with the atomic space-time sheets define bio-rhythms in the molecular length and time scales.

This does not of course exclude the possibility that Josephson currents in ELF frequency scale are important. That this might be the case is suggested by the fact that the amplitude of the Josephson current does not depend on potential difference. These extremely small small potential differences, if present, must be between the space-time sheets representing relatively large bio-structures. One possibility is that pairs or parallel super-conducting magnetic flux tubes form Josephson junctions. Indeed, at the higher levels of dark matter hierarchy one obtains both time-like and space-like soliton sequences and their Lorentz boosts. At $k_{em} = 4$ level these waves are excellent candidates for the counterparts of standing and moving EEG waves. The recent model for nerve pulse indeed predicts also kHz synchrony and EEG as Josephson radiation: synchrony is in both cases an automatic prediction and follows from boundary conditions for soliton sequences.

What remained open in the earlier picture was the relationship between Josephson current circuitry and EEG, ZEG, and nerve pulse generation and the possible analogs of EEG, ZEG (and WEG) and nerve pulse generation in various other frequency scales. The discovery of generalized EWEG hierarchy associated with dark matter hierarchy lead to a general quantitative picture in this respect and allowed to interpret the components of generalized EEG in terms of cyclotron radiation and Josephson radiation as a response to cyclotron radiation. A fascinating possibility is that scaled up variants of nerve pulses with typical time scale of about 2 seconds instead of millisecond associated with say neuronal bi-layers are realized in higher vertebrates. At the next level the "nerve pulses" would have duration of order 1.1 hours.

Josephson currents suggest an important additional piece to the picture about of quantum control. Constructive interference of supra currents leads to a large net Josephson current and various biological clocks could rely on this mechanism. When reference supra current representing the expected sensory input and a current representing real sensory input and flowing in parallel manner in weakly coupled super conductors, are sufficiently near to each other, constructive interference of the Josephson currents occurs and can give rise to a synchronous firing. This makes possible conscious comparison circuits. Conscious novelty detectors can be build easily from comparison circuits using inhibitory and excitatory synaptic connections.

It must be emphasized that detailed models cannot be taken too seriously. There are simply quite too many new physic mechanisms to be considered. The following considerations actually represent the first general vision about the role of super conductivity in living matter, and also this is a good reason for not taking them too literally. As in the case of other similar sections, I have made the decision to keep it as such since the general vision might apply also in the recent framework although it failed in the original model of nerve pulse and EEG. The replacement of the representation of Josephson junction by magnetic flux tubes carrying dark variants of electrons and ions might provide a general realization of the vision. For instance, standing wave solitons associated with the Josephson currents between cytoskeletal microtubules and regions of the cell membrane could be involved with DNA - cell membrane tqc. These currents - at least in the case of axons- might be also responsible for ordinary EEG (note that a hierarchy of fractal variants of EEG are predicted [M3].

### 2.9.1 Simple model for weakly coupled super conductors

Several kinds of Josephson currents between cell interior and exterior are possible. Solitons represent quantized Josephson currents which are large and able to facilitate the generation of nerve pulse in the case of $Na_+$ and $Ca_{++}$. Soliton sequences are the simplest solutions of Sine-Gordon equation for the Josephson junctions associated with a linear structure such as axon idealized as an infinitely long and thin cylindrical surface and are mathematically equivalent with a rotating gravitational pendulum.

The most general formulation starts from the Klein-Gordon equation for the order parameters $\Psi_i$, $i = 1,2$ for the super-conductors coupled linearly to each other in the junction

$$\begin{aligned} D\Psi_1 &= m^2\Psi_1 + m_{12}^2\Psi_2 \ , \\ D\Psi_2 &= m^2\Psi_2 + m_{12}^2\Psi_1 \ , \\ D &= (\partial_\mu + iZeA_\mu)(\partial_\mu - iZeA_\mu) \end{aligned} \tag{2.9.1}$$

Here $m$ denotes the charge of the super-conducting particle (say Cooper pair) and $m_{12}^2$ is real parameter characterizing the coupling between the super conductors. $A_\mu$ denotes electromagnetic vector potential associated with the super conductors. $D$ denotes d'Alembert operator $\partial_t^2 - \nabla^2$.

Weakly coupled super conductors are assumed to possess cylindrical symmetry and can regarded as inner and out cylinder with Josephson junctions idealized with smooth distribution of them. If ME acts as Josephson junctions this assumption is exact. Weak coupling means that that the densities of charge carriers are same at the two sides of the junction in a good approximation:

$$\Psi_i = \sqrt{n}exp(i\Phi_i) \ , \quad i = 1,2 \ . \tag{2.9.2}$$

Under these assumptions one obtains for the phase difference $\Phi \equiv \Phi_1 - \Phi_2$ the Sine-Gordon equation with a coupling to the vector potential

$$\partial^\mu \left[\partial_\mu \Phi - q\Delta A_\mu\right] = m_{12}^2 sin(\Phi) \tag{2.9.3}$$

$\Delta A_\mu$ denotes the difference of the vector potential over the junction. $q$ denotes the charge of the super-conducting charge carrier.

Note that Lorentz gauge condition

$$\partial_\mu A^\mu = 0 \tag{2.9.4}$$

does not trivialize the coupling to the vector potential since the equation holds true only in 3-dimensional surface defining the junction and the contribution from the direction of the normal is not present.

Josephson current $J_J$ can be identified as the divergence of the 4-current $j_\mu = Ze\rho = Ze\Psi^*(\partial_\mu^{\rightarrow} - \partial_\mu^{\leftarrow})\Psi$ at the either side of the junction.

$$J_J = \partial_\mu J^\mu = Ze \times \frac{n}{m} \times m_{12}^2 sin(\Phi) \ . \tag{2.9.5}$$

The Josephson current per unit length of axonal membrane of radius $R$ and thickness $d$ is given by

$$J = Ze \times \frac{n2\pi Rd}{m} \times m_{12}^2 sin(\Phi) \ . \tag{2.9.6}$$

The parameter $m_{12}^2$ is analogous to the inverse of the magnetic penetration length squared ($\hbar = c = 1$) for the super-conductors involved.

$$m_{12}^2 = \frac{1}{\Lambda^2} \ . \tag{2.9.7}$$

If one can regard the Josephson junction region as a defect in a super-conductor, $\Lambda$ is apart from a numerical constant of order unity equal to the thickness of the Josephson junction. In the case of the cell membrane this would mean that the small oscillations associated with the Josephson junction have frequencies of order $10^{16}$ Hz and correspond to quanta with energies of order 100 eV.

The covariant constancy conditions

$$\begin{aligned} \partial_t\Phi &= ZeV(t,z) \ , \\ \partial_z\Phi &= ZeA_z(t,z) \ . \end{aligned} \tag{2.9.8}$$

are mutually consistent only if the electric field in the axial direction vanishes. They are not however consistent with the right hand side of the equation and only one of the conditions can be satisfied. The condition effectively reduces the equation to an ordinary differential equation. Of course, one cannot assume the condition for general solutions.

For a constant potential difference $V_0$ the Josephson current is sinusoidal for $\partial_t\Phi = ZeV_0$ ansatz with the basic frequency given by $\omega = eV_0$. An exact treatment replaces the sinusoidal time dependence of $\Phi$ with the time dependence of the angle coordinate of gravitational pendulum so that higher harmonics are involved. In the case of cell membrane $V(t)$ is typically a sum of constant part and time dependent part giving rise to frequency modulation of the basic Josephson current:

$$\omega(t) = eV = eV_0 + eV_1(t) \ .$$

Entire hierarchy of frequency modulations is possible since also $eV_1$ can be frequency modulated by Josephson currents.

### 2.9.2 Simplest solutions of Sine-Gordon equation

Free Sine-Gordon equation resulting, when the coupling to the em field can be neglected, gives a good view about the solutions of full equation. In cylindrical geometry Sine-Gordon equation becomes effectively 2-dimensional under rather natural conditions. This is rather nice since two-dimensional Sine-Gordon equation is completely integrable and thus allows an infinite number of conserved charges[20].

Sine-Gordon equation allows two kinds of vacua. The vacua of first type correspond to $\Phi = 2n\pi$ ground state configuration and vacua second type to $\Phi = (2n+1)\pi$. The small perturbations around these vacua correspond to massive 1+2 dimensional free field theory with field equations

$$\begin{aligned}
D\Phi &= \epsilon\frac{1}{\Lambda^2}\Phi \ ; \\
D &= \partial_t^2 - \nabla^2 \ , \\
\epsilon &= -1 \ \text{for} \ \Phi = n2\pi \ , \\
\epsilon &= 1 \ \text{for} \ \Phi = (2n+1)\pi \ .
\end{aligned} \tag{2.9.9}$$

In the language of quantum field theory, the small perturbations around $\Phi = n2\pi$ describe particle with mass squared $m^2 = \frac{1}{\Lambda^2}$ whereas the small perturbations of the $\Phi = (2n+1)\pi$ vacuum describe tachyons with negative mass squared $m^2 = -\frac{1}{\Lambda^2}$. Therefore these vacua will be referred to as time like and space-like respectively.

One might argue that the space-like vacua are un-stable in the case that the continuous sheet of the Josephson junctions consists actually of discrete Josephson junctions, whose dynamics is given by the differential equation

$$\frac{d^2\Phi}{dt^2} = -\frac{sin(\Phi)}{\Lambda^2}$$

allowing only $\Phi = n2\pi$ as stable ground state. For MEs acting as Josephson junction the situation is different. On the other hand, the ground state at which soliton generation is possible should be quantum critical and hence very sensitive to external perturbations. Note that time like and space-like sectors in axonal portion of neuron are permuted by a duality transformation $z \leftrightarrow vt$ (v=c=1), $\Phi \rightarrow \Phi + \pi$, which is exact symmetry of the 1+1-dimensional Sine-Gordon equation.

The propagating waves are of form $sin(u)$, where one has

$$\begin{aligned}
u &= \gamma_P(t - \frac{v_P z}{v^2}) \ , \ \text{time like case} \\
u &= \gamma_P(z - v_P t) \ , \ \text{space-like case} \\
\gamma_P &= \sqrt{\frac{1}{1-(\frac{v_P}{v})^2}} \ .
\end{aligned} \tag{2.9.10}$$

Here $v_P$ is the velocity parameter characterizing the boost. The frequency of these small propagating oscillations (plane waves) is in two cases given by

$$\begin{aligned}
\Omega &= \frac{\gamma_P v}{\Lambda} \ , \ \text{time like case} \ , \\
\Omega &= \frac{\gamma_P v_P}{\Lambda} \ , \ \text{space-like case} \ .
\end{aligned} \tag{2.9.11}$$

The frequency is very high for time like waves, of order $10^{10}$ Hz and therefore a typical time scale for the conformational dynamics of proteins. In space-like case the phase velocity of the propagating waves is $v_P < v$ and frequencies are small and one could consider the possibility of identifying these oscillations as propagating EEG waves. For the time like excitations phase velocity is $v_p = v^2/v_P > v$ and larger than light velocity. For ordinary elementary particles the situation is same but since phase velocity is in question, there are no interpretational problems.

One-dimensional solutions of the Sine-Gordon equation give quite satisfactory picture about the situation as far as the physical interpretation is considered. The simplest solutions of this type correspond to solutions depending on time or spatial coordinates only. For time like vacua one-dimensional solutions depend on time only: note that these solutions are possible for arbitrary geometry of the Josephson junction. For space-like like vacua one-dimensional solutions are possible in the axonal portions of the neuron: the simplest one-dimensional solutions depend on the axonal coordinate $z$ only.

Field equations reduce to the equations of motion for gravitational pendulum:

$$\frac{d^2\Phi}{du^2} = -\frac{1}{\Lambda^2}sin(\Phi) \ . \tag{2.9.12}$$

$u = vt$ holds true in time like case ($v = c \equiv 1$ is good approximation). $u = z$ holds true in space-like case (in this case equation makes sense for axonal portions only). Energy conservation for the gravitational pendulum gives

$$\frac{1}{2}v^2(\frac{d\Phi}{du})^2 + \frac{v^2}{\Lambda^2}\left[1 - cos(\Phi)\right] = K\frac{2v^2}{\Lambda^2} \ , \tag{2.9.13}$$

where $K$ is dimensionless constant analogous to energy. There are two kinds of solutions: oscillating solutions ($K < 1$) and rotating solutions ($K > 1$): single soliton solution corresponds to $K = 1$.

One can integrate the conservation law for energy to give the time/spatial period of oscillation or rotation ($T/\lambda$). For oscillating solutions one has

$$T = \frac{\lambda}{v} = \frac{\Lambda}{v}\int_{-\Phi_0}^{+\Phi_0} d\Phi \frac{1}{\sqrt{2\left[-cos(\Phi_0) + cos(\Phi)\right]}} \ . \tag{2.9.14}$$

Here $\Phi_0$ is maximum value of the phase angle for oscillating solution. For the rotation period one obtains

$$T = \frac{\lambda}{v} = \frac{\Lambda}{v}\int_{0}^{2\pi} d\Phi \frac{1}{\sqrt{(\frac{d\Phi}{dt})^2(\Phi = \pi) + 2\left[1 - cos(\Phi)\right]}} \ . \tag{2.9.15}$$

By Lorentz-boosting space-like axonal solutions to move with velocity $v_p$ one obtains propagating soliton sequences.

Sine-Gordon equation is completely integrable and thus allows an infinite number of conserved charges. In quantum theory the eigenvalues of mutually commuting charges characterize the quantum state and these charges are basic quantum observables. Does it make sense to quantize Sine-Gordon and could one characterize the state of the axonal membrane in terms of these charges? Here one must point out the similarity to the ideas of Nanopoulos [63], who speculates with the possibility that certain 2-dimensional conformal field theory characterizes the state of micro-tubule and the infinite number of conserve charges characterize the information content of the micro-tubule. It is perhaps also worth of mentioning that the quantum group $SU(2)$ appears in the quantization of the Sine-Gordon equation [21]: could quantum groups have important applications in biology?

### 2.9.3 Are both time like and space-like soliton sequences possible ground states?

The model for the Josephson junction predicts the existence of both time like and space-like soliton sequences. Mathematician would expect that both ground states of coupled super conductors are realized in brain. The presence of space-like and time like modes could provide general insights to brain functioning and could relate to the fundamental dichotomies of brain consciousness.

### The physical interpretation of time like ground states

Time like soliton sequences do not in general propagate and if they propagate, the phase velocity exceeds light velocity. The size of coherence region in the case of gap junction connected neurons can be rather large. Also micro-tubuli could form large coherent regions.

The time scales involved with the time like soliton sequence are however very fast, much faster that the time scales of EEG. This suggests that soliton sequences and oscillations are responsible for a synchronization in various scales defined by p-adic and dark matter hierarchies. There are intriguing analogies with right-left dichotomy of brain functioning and standing and propagating EEG waves and one cannot exclude the possibility that the appearance of time like soliton sequences correlates with the emergence of standing EEG waves and synchronous firing whereas propagating space-like soliton sequences could accompany nerve pulse conduction. Standing soliton sequences could be associated with neuronal cell bodies and propagating soliton sequences with axons.

Oscillating and rotating time like waves could provide a general realization of biological clocks and facilitate the generation of macroscopic quantum systems. For instance, ordinary cells and glial cells could correspond to time like solitons. Also the gap junction connected neuron groups associated with primary sensory organs, various organs and brain could correspond to time like solitons.

For ordinary value of $\hbar$ the small oscillations for time like ground state have period of order $10^{-10}$ seconds: this follows solely from the spatial extension of nerve pulse of order $\Lambda \sim 10^{-2}$ meters and involves no assumptions about the detailed properties of the super conductor. These oscillations could coordinate protein dynamics. I do not know whether endoplasma membranes inside cells have resting potential: if not, they are good candidates for the carriers of time like ground states with oscillating voltage.

For cell membrane situation is different and the only possible interpretation is that the resting potential corresponds to the $10^{-13}$ second time scale determined by the membrane voltage and the mechanical analog is very rapidly rotating gravitational pendulum. At the higher levels of dark matter hierarchy the frequency is scaled down by a power of $1/\lambda \simeq 2^{-11}$, and $k_{em} = 4$ level would correspond to 5 Hz oscillation frequency if precise scaling holds true. These time-like solitons could indeed be interpreted as standing EEG waves whereas space-like solitons would correspond to propagating EEG waves. The presence of perturbations appearing at multiples of cyclotron frequencies of biologically important ions means that standing and moving waves at other frequencies are possible.

Glial cells [23] form a considerable fraction of cell population of brain are glial cells and are connected to each other by gap junctions, which can serve as Josephson junctions. In glial cells large amplitude oscillations with longer oscillation period could be present. The ciliar beating of monocellular animals [23] could be coordinated to coherent motion (making possible swimming of the monocellular organism) by the "EEG" waves.

Gap junctions between the nerve cells are not common but are encountered in the large coherently firing groups of nerve cells in the brain, in the sensory organs and other organs such as heart. The value of the parameter $K$ is only slightly larger than the critical value $K = 1$ for EEG since the period of EEG oscillations is typically by a factor of order $10^8$ longer than the period of small oscillations. The problem disappears when higher levels of dark matter hierarchy are allowed. Of course, if the potential difference in question corresponds to the membrane potential, one must have $K \gg 1$. One can wonder whether the criticality might have some deeper significance: perhaps phase transitions between EEG:s corresponding to rotating and oscillating gravitational penduli are possible.

### Do the frequency scales of right and left brain EEGs differ by a factor 1/2?

The model for fractal hierarchy of EEGs [M3] suggests a deep difference between right and left brain hemispheres. Since the model makes the considerations in sequel more comprehensible it deserves to be reviewed.

1. The basic prediction is that quantum control from $k_{em} = 4$ magnetic body is carried out by using cyclotron radiation travelling along magnetic flux sheets traversing through DNA and containing genes very much like pages of book contain written text. Single text line contains genes from very many cells and even cells from different organisms.

2. Most biologically important bosonic ions have cyclotron frequencies $f_c$ in alpha band of the strength of the endogenous magnetic field at flux sheets is $B = 2B_E/5$, $B_E = .5$ Gauss. Sensory

input to magnetic body comes from neuronal membrane at frequencies $nf_c \pm f_J$, $f_J = 5$ Hz. This means that theta and beta bands can be assigned to sensory input and can be regarded as satellites of alpha band representing the sensory response of cell membrane to the cyclotron radiation from magnetic body. $f_J = 5$ Hz for $Z = 2$ correspond to a fundamental "drum beat". Note that for $Z = 1$ (assignable to say exotic bosonic ions of type $I^{++,-}$, $I = Ca, Mg, Mn, ...$) one has $f_J = 2.5$ Hz.

3. The model explains the band structure of EEG and predicts correctly the narrow resonances at $3, 5, 7$ Hz and $13, 15, 17$ Hz [47]. Also the basic correlations between EEG and the state of consciousness can be understood, in particular why the chaotic character of beta band correlates with a state of strong concentration and high activity can be understood directly from the general expression of the Josephson current.

4. The difference between EEGs during wake-up and sleep can be understood if there are two classes of neurons such that the magnetic flux quantization condition $Ze\int BdS = n\hbar(k_{em})$ corresponds to $Z = 1$ for type I neurons $Z = 2$ for type II neurons so that the magnetic field strength assignable to flux sheets traversing DNA is $B_E$ for type I and $B_E/2$ for type II. The key implication is that the cyclotron frequency scales differ by a factor 1/2 so that the alpha bands would be around 10 Hz *resp.* 5 Hz for these two types of neurons. The first guess is that $Z = 1$ *resp.* $Z = 2$ correspond to neurons of right *resp.* left hemisphere. Left and right hemispheres could actually correspond to separate magnetic bodies with different field strengths.

   Also the value of $\hbar$ could be by a factor 2 larger for the right magnetic body so that also $f_J$ would scale down by factor 1/2. If also magnetic field for right magnetic body is weaker by a factor 1/2, the area of of its flux quanta would is a factor 4 larger than for left magnetic body.

If the portions of brain corresponding to type I neurons falls first in sleep the control signals in alpha band and sensory input in beta and theta bands to the (corresponding) magnetic body disappear and only their scaled down variants remain. This explains why only theta and delta bands are present during sleep. Sleeping spindles can be understood as occasional wake-ups of type I regions. In the deepest stage of sleep only the cyclotron delta bands around 1 Hz and .5 Hz assignable to DNA cyclotron frequencies for type I and II neurons and having interpretation in terms of quantum control applied to DNA remain.

That at $k_{em} = 3$ level of hierarchy .5 Hz corresponds to kHz frequency of neuronal synchrony suggests that $k_{em} = 3$ magnetic bodies are in deep sleep during neuronal synchrony. In a similar manner deep sleep at our level would correspond to the analog of neuronal synchrony at higher level corresponding perhaps to the analogs of nerve pulse patterns assignable to double neuron layers and characterized by a time scale of 2 seconds instead of millisecond. The analog of type I (II) alpha band would correspond to a time scale of 200 (400) seconds and might define a detectable biorhythm.

### Left/right $\leftrightarrow$ space-like/time like?

It has been already proposed that space-like/time-like dichotomy most naturally corresponds to axon-neuron body dichotomy. One can however consider also alternative possibilities. The difference of EEG frequency scales (if assignable to left-right dichotomy) need not be the only difference between the EEGs of right and left hemispheres. If there is a correlation between the character of EEG waves and that of solitons sequences at $k_{em} = 4$ level of dark hierarchy, the difference between left and right brain could indeed reflect the differences between space-like propagating space-like soliton sequences and non-propagating time like soliton sequences. Only dominance would be in question, both modes would appear certain fraction of time in both brain hemispheres (recall that millisecond is the natural unit of time and $10^{39}$ quantum jumps occurs during one second). Propagating soliton sequences could give rise to a relatively large number of sub-selves (mental images) corresponding geometrically to linear brain circuits and representing linear and temporal aspects of cognition (speech and thought). 'Boolean' mind represented by sequences of cognitive neutrino pairs might be possible only in this mode[1]. Time like soliton sequences would be associated with relatively few and large spatial regions representing selves. This would give rise to a parallel processing of information.

[1] See the chapter "Genes and memes".

An interesting question is whether epileptic seizures could involve non-propagating EEG of anomalously high amplitude. Also meditative states and 'whole-body consciousness' might involve non-propagating EEG: the basic procedure for achieving meditative states is emptying of mind from all possible mental images which means formation of large sub-selves represented by brain regions with time like EEG. The identification of the dominance of standing EEG waves with this kind of mental states is consistent with the absence of sensory consciousness. The low level of motor activity suggests that the standing EEG waves produced by time like soliton sequences are not responsible for motor control.

### 2.9.4 Quantum tools for bio-control and -coordination

Coordination and control are the two fundamental aspects in the functioning of the living matter. TGD suggests that at quantum level deterministic unitary time evolution of Dirac equation corresponds to coordination whereas time evolution by quantum jumps corresponds to quantum control. More precisely, the non-dissipative Josephson currents associated with weakly coupled super conductors would be the key element in coordination whereas resonant dissipative currents between weakly coupled super conductors would make possible quantum control.

This view allows to consider more detailed mechanisms. What is certainly needed in the coordination of the grown up organism are biological clocks, which are oscillators coupled to the biological activity of the organ. Good examples are the clocks coordinating the brain activity, respiration and heart beat [24]. For example, in the heart beat the muscle contractions in various parts of heart occur in synchronized manner with a well defined phase differences. Various functional disorders, say heart fibrillation, result from the loss of this spatial coherence. For a control also biological alarm clocks are needed. An alarm clock is needed to tell when the time is ripe for the cell to replicate during morphogenesis. Some signal must tell that is time to begin differentiation to substructures during morphogenesis: for example, in the case of the vertebrates the generation of somites is a very regular process starting at certain phase of development and proceeding with a clockwise precision.

#### Homeostasis as many-sheeted ionic flow equilibrium

The experimental work of Ling, Sachs and Qin [34, 39] and other pioneers [40, 47] challenges the notions of ionic channels and pumps central to the standard cell biology. Ling has demonstrated that the ionic concentrations of a metabolically deprived cell are not changed at all: this challenges the notion of cell membrane ionic pumps. The work of Sachs and Qin and others based on patch-clamp technique shows that the quantal ionic currents through cell membrane remain essentially as such when the membrane is replaced by a silicon rubber membrane or by a cell membrane purified from channel proteins! this challenges the notion of cell membrane ionic channels. A further puzzling observation is much more mundane: ordinary hamburger contains roughly 80 per cent of water and is thus like a wet sponge: why it is so difficult to get the water out of it?

These puzzling observations can be understood if the homeostasis of cell and its exterior is regarded as an ionic flow equilibrium in the many-sheeted space-time. Ionic super currents from super-conducting controlling space-time sheets flow to controlled atomic space-time sheets and back. Currents are of course ohmic at the atomic space-time sheets. One can understand how extremely small ionic densities and super currents at cellular space-time sheets can control ionic currents and much higher ionic densities at atomic space-time sheets. Immense savings in metabolic energy are achieved if the ohmic currents at the atomic space-time sheets flow through the cell membrane region containing the strong electric field along super-conducting cell membrane space-time sheet (rather than atomic space-time sheets) as a non-dissipative supra current. This clever energy saving trick makes also the notion of ionic channels obsolete for weak ionic currents at least.

Super-conducting space-time sheets contain a plan of the bio-system coded to ion densities and magnetic quantum numbers characterizing the super currents. Bio-control by em fields affects these super currents and one can understand the effects of ELF em fields on bio-system in this framework. The model relies crucially on the liquid crystal property of bio-matter (hamburger mystery!) making possible ohmic current circuitry at the atomic space-time sheets as a part of the many-sheeted control circuitry. There is a considerable evidence for this current circuitry, Becker is one of the pioneers in the field [79]: among other things the circuitry could explain how acupuncture works.

### Quantum model for pattern recognition

Time translation invariant pattern recognition circuit can be realized by using two coupled super-conductors. The first super-conductor contains the reference supra current and second super-conductor contains the supra current determined by the sensory input. Supra currents are assumed to have same spatially and temporally constant intensity. If the supra currents have spatially constant phase difference, also Josephson currents are in the same phase and sum up to a large current facilitating synchronous firing. The temporal phase difference of supra currents does not matter since it affects only the overall phase of the Josephson current. Therefore patterns differing by time translations are treated as equivalent. Quite generally, the requirement of time translational invariance, favors the coding of the sensory qualia to transition frequencies.

The destructive interference of supra currents provides an tool of pattern cognition in situations when the precise timing is important. The pattern to be recognized can be represented as a reference current pattern in some neuronal circuit. Input pattern determined by sensory input in turn is represented by supra current interfering with the reference current. If interference is destructive, synchronous generation of nerve pulses in the circuit occurs and leads to a conscious pattern recognition. Obviously the loss of time translation invariance makes this mechanism undesirable in the situations in which the precise timing of the sensory input does not matter. One can however imagine situations when timing is important: for instance, the deduction of the direction of the object of the auditory field from the phase difference associated with signals entering into right and left ears could correspond to this kind of situation.

In both cases one can worry about the regeneration of reference currents. The paradigm of four-dimensional quantum brain suggests that sensory input leads by self-organization to a stationary spatial patterns of supra-currents and this process depends only very mildly on initial values. Thus self-organization would generate automatically pattern recognizers.

### General mechanism making possible biological clocks and alarm clocks, comparison circuits and novelty detectors

Weakly coupled super conductors and auantum self-organization make possible very general models of biological clocks and alarm clocks as well as comparison circuits and novelty detectors.

The Josephson junction between two super-conductors provides a manner to realize a biological clock. Josephson current can be written in the form [29]

$$\begin{aligned} J &= J_0 sin(\Delta\Phi) = J_0 sin(\Omega t) \ , \\ \Omega &= ZeV \ , \end{aligned} \tag{2.9.16}$$

where $\Omega$ is proportional to the potential difference over the Josephson junction. Josephson current flows without dissipation.

In BCS theory of super-conductivity the value of the current $J_0$ can be expressed in terms of the energy gap $\Delta$ of the super conductor and the ordinary conductivity of the junction. When the temperature is much smaller than critical temperature, the current density for a junction is given by the expression [29]

$$J_0 = \frac{\pi}{2e}\frac{\sigma_s\Delta}{d} \ . \tag{2.9.17}$$

Here $\sigma_s$ is the conductivity of the junction in the normal state assuming that all conduction electrons can become carriers of the supra current. $d$ is the distance between the super conductors. The current in turn implies a position independent(!) oscillation of the Cooper pair density inside the two super conductors. By the previous arguments the density of the Cooper pairs is an ideal tool of bio-control and a rhythmic change in biological activity expected to result in general. Josephson junctions are therefore good candidates for pacemakers not only in brain but also in heart and in respiratory system.

In the presence of several parallel Josephson junctions quantum interference effects become possible if supra currents flow in the super conductors. Supra current is proportional to the gradient of the phase angle associated with the order parameter, so that the phase angle $\Phi$ is not same for the Josephson junctions anymore and the total Josephson current reads as

$$J = \sum_n J_0(n) sin(\Omega t + \Delta\Phi(n)) \ . \tag{2.9.18}$$

It is clear that destructive interference takes place. The degree of the destructive interference depends on the magnitude of the supra currents and on the number of Josephson junctions.

There are several options depending on whether both super conductors carry parallel supra currents or whether only second super conductor carries supra current.

1. If both super conductors carry supra currents of same magnitude but different velocity, the phases associated with the currents have different spatial dependence and destructive interference occurs unless the currents propagate with similar velocity. This mechanism makes possible comparison circuit serving as a feature detector. What is needed is to represent the feature to be detected by a fixed supra current in the second super conductor and the input as supra current with same charge density but difference velocity. The problem is how the system is able to generate and preserve the reference current. If case that feature detector 'wakes-up' into self state when feature detection occurs, the subsequent quantum self-organization should lead to the generation of the reference current representing the feature to be detected.

2. If only second super conductor carries supra current and of this supra current for some reason decreases or becomes zero, constructive interference occurs for individual Josephson currents and net Josephson current increases: current causes large gradients of Cooper pair density and can lead to the un-stability of the structure. When the supra current in the circuit dissipates below a critical value, un-stability emerges. This provides a general mechanism of biological alarm clock.

   Assume that the second super conductor carriers a supra current. As the time passes the reference current dissipates by phase slippages[30, 29]. If the reference current is large enough, the dissipation takes place with a constant rate. This in turn means that the Josephson current increases in the course of time. When the amplitude of the Josephson current becomes large enough, the density gradients of the charge carriers implied by it lead to a un-stability of the controlled system: the clock rings. Since the dissipation of (a sufficiently large) Josephson current takes place at constant rate this alarm clock can be quite accurate. It will be found that a variant of this mechanism might be at work even in the replication of DNA. The un-stability itself can regenerate the reference current to the clock. If the alarm clock actually 'wakes-up' the alarm clock to self state, self-organization by quantum jumps must lead to an asymptotic self-organization pattern in which the supra current in the circuit is the original one. Actually this should occur since asymptotic self-organization pattern depends only weakly on the initial values.

3. Novelty detector can be build by feeding the outputs of the feature detectors to an alarm clock circuit. In alarm clock circuit only the second super conductor carries supra current, which represents the sum of the outputs of the feature detectors. Since the output of a feature detector is non-vanishing only provided the input corresponds to the feature to be detected, the Josephson current in additional circuit becomes large only when the input does not correspond to any familiar pattern.

### How MEs could generate soliton sequences?

MEs could as bio-controllers using the same general mechanism which underlies remote mental interactions and this aspect of bio-control could be seen as endogenous remote mental interactions between cells and other parts of organism. Pairs of low and high frequency MEs are involved. Low frequency MEs, say EEG MEs, serve as correlates for quantum entanglement between body parts: already this is enough for remote viewing regarded as sharing of mental images by fusion of mental images. The psychokinesis aspect is possible by high frequency MEs propagating like massless particles inside low frequency MEs. These MEs induce bridges and thus leakage of ions between various space-time sheets at the receiving end. This means self-organization by dissipation.

MEs can also act as Josephson junctions connecting super-conducting space-time sheet characterized by p-adic primes which can be different. This kind of Josephson junction contains the em field associated with ME as an external field and the mathematical description of this coupling follows from the model for the coupling of electromagnetic field to super conducting order parameters. In Minkowski coordinates the modification of the Sine-Gordon equation is simple:

$$\partial^{\mu}\left[\partial_{\mu}\Phi - Ze\Delta A_{\mu}\right] = m_{12}^2 sin(\Phi) \ . \tag{2.9.19}$$

Here $\Phi$ denotes the phase difference over the Josephson junction, which is idealized with a continuous Josephson junction, and actually is a continuous Josephson junction in the case of ME. $\Delta A_{\mu}$ denotes the difference of the vector potential over the junction.

The coupling to the vector potential can in the lowest order described by the condition

$$\partial_{\mu}\Phi_0 = Ze\Delta A_{\mu}$$

assumed to hold for a maximal number of components of vector potential. Here of course integrability conditions pose restrictions. One can develop perturbation series for $\Phi$ by substituting $\Phi_0$ to the right hand side and calculating $\Phi_1$ using the right hand side as a source term, and so on.

If the transversal em field associated with ME contains time independent radial electric field this gives rise to a constant potential term giving rise to a generation of soliton sequences. The period $\Omega$ of rotation for the soliton satisfies $\Omega = eV$, where $eV$ corresponds to the potential difference defined by the constant part of the electric field of ME. It can also happen that ME contains only the oscillatory electromagnetic field: if the frequency is same as the frequency associated with small oscillations of the Sine-Gordon pendulum a resonant coupling is expected to result. In this case the frequency is in radio frequency range.

Also noise is present and it is quite possible that the noise provides the energy needed to amplify the weak periodic signal provided by ME to a soliton sequence by stochastic resonance. The mechanism is discussed in detail in the chapter "Quantum model for EEG and nerve pulse". This suggests that MEs could basically control small very fast oscillations of the membrane potential.

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# Chapter 3

# Dark Matter Hierarchy and Hierarchy of EEGs

## 3.1 Introduction

The model for EEG and ZEG, as well as their variants with E in the middle replaced by K or something else, follows neatly from the general model of high $T_c$ superconductivity [J1, J2]. A fractal hierarchy of EEGs and ZEGs is predicted labelled by p-adic length scales and an integer characterizing the value of $\hbar$ at various levels of dark matter hierarchy. To make the representation self-contained this model is discussed in detail before proceeding to the models of EEG and ZEG.

### 3.1.1 General mechanisms of bio-superconductivity

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the 'dropping' of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high $T_c$ macroscopic quantum phases are met.

The possibility of large $\hbar$ quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

Wormhole contacts can be interpreted as Higgs type fields [F2] and photon massivation could be understood in terms of a coherent state of charged wormhole contacts. The coherent states of charged wormhole contacts and of Cooper pairs do not imply non-conservation of energy, charge, and fermion number in zero energy ontology [C2].

A crucial element is quantum criticality predicting a new kind of superconductivity explaining the strange features of high $T_c$ super-conductivity. There are two kinds of Cooper pairs, exotic Cooper pairs and counterparts of ordinary BCS type Cooper pairs. Both correspond to a large value of Planck constant. Exotic Cooper pairs are quantum critical meaning that they can decay to ordinary electrons. Below temperature $T_{c_1} > T_c$ only exotic Cooper pairs with spin are present and their finite lifetime implies that super-conductivity is broken to ordinary conductivity satisfying scaling laws characteristic for criticality. At $T_c$ spinless BCS type Cooper pairs become stable and exotic Cooper pairs can decay to them and vice versa. An open question is whether the BCS type Cooper pairs can be present also in the interior of cell.

These two superconducting phases compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living matter. Also high $T_c$ superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic and $Z^0$ magnetic flux tubes and sheets are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for exotic Cooper pairs. The fact that the critical magnetic ($Z^0$ magnetic) fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and in principle works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high $T_c$ bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature besides Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged [F8].

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

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the value of $\hbar(k_d) = \lambda^{k_d}\hbar_0$, $\lambda = 2^{11}$.

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

2. Cyclotron energies scale as as $\lambda^{k_d}$ so that for a sufficiently high value of $k$ thermal stability of cyclotron states at room temperature is achieved. Same applies to spin flip transitions in the recent scenario.

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

### 3.1.3 Fractal hierarchy of magnetic flux sheets

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

There are several manners to achieve quantization of magnetic flux with quantized value of effective Planck constant $\hbar_{eff}/\hbar_0 = \hbar(M^4_\pm)/\hbar(CP_2)$ appearing in Schrödinger equation. From the point of view of EEG and ZEG especially interesting are flux flux sheets which have thickness $5L(167)/\lambda = L(151) =$ 6.25 nm carrying magnetic field having strength of endogenous magnetic field. These flux sheets have thickness slightly more that the $L(149) = 5$ nm thickness the lipid layer of cell membrane and total transversal length $L(169 + 5 \times 22) = L(257) = 1.6 \times 10^8$ km from flux quantization at $k_d = 4$ level of dark matter hierarchy necessary in order that the energies associated with cyclotron frequencies are above thermal threshold. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure.

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

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

### 3.1.4 Fractal hierarchy of EEGs and ZEGs

There are three contributions to EEG besides neural noise: Schumann frequencies, cyclotron frequencies, and the frequencies associated with Josephson junctions determined by the sum of the constant voltage and voltage perturbation determined by the superposition of cyclotron frequencies. Cyclotron contribution can be interpreted as a control signal from a magnetic body in question labelled by $k_d$ and affects both the ions at the flux sheets traversing DNA and the Josephson junction. The coherent state of photons generated by Josephson current corresponds to a reaction to this signal received by the magnetic body as a feedback. Schumann frequencies can be assigned to the control by magnetic body of Earth and correlate with the collective aspects of consciousness.

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

In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. One explanation is that right *resp.* left brain hemisphere corresponds to $Z = 2$ *resp.* $Z = 1$ quantization condition $Z \int BdS = n\hbar$ for the magnetic flux. $Z = 2$ case allows only doubly charged bosonic ions at magnetic flux sheets. $Z = 1$ case also also singly charged ions be their bosons or fermions and for this option magnetic field is scaled down by a factor of 1/2. The alternative explanation is that during sleep only Bose-Einstein condensates of singly charged exotic ions resulting when color bond inside nucleus becomes charged are present. This reduces the scale of cyclotron frequencies by a factor 1/2 and leaves only theta and delta bands. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. For $k_d = 3$ and magnetic field scaled up by $\lambda$ and flux tube area scaled down by $\lambda^{-2}$ DNA frequencies are scaled up to kHz for $Z = 2$ flux quantization and might define neuronal synchronization frequencies.

The generalization of the model for EEG hierarchy to the case of ZEG is straightforward and cyclotron frequency spectrum is essentially the same. $Z^0$ ions are obtained when nuclear color bonds become charged and the combination of ordinary and exotic ionization can produce also em neutral $Z^0$ ions. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

### 3.1.5 The effects of ELF em fields on brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in endogenous magnetic field of .2 Gauss on vertebrate brains [58] provide a test bench for the fractal hierarchy of EEGs. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and ZEGs.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in $B = . - 2$ Gauss. They occur only in amplitude windows. The first one is around $10^{-7}$ V/m and second corresponds to the range $1 - 10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

The temperature interval has interpretation in terms of quantum criticality of high $T_c$ superconductivity (both interior and boundary super currents are possible in this interval). Amplitude windows correspond to resonant EEG bands if the voltage perturbations contribute to the voltages over Josephson junctions and are thus coded to EEG. That the effects occur only for cyclotron frequencies and in the amplitude windows can be understood if there is AND gate involved. The voltage signal affects the interior of the cell nucleus opening communication line to the magnetic body if a harmonic of cyclotron frequency is in question. The signal affects also the Josephson junction which sends a signal to magnetic body if the voltage of the perturbation is large enough and corresponds to a frequency in the resonance band of EEG. The response of the magnetic body affects nucleus only if the communication line is open. This AND gate eliminates very effectively the effects of neural noise.

### 3.1.6 TGD assigns 10 Hz biorhythm to electron as an intrinsic frequency scale

p-Adic coupling constant evolution and origins of p-adic length scale hypothesis have remained for a long time poorly understood. The progress made in the understanding of the S-matrix of the theory (or rather, its generalization M-matrix) [C2] has however changed the situation. The unexpected prediction is that zero energy ontology assigns to elementary particles macroscopic times scales. In particular, the time scale assignable to electron correspond to the fundamental biorhythm of 10 Hz.

#### M-matrix and coupling constant evolution

The final breakthrough in the understanding of p-adic coupling constant evolution came through the understanding of S-matrix, or actually M-matrix defining entanglement coefficients between positive and negative energy parts of zero energy states in zero energy ontology [C2]. M-matrix has interpretation as a "complex square root" of density matrix and thus provides a unification of thermodynamics and quantum theory. S-matrix is analogous to the phase of Schrödinger amplitude multiplying positive and real square root of density matrix analogous to modulus of Schrödinger amplitude.

The notion of finite measurement resolution realized in terms of inclusions of von Neumann algebras allows to demonstrate that the irreducible components of M-matrix are unique and possesses huge symmetries in the sense that the hermitian elements of included factor $\mathcal{N} \subset \mathcal{M}$ defining the measurement resolution act as symmetries of M-matrix, which suggests a connection with integrable quantum field theories.

It is also possible to understand coupling constant evolution as a discretized evolution associated with time scales $T_n$, which come as octaves of a fundamental time scale: $T_n = 2^n T_0$. Number theoretic universality requires that renormalized coupling constants are rational or at most algebraic numbers and this is achieved by this discretization since the logarithms of discretized mass scale appearing in the expressions of renormalized coupling constants reduce to the form $log(2^n) = nlog(2)$ and with a proper choice of the coefficient of logarithm log(2) dependence disappears so that rational number results.

#### p-Adic coupling constant evolution

Could the time scale hierarchy $T_n = 2^n T_0$ defining hierarchy of measurement resolutions in time variable induce p-adic coupling constant evolution and explain why p-adic length scales correspond to $L_p \propto \sqrt{p}R$, $p \simeq 2^k$, $R$ $CP_2$ length scale? This looks attractive but there is a problem. p-Adic length scales come as powers of $\sqrt{2}$ rather than 2 and the strongly favored values of $k$ are primes and thus odd so that $n = k/2$ would be half odd integer. This problem can be solved.

1. The observation that the distance traveled by a Brownian particle during time $t$ satisfies $r^2 = Dt$ suggests a solution to the problem. p-Adic thermodynamics applies because the partonic 3-surfaces $X^2$ are as 2-D dynamical systems random apart from light-likeness of their orbit. For $CP_2$ type vacuum extremals the situation reduces to that for a one-dimensional random light-like curve in $M^4$. The orbits of Brownian particle would now correspond to light-like geodesics $\gamma_3$ at $X^3$. The projection of $\gamma_3$ to a time=constant section $X^2 \subset X^3$ would define the 2-D path $\gamma_2$ of the Brownian particle. The $M^4$ distance $r$ between the end points of $\gamma_2$ would be given $r^2 = Dt$. The favored values of $t$ would correspond to $T_n = 2^n T_0$ (the full light-like geodesic). p-Adic length scales would result as $L^2(k) = DT(k) = D2^k T_0$ for $D = R^2/T_0$. Since only $CP_2$ scale is available as a fundamental scale, one would have $T_0 = R$ and $D = R$ and $L^2(k) = T(k)R$.

2. p-Adic primes near powers of 2 would be in preferred position. p-Adic time scale would not relate to the p-adic length scale via $T_p = L_p/c$ as assumed implicitly earlier but via $T_p = L_p^2/R_0 = \sqrt{p}L_p$, which corresponds to secondary p-adic length scale. For instance, in the case of electron with $p = M_{127}$ one would have $T_{127} = .1$ second which defines a fundamental biological rhythm. Neutrinos with mass around .1 eV would correspond to $L(169) \simeq 5$ $\mu$m (size of a small cell) and $T(169) \simeq 1. \times 10^4$ years. A deep connection between elementary particle physics and biology becomes highly suggestive.

3. In the proposed picture the p-adic prime $p \simeq 2^k$ would characterize the thermodynamics of the random motion of light-like geodesics of $X^3$ so that p-adic prime $p$ would indeed be an inherent property of $X^3$.

4. The fundamental role of 2-adicity suggests that the fundamental coupling constant evolution and p-adic mass calculations could be formulated also in terms of 2-adic thermodynamics. With a suitable definition of the canonical identification used to map 2-adic mass squared values to real numbers this is possible, and the differences between 2-adic and p-adic thermodynamics are extremely small for large values of for $p \simeq 2^k$. 2-adic temperature must be chosen to be $T_2 = 1/k$ whereas p-adic temperature is $T_p = 1$ for fermions. If the canonical identification is defined as

$$\sum_{n\geq 0} b_n 2^n \rightarrow \sum_{m\geq 1} 2^{-m+1} \sum_{(k-1)m\leq n<km} b_n 2^n \quad .$$

   It maps all 2-adic integers $n < 2^k$ to themselves and the predictions are essentially same as for p-adic thermodynamics. For large values of $p \simeq 2^k$ 2-adic real thermodynamics with $T_R = 1/k$ gives essentially the same results as the 2-adic one in the lowest order so that the interpretation in terms of effective 2-adic/p-adic topology is possible.

### p-Adic length scale hypothesis and biology

The basic implication of zero energy ontology is the formula $T(k) \simeq 2^{k/2}L(k)/c = L(2,k)/c$. This would be the analog of $E = hf$ in quantum mechanics and together hierarchy of Planck constants would imply direct connection between elementary particle physics and macroscopic physics. Especially important this connection would be in macroscopic quantum systems, say for Bose Einstein condensates of Cooper pairs, whose signature the rhythms with $T(k)$ as period would be. The presence of this kind of rhythms might even allow to deduce the existence of Bose-Einstein condensates of hitherto unknown particles.

1. For electron one has $T(k) = .1$ seconds which defines the fundamental $f_e = 10$ Hz bio-rhythm appearing as a peak frequency in alpha band. This could be seen as a direct evidence for a Bose-Einstein condensate of Cooper pairs of high $T_c$ super-conductivity. That transition to "creative" states of mind involving transition to resonance in alpha band might be seen as evidence for formation of large BE condensates of electron Cooper pairs.

2. TGD based model for atomic nucleus [F9] predicts that nucleons are connected by flux tubes having at their ends light quarks and anti-quarks with masses not too far from electron mass. The corresponding p-adic frequencies $f_q = 2^k f_e$ could serve as a biological signature of exotic quarks connecting nucleons to nuclear strings . $k_q = 118$ suggested by nuclear string model would give $f_q = 2^{18} f_e = 26.2$ Hz. Schumann resonances are around 7.8, 14.3, 20.8, 27.3 and 33.8 Hz and $f_q$ is not too far from 27.3 Hz Schumann resonance and the cyclotron frequency $f_c(^{11}B^+) = 27.3$ Hz for $B = .2$ Gauss explaining the effects of ELF em fields on vertebrate brain.

3. For a given $T(k)$ the harmonics of the fundamental frequency $f = 1/T(k)$ are predicted as special time scales. Also resonance like phenomena might present. In the case of cyclotron frequencies they would favor values of magnetic field for which the resonance condition is achieved. The magnetic field which in case of electron gives cyclotron frequency equal to 10 Hz is $B_e \simeq 3.03$ nT. For ion with charge $Z$ and mass number $A$ the magnetic field would be $B_I = \frac{A}{Z}(m_p/m_e)B_e$. The $B = .2$ Gauss magnetic field explaining the findings about effects of ELF em fields on vertebrate

brain is near to $B_I$ for ions with $f_c$ alpha band. Hence the value of $B$ could be understood in terms of resonance with electronic B-E condensate.

4. The hierarchy of Planck constants predicts additional time scales $T(k)$. The prediction depends on the strength of the additional assumptions made. One could have scales of form $nT(k)/m$ with $m$ labeling the levels of hierarchy. $m=1$ would give integers multiples of $T(k)$. Integers $n$ could correspond to ruler and compass integers expressible as products of first powers of Fermat primes and power of 2. There are only four known Fermat primes so that one has $n=2^n\prod_i F_i$, $F_i\in\{3,5,17,257,2^{16}+1\}$. In the first approximation only 3- and 5- and 17-multiples of 2-adic length scales would result besides 2-adic length scales. In more general case products $m_1m_2$ and ratios $m_1/m_2$ of ruler and compass integers and their inverses $1/m_1m_2$ and $m_2m_1$ are possible.

5. Mersenne primes are expected to define the most important fundamental p-adic time scales. The list of real and Gaussian (complex) Mersennes $M_n$ possibly relevant for biology is given by n=89, 107, 113*, 127, 151*,157*, 163*, 167* ('*' tells that Gaussian Mersenne is in question).

$$
\begin{array}{lllll}
n & 89 & 107 & 113 & 127 \\
f/Hz & 2.7\times 10^{12} & 1.0\times 10^{7} & 1.6\times 10^{5} & 10 \\
n & 151 & 157 & 163 & 167 \\
T & 19.4\ d & 3.40\ y & 218.0\ y & 3.49\times 10^{3}\ y
\end{array}
\quad (3.1.1)
$$

### 3.1.7 DNA and topological quantum computation

The model of DNA as topological quantum computer led to a dramatic progress in the understanding of how magnetic body interacts with the biological body. The model which looks the most plausible one relies on two specific ideas.

1. Sharing of labor means conjugate DNA would do tqc and DNA would "print" the outcome of tqc in terms of RNA yielding amino-acids in the case of exons. RNA could result in the case of introns. The experience about computers and the general vision provided by TGD suggests that introns could express the outcome of tqc also electromagnetically in terms of standardized field patterns. Also speech would be a form of gene expression. The quantum states braid would entangle with characteristic gene expressions.

2. The manipulation of braid strands transversal to DNA must take place at 2-D surface. The ends of the space-like braid are dancers whose dancing pattern defines the time-like braid, the running of classical tqc program. Space-like braid represents memory storage and tqc program is automatically written to memory during the tqc. The inner membrane of the nuclear envelope and cell membrane with entire endoplasmic reticulum included are good candidates for dancing halls. The 2-surfaces containing the ends of the hydrophobic ends of lipids could be the parquets and lipids the dancers. This picture seems to make sense.

One ends up to the model also in top-down manner.

1. Darwinian selection for which standard theory of self-organization provides a model, should apply also to tqc programs. Tqc programs should correspond to asymptotic self-organization patterns selected by dissipation in the presence of metabolic energy feed. The spatial and temporal pattern of the metabolic energy feed characterizes the tqc program - or equivalently - sub-program call.

2. Since braiding characterizes the tqc program, the self-organization pattern should correspond to a hydrodynamical flow or a pattern of magnetic field inducing the braiding. Braid strands must correspond to magnetic flux tubes of the magnetic body of DNA. If each nucleotide is transversal magnetic dipole it gives rise to transversal flux tubes, which can also connect to the genome of another cell.

3. The output of tqc sub-program is probability distribution for the outcomes of state function reduction so that the sub-program must be repeated very many times. It is represented as four-dimensional patterns for various rates (chemical rates, nerve pulse patterns, EEG power distributions,...) having also identification as temporal densities of zero energy states in various scales. By the fractality of TGD Universe there is a hierarchy of tqcs corresponding to p-adic and dark matter hierarchies. Programs (space-time sheets defining coherence regions) call programs in shorter scale. If the self-organizing system has a periodic behavior each tqc module defines a large number of almost copies of itself asymptotically. Generalized EEG could naturally define this periodic pattern and each period of EEG would correspond to an initiation and halting of tqc. This brings in mind the periodically occurring sol-gel phase transition inside cell near the cell membrane.

4. Fluid flow must induce the braiding which requires that the ends of braid strands must be anchored to the fluid flow. Recalling that lipid mono-layers of the cell membrane are liquid crystals and lipids of interior mono-layer have hydrophilic ends pointing towards cell interior, it is easy to guess that DNA nucleotides are connected to lipids by magnetic flux tubes and hydrophilic lipid ends are stuck to the flow.

5. The topology of the braid traversing cell membrane cannot not affected by the hydrodynamical flow. Hence braid strands must be split during tqc. This also induces the desired magnetic isolation from the environment. Halting of tqc reconnects them and make possible the communication of the outcome of tqc.

6. There are several problems related to the details of the realization. How nucleotides A,T,C,G are coded to strand color and what this color corresponds to? The prediction that wormhole contacts carrying quark and anti-quark at their ends appear in all length scales in TGD Universe resolves the problem. How to split the braid strands in a controlled manner? High $T_c$ super conductivity provides the mechanism: braid strand can be split only if the supra current flowing through it vanishes. A suitable voltage pulse induces the supra-current and its negative cancels it. The conformation of the lipid controls whether it it can follow the flow or not. How magnetic flux tubes can be cut without breaking the conservation of the magnetic flux? The notion of wormhole magnetic field saves the situation now: after the splitting the flux returns back along the second space-time sheet of wormhole magnetic field. The model inspires several testable hypothesis about DNA itself: in particular, the notion of anomalous em charge of DNA leads to several predictions of this kind. Also new mechanisms of catalytic action based on phase transitions reducing the value of Planck constant emerge.

### 3.1.8 EEG, ZEG, and consciousness

The interpretation of cyclotron phase transitions from the point of view of conscious experience is discussed. Cyclotron frequencies are ideal for communication, control, and coding purposes. One can also ask whether cyclotron transitions correspond to some sensory qualia. "General feeling of existence" possibly accompanying all sensory qualia is one possible identification for the quale involved. Also the possibility that cyclotron phase transitions could serve as quantum correlates for tastes and odors is discussed.

## 3.2 General TGD based view about super-conductivity

Today super-conductivity includes besides the traditional low temperature super-conductors many other non-orthodox ones [26]. These unorthodox super-conductors carry various attributes such cuprate, organic, dichalcogenide, heavy fermion, bismute oxide, ruthenate, antiferromagnetic and ferromagnetic. Mario Rabinowitz has proposed a simple phenomenological theory of superfluidity and super-conductivity which helps non-specialist to get a rough quantitative overall view about super-conductivity [26].

### 3.2.1 Basic phenomenology of super-conductivity

**Basic phenomenology of super-conductivity**

The transition to super-conductivity occurs at critical temperature $T_c$ and involves a complete loss of electrical resistance. Super-conductors expel magnetic fields (Meissner effect) and when the external magnetic field exceeds a critical value $H_c$ super-conductivity is lost either completely or partially. In the transition to super-conductivity specific heat has singularity. For long time magnetism and super-conductivity were regarded as mutually exclusive phenomena but the discovery of ferromagnetic super-conductors [28, 30] has demonstrated that reality is much more subtle.

The BCS theory developed by Bardeen, Cooper, and Schrieffer in 1957 provides a satisfactory model for low $T_c$ super-conductivity in terms of Cooper pairs. The interactions of electrons with the crystal lattice induce electron-electron interaction binding electrons to Cooper pairs at sufficiently low temperatures. The electrons of Cooper pair are at the top of Fermi sphere (otherwise they cannot interact to form bound states) and have opposite center of mass momenta and spins. The binding creates energy gap $E_{gap}$ determining the critical temperature $T_c$. The singularity of the specific heat in the transition to super-conductivity can be understood as being due to the loss of thermally excitable degrees of freedom at critical temperature so that heat capacity is reduced exponentially. BCS theory has been successful in explaining the properties of low temperature super conductors but the high temperature super-conductors discovered in 1986 and other non-orthodox superconductors discovered later remain a challenge for theorists.

The reasons why magnetic fields tend to destroy super-conductivity is easy to understand. Lorentz force induces opposite forces to the electrons of Cooper pair since the momenta are opposite. Magnetic field tends also to turn the spins in the same direction. The super-conductivity is destroyed in fields for which the interaction energy of magnetic moment of electron with field is of the same order of magnitude as gap energy $E_{gap} \sim T_c$: $e\hbar H_c/2m \sim T_c$.

If spins are parallel, the situation changes since only Lorentz force tends to destroy the Cooper pair. In high $T_c$ super-conductors this is indeed the case: electrons are in spin triplet state ($S = 1$) and the net orbital angular momentum of Cooper pair is $L = 2$. The fact that orbital state is not $L = 0$ state makes high $T_c$ super-conductors much more fragile to the destructive effect of impurities than conventional super-conductors (due to the magnetic exchange force between electrons responsible for magnetism). Also the Cooper pairs of $^3He$ superfluid are in spin triplet state but have $S = 0$.

The observation that spin triplet Cooper pairs might be possible in ferro-magnets stimulates the question whether ferromagnetism and super-conductivity might tolerate each other after all, and the answer is affirmative [30]. The article [28] provides an enjoyable summary of experimental discoveries.

**Basic parameters of super-conductors from universality?**

Super conductors are characterized by certain basic parameters such as critical temperature $T_c$ and critical magnetic field $H_c$, densities $n_c$ and $n$ of Cooper pairs and conduction electrons, gap energy $E_{gap}$, correlation length $\xi$ and magnetic penetration length $\lambda$. The super-conductors are highly complex systems and calculation of these parameters from BCS theory is either difficult or impossible.

It has been suggested [26] that these parameters might be more or less universal so that they would not depend on the specific properties of the interaction responsible for the formation of Cooper pairs. The motivation comes from the fact that the properties of ordinary Bose-Einstein condensates do not depend on the details of interactions. This raises the hope that these parameters might be expressible in terms of some basic parameters such as $T_c$ and the density of conduction electrons allowing to deduce Fermi energy $E_F$ and Fermi momentum $k_F$ if Fermi surface is sphere. In [26] formulas for the basic parameters are indeed suggested based on this of argumentation assuming that Cooper pairs form a Bose-Einstein condensate.

1. The most important parameters are critical temperature $T_c$ and critical magnetic field $H_c$ in principle expressible in terms of gap energy. In [26] the expression for $T_c$ is deduced from the condition that the de Broglie wavelength $\lambda$ must satisfy in supra phase the condition

$$\lambda \geq 2d = 2(\frac{n_c}{g})^{-1/D} \tag{3.2.1}$$

guaranteing the quantum overlap of Cooper pairs. Here $n_c$ is the density of Bose-Einstein condensate of Cooper pairs and $g$ is the number of spin states and $D$ the dimension of the condensate. This condition follows also from the requirement that the number of particles per energy level is larger than one (Bose-Einstein condensation).

Identifying this expression with the de Broglie wavelength $\lambda = \hbar/\sqrt{2mE}$ at thermal energy $E = (D/2)T_c$, where $D$ is the number of degrees of freedom, one obtains

$$T_c \leq \frac{h^2}{4Dm}(\frac{n_c}{g})^{2/D} \quad . \tag{3.2.2}$$

$m$ denotes the effective mass of super current carrier and for electron it can be even 100 times the bare mass of electron. The reason is that the electron moves is somewhat like a person trying to move in a dense crowd of people, and is accompanied by a cloud of charge carriers increasing its effective inertia. In this equation one can consider the possibility that Planck constant is not the ordinary one. This obviously increases the critical temperature unless $n_c$ is scaled down in same proportion in the phase transition to large $\hbar$ phase.

2. The density of $n_c$ Cooper pairs can be estimated as the number of fermions in Fermi shell at $E_F$ having width $\Delta k$ deducible from $kT_c$. For $D = 3$-dimensional spherical Fermi surface one has

$$\begin{aligned} n_c &= \frac{1}{2}\frac{4\pi k_F^2\Delta k}{\frac{4}{3}\pi k_F^3}n \ , \\ kT_c &= E_F - E(k_F - \Delta k) \simeq \frac{h^2 k_F\Delta k}{m} \quad . \end{aligned} \tag{3.2.3}$$

Analogous expressions can be deduced in $D = 2$- and $D = 1$-dimensional cases and one has

$$n_c(D) = \frac{D}{2}\frac{T_c}{E_F}n(D) \quad . \tag{3.2.4}$$

The dimensionless coefficient is expressible solely in terms of $n$ and effective mass $m$. In [26] it is demonstrated that the inequality 3.2.2 replaced with equality when combined with 3.2.4 gives a satisfactory fit for 16 super-conductors used as a sample.

Note that the Planck constant appearing in $E_F$ and $T_c$ in Eq. 3.2.4 must correspond to ordinary Planck constant $\hbar_0$. This implies that equations 3.2.2 and 3.2.4 are consistent within orders of magnitudes. For $D = 2$, which corresponds to high $T_c$ superconductivity, the substitution of $n_c$ from Eq. 3.2.4 to Eq. 3.2.2 gives a consistency condition from which $n_c$ disappears completely. The condition reads as

$$n\lambda_F^2 = \pi = 4g \quad .$$

Obviously the equation is not completely consistent.

3. The magnetic penetration length $\lambda$ is expressible in terms of density $n_c$ of Cooper pairs as

$$\lambda^{-2} = \frac{4\pi e^2 n_c}{m_e} \quad . \tag{3.2.5}$$

The ratio $\kappa \equiv \frac{\lambda}{\xi}$ determines the type of the super conductor. For $\kappa < \frac{1}{\sqrt{2}}$ one has type I super conductor with defects having negative surface energy. For $\kappa \geq \frac{1}{\sqrt{2}}$ one has type II super conductor and defects have positive surface energy. Super-conductors of type I this results in complex stripe like flux patterns maximizing their area near criticality. The super-conductors of type II have $\kappa > 1/\sqrt{2}$ and the surface energy is positive so that the flux penetrates as flux quanta minimizing their area at lower critical value $H_{c_1}$ of magnetic field and completely at higher critical value $H_{c_2}$ of magnetic field. The flux quanta contain a core of size $\xi$ carrying quantized magnetic flux.

4. Quantum coherence length $\xi$ can be roughly interpreted as the size of the Cooper pair or as the size of the region where it is sensible to speak about the phase of wave function of Cooper pair. For larger separations the phases of wave functions are un-correlated. The values of $\xi$ vary in the range $10^3 - 10^4$ Angstrom for low $T_c$ super-conductors and in the range $5-20$ Angstrom for high $T_c$ super-conductors (assuming that they correspond to ordinary $\hbar$!) the ratio of these coherence lengths varies in the range $[50-2000]$, with upper bound corresponding to $n_F = 2^{11}$ for $\hbar$. This would give range $1-2$ microns for the coherence lengths of high $T_c$ super-conductors with lowest values of coherence lengths corresponding to the highest values of coherence lengths for low temperatures super conductors.

Uncertainty Principle $\delta E \delta t = \hbar/2$ using $\delta E = E_{gap} \equiv 2\Delta$, $\delta t = \xi/v_F$, gives an order of magnitude estimate for $\xi$ differing only by a numerical factor from the result of a rigorous calculation given by

$$\xi = \frac{4\hbar v_F}{E_{gap}} \ . \tag{3.2.6}$$

$E_{gap}$ is apart from a numerical constant equal to $T_c$: $E_{gap} = nT_c$. Using the expression for $v_F$ and $T_c$ in terms of the density of electrons, one can express also $\xi$ in terms of density of electrons.

For instance, BCS theory predicts $n = 3.52$ for metallic super-conductors and $n = 8$ holds true for cuprates [26]. For cuprates one obtains $\xi = 2n^{-1/3}$ [26]. This expression can be criticized since cuprates are Mott insulators and it is not at all clear whether a description as Fermi gas makes sense. The fact that high $T_c$ super-conductivity involves breakdown of anti-ferromagnetic order might justify the use of Fermi gas description for conducting holes resulting in the doping.

For large $\hbar$ the value of $\xi$ would scale up dramatically if deduced theoretically from experimental data using this kind of expression. If the estimates for $\xi$ are deduced from $v_F$ and $T_c$ purely calculationally as seems to be the case, the actual coherence lengths would be scaled up by a factor $\hbar/\hbar_0 = n_F$ if high $T_c$ super-conductors correspond to large $\hbar$ phase. As also found that this would also allow to understand the high critical temperature.

### 3.2.2 Universality of parameters in TGD framework

Universality idea conforms with quantum criticality of TGD Universe. The possibility to express everything in terms of density of critical temperature coding for the dynamics of Cooper pair formation and the density charge carriers would make it also easy to understand how p-adic scalings and transitions to large $\hbar$ phase affect the basic parameters. The possible problem is that the replacement of inequality of Eq. 3.2.2 with equality need not be sensible for large $\hbar$ phases. It will be found that in many-sheeted space-time $T_c$ does not directly correspond to the gap energy and the universality of critical temperature follows from the p-adic length scale hypothesis.

#### The effective of p-adic scaling on the parameters of super-conductors

*1. The behavior of the basic parameters under p-adic scaling and scaling of Planck constant*

p-Adic fractality expresses as $n \propto 1/L^3(k)$ would allow to deduce the behavior of the various parameters as function of the p-adic length scale and naive scaling laws would result. For instance, $E_{gap}$ and $T_c$ would scale as $1/L^2(k)$ if one assumes that the density $n$ of particles at larger space-time sheets scales p-adically as $1/L^3(k)$. The basic implication would be that the density of Cooper pairs and thus also $T_c$ would be reduced very rapidly as a function of the p-adic length scale. Without thermal isolation between these space-time sheets and hight temperature space-time sheets there would not be much hopes about high $T_c$ super-conductivity.

In the scaling of Planck constant basic length scales scale up and the overlap criterion for super-conductivity becomes easy to satisfy unless the density of electrons is reduced too dramatically. As found, also the critical temperature scales up so that there are excellent hopes of obtain high $T_c$ super-conductor in this manner. The claimed short correlation lengths are not a problem since they are calculational quantities. As a matter fact, the

*2. Could gap energies be universal?*

Suppose that the super-conducting electrons are at a space-time sheet corresponding to some p-adic length scale. They can leak to either larger or smaller space-time sheets via the formation of join along boundaries bonds. The energy $E_J$ associated with the formation of a join along boundaries bond connecting two space-time sheets characterized by $k_1$ and $k_2$ mediating transfer of Cooper pair to smaller space-time sheet defines a potential barrier so that for thermal energies below this energy no join along boundaries bonds are formed to smaller space-time sheets. The gap energy deduced from $T_c$ would not necessarily correspond in this case to the binding energy of Cooper pair but to the energy $E_J > E_{gap}$ of the join along boundaries bond.

One can imagine two options for $E_J$ in the approximation that the interaction energy of Cooper pair with surroundings is neglected.

Option I: The formation of JAB is a process completely independent from the flow of Cooper pair through it and thermal photons are responsible for it. In this case the order of magnitude for $E_J$ would naturally correspond to $\hbar/L(k_1)$. Cell size $L(167) = 2.5$ $\mu$m would correspond to $E_J \sim .4$ eV which does not make sense.

Option II: One cannot separate the flow of the Cooper pair through the JAB from its formation involving the localization to smaller space-time sheet requiring thermal photon to provide the difference of zero point kinetic energies. $E_J$ would naturally correspond to the difference $\Delta E_0 = E_0(k_1) - E_0(k_2)$ of zero point kinetic energies $E_0(k) = D\pi^2\hbar^2/4mL^2(k)$ of the Cooper pair, where $D$ is the effective dimensionality of the sheets. The reason why JABs inducing the flow $k_1 \rightarrow k_2$ of charge carriers are not formed spontaneously must be that charge carriers at $k_1$ space-time sheet are in a potential well. This option seems to work although it is certainly oversimplified since it neglects the interaction energy of Cooper pairs with other particles and wormhole throats behaving effectively like particles.

If $E_J$ given as difference of zero point kinetic energies, determines the critical temperature rather than $E_{gap}$, universality of the critical temperature as a difference of zero point kinetic energies is predicted. In this kind of situation the mechanism binding electrons to Cooper pairs is not relevant for what is observed as long as it produces binding energy and energy gap between ground state and first excited state larger than the thermal energy at the space-time sheet in question. This temperature is expected to scale as zero point kinetic energy. As already found, the work of Rabinowitz [26] seems to support this kind of scaling law.

*3. Critical temperatures for low and high $T_c$ super conductors*

Consider now critical temperatures for low and high $T_c$ electronic super-conductors for option II assuming $D = 3$.

1. For low $T_c$ super conductors and for the transition $k_2 = 167 \rightarrow k_1 = 163$ this would give $\Delta E_0 = E_0(163) \sim 6 \times 10^{-6}$ eV, which corresponds to $T_c \sim .06$ K. For $k_2 = 163 \rightarrow 157$ this would give $\Delta E \sim 1.9 \times 10^{-4}$ eV corresponding to 1.9 K. These orders of magnitude look rather reasonable since the coherence length $\xi$ expected to satisfy $\xi \leq L(k_2)$, varies in the range $.1 - 1$ $\mu$m for low $T_c$ super conductors.

2. For high $T_c$ super-conductors with $\xi$ in the range $5 - 20$ Angstrom, $E_J \sim 10^{-2}$ eV would give $k_1 = 149$, which would suggest that high $T_c$ super-conductors correspond to $k = 151$ and $\xi \ll L(k_2 = 151) = 10$ nm (cell membrane thickness). In this case $\Delta << E_J$ is quite possible so that high $T_c$ super-conductivity would be due to thermal isolation rather than a large value of energy gap. This provides a considerable flexibility concerning the modelling of mechanisms of Cooper pair formation.

*4. $E_J < E_{gap}$ case as a transition to partial super-conductivity*

For $E_J < E_{gap}$ the transition at $T_c \simeq E_J$ does not imply complete loss of resistivity since the Cooper pairs can flow to smaller space-time sheets and back without being destroyed and this is expected to induce dissipative effects. Some super-conductors such as $ZrZn_2$ ferromagnet do not lose their resistivity completely and the anomaly of specific heat is absent [28]. The mundane explanation is that super-conductivity exists only in clusters.

**The effect of the scaling of $\hbar$ to the parameters of BCS super-conductor**

It is of interest to study the behavior of the various parameters in the transition to the possibly existing large $\hbar$ variant of super-conducting electrons. Also small scalings of $\hbar$ are possible and the considerations to follow generalize trivially to this case. Under what conditions the behavior of the various parameters in the transition to large $\hbar$ phase is dictated by simple scaling laws?

1. *Scaling of $T_c$ and $E_{gap}$*

$T_c$ and $E_{gap}$ remain invariant if $E_{gap}$ corresponds to a purely classical interaction energy remaining invariant under the scaling of $\hbar$. This is not the case for BCS super-conductors for which the gap energy $\Delta$ has the following expression.

$$\begin{aligned}
\Delta &= \hbar\omega_c exp(-1/X) \ , \\
X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\
n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ . \\
\omega_c &= \omega_D = (6\pi^2)^{1/3}c_s n_n^{1/3} \ . \qquad (3.2.7)
\end{aligned}$$

Here $\omega_c$ is the width of energy region near $E_F$ for which "phonon" exchange interaction is effective. $n_n$ denotes the density of nuclei and $c_s$ denotes sound velocity.

$N(E_F)$ is the total number of electrons at the super-conducting space-time sheet. $U_0$ would be the parameter characterizing the interaction strength of of electrons of Cooper pair and should not depend on $\hbar$. For a structure of size $L \sim 1\ \mu$ m one would have $X \sim n_a 10^{12}\frac{U_0}{E_F}$, $n_a$ being the number of exotic electrons per atom, so that rather weak interaction energy $U_0$ can give rise to $\Delta \sim \omega_c$.

The expression of $\omega_c$ reduces to Debye frequency $\omega_D$ in BCS theory of ordinary super conductivity. If $c_s$ is proportional to thermal velocity $\sqrt{T_c/m}$ at criticality and if $n_n$ remains invariant in the scaling of $\hbar$, Debye energy scales up as $\hbar$. This can imply that $\Delta > E_F$ condition making scaling non-sensible unless one has $\Delta \ll E_F$ holding true for low $T_c$ super-conductors. This kind of situation would *not* require large $\hbar$ phase for electrons. What would be needed that nuclei and phonon space-time sheets correspond to large $\hbar$ phase.

What one can hope is that $\Delta$ scales as $\hbar$ so that high $T_c$ superconductor would result and the scaled up $T_c$ would be above room temperature for $T_c > .15$ K. If electron is in ordinary phase $X$ is automatically invariant in the scaling of $\hbar$. If not, the invariance reduces to the invariance of $U_0$ and $E_F$ under the scaling of $\hbar$. If $n$ scales like $1/\hbar^D$, $E_F$ and thus $X$ remain invariant. $U_0$ as a simplified parametrization for the interaction potential expressible as a tree level Feynman diagram is expected to be in a good approximation independent of $\hbar$.

It will be found that high in high $T_c$ super-conductors, which seem to be quantum critical, a high $T_c$ variant of phonon mediated superconductivity and exotic superconductivity could be competing. This would suggest that the phonon mediated superconductivity corresponds to a large $\hbar$ phase for nuclei scaling $\omega_D$ and $T_c$ by a factor $\simeq 2^{11}$.

Since the total number $N(E_F)$ of electrons at larger space-time sheet behaves as $N(E_F) \propto E_F^{D/2}$, where $D$ is the effective dimension of the system, the quantity $1/X \propto E_F/n(E_F)$ appearing in the expressions of the gap energy behaves as $1/X \propto E_F^{-D/2+1}$. This means that at the limit of vanishing electron density $D = 3$ gap energy goes exponentially to zero, for $D = 2$ it is constant, and for $D = 1$ it goes zero at the limit of small electron number so that the formula for gap energy reduces to $\Delta \simeq \omega_c$. These observations suggests that the super-conductivity in question should be 2- or 1-dimensional phenomenon as in case of magnetic walls and flux tubes.

2. *Scaling of $\xi$ and $\lambda$*

If $n_c$ for high $T_c$ super-conductor scales as $1/\hbar^D$ one would have $\lambda \propto \hbar^{D/2}$. High $T_c$ property however suggests that the scaling is weaker. $\xi$ would scale as $\hbar$ for given $v_F$ and $T_c$. For $D = 2$ case the this would suggest that high $T_c$ super-conductors are of type I rather than type II as they would be for ordinary $\hbar$. This conforms with the quantum criticality which would be counterpart of critical behavior of super-conductors of type I in nearly critical magnetic field.

*3. Scaling of $H_c$ and $B$*

The critical magnetization is given by

$$H_c(T) = \frac{\Phi_0}{\sqrt{8\pi}\xi(T)\lambda(T)} \tag{3.2.8}$$

where $\Phi_0$ is the flux quantum of magnetic field proportional to $\hbar$. For $D=2$ and $n_c \propto \hbar^{-2}$ $H_c(T)$ would not depend on the value of $\hbar$. For the more physical dependence $n_c \propto \hbar^{-2+\epsilon}$ one would have $H_c(T) \propto \hbar^{-\epsilon}$. Hence the strength of the critical magnetization would be reduced by a factor $2^{-11\epsilon}$ in the transition to the large $\hbar$ phase with $n_F = 2^{-11}$.

Magnetic flux quantization condition is replaced by

$$\int 2eBdS = n\hbar 2\pi \ . \tag{3.2.9}$$

$B$ denotes the magnetic field inside super-conductor different from its value outside the super-conductor. By the quantization of flux for the non-super-conducting core of radius $\xi$ in the case of super-conductors of type II $eB = \hbar/\xi^2$ holds true so that $B$ would become very strong since the thickness of flux tube would remain unchanged in the scaling.

### 3.2.3 Quantum criticality and super-conductivity

The notion of quantum criticality has been already discussed in introduction. An interesting prediction of the quantum criticality of entire Universe also gives naturally rise to a hierarchy of macroscopic quantum phases since the quantum fluctuations at criticality at a given level can give rise to higher level macroscopic quantum phases at the next level. A metaphor for this is a fractal cusp catastrophe for which the lines corresponding to the boundaries of cusp region reveal new cusp catastrophes corresponding to quantum critical systems characterized by an increasing length scale of quantum fluctuations.

Dark matter hierarchy could correspond to this kind of hierarchy of phases and long ranged quantum slow fluctuations would correspond to space-time sheets with increasing values of $\hbar$ and size. Evolution as the emergence of modules from which higher structures serving as modules at the next level would correspond to this hierarchy. Mandelbrot fractal with inversion analogous to a transformation permuting the interior and exterior of sphere with zooming revealing new worlds in Mandelbrot fractal replaced with its inverse would be a good metaphor for what quantum criticality would mean in TGD framework.

#### How the quantum criticality of superconductors relates to TGD quantum criticality

There is empirical support that super-conductivity in high $T_c$ super-conductors and ferromagnetic systems [28, 29] is made possible by quantum criticality [27]. In the experimental situation quantum criticality means that at sufficiently low temperatures quantum rather than thermal fluctuations are able to induce phase transitions. Quantum criticality manifests itself as fractality and simple scaling laws for various physical observables like resistance in a finite temperature range and also above the critical temperature. This distinguishes sharply between quantum critical super conductivity from BCS type super-conductivity. Quantum critical super-conductivity also exists in a finite temperature range and involves the competition between two phases.

The absolute quantum criticality of the TGD Universe maps to the quantum criticality of subsystems, which is broken by finite temperature effects bringing dissipation and freezing of quantum fluctuations above length and time scales determined by the temperature so that scaling laws hold true only in a finite temperature range.

Reader has probably already asked what quantum criticality precisely means. What are the phases which compete? An interesting hypothesis is that quantum criticality actually corresponds to criticality with respect to the phase transition changing the value of Planck constant so that the competing phases would correspond to different values of $\hbar$. This hypothesis seems to work in the case of high $T_c$ super-conductivity. The prediction is that quantum criticality sets on at some critical temperature $T_{c_1} > T_c$ meaning the emergence of exotic Cooper pairs which are however unstable against decay to ordinary electrons so that the super-conductivity in question gives rise to ordinary conductivity in time scales longer than the lifetime of exotic Cooper pair dictated by temperature. These exotic Cooper pairs can also transform to BCS type Cooper pairs which are stable below $T_c$.

**Scaling up of de Broglie wave lengths and criterion for quantum overlap**

Compton lengths and de Broglie wavelengths are scaled up by an integer $n$, whose preferred values correspond to $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes. In particular, $n_F = 2^{k11}$ seem to be favored. The scaling up means that the overlap condition $\lambda \geq 2d$ for the formation of Bose-Einstein condensate can be satisfied and the formation of Cooper pairs becomes possible. Thus a hierarchy of large $\hbar$ super-conductivities would be associated with to the dark variants of ordinary particles having essentially same masses as the ordinary particles.

Unless one assumes fractionization, the invariance of $E_F \propto \hbar_{eff}^2 n^{2/3}$ in $\hbar$ increasing transition would require that the density of Cooper pairs in large $\hbar$ phase is scaled down by an appropriate factor. This means that supra current intensities, which are certainly measurable quantities, are also scaled down. Of course, it could happen that $E_F$ is scaled up and this would conform with the scaling of the gap energy.

**Possible implications of charge and spin fractionization**

Masses as given by representations of super conformal algebras and p-adic thermodynamics are invariant under changes of the Planck constants. The original assumption that Poincare quantum numbers are invariant in Planck constant changing quantum transition is however too strong and conflicts with the model explaining quantization of planetary orbits in terms of gigantic value of $\hbar_{eff}$ [D6, J6]. What happens is spin fractionization with unit of spin replaced with $n_a/n_b$ and fractionization of color and presumably of also electro-weak charges with unit given by $n_b/n_a$. For instance, $n_a/n_b$ fractionization would happen for angular momentum quantum number $m$, for the integer $n$ characterizing the Bohr orbits of atom, harmonic oscillator, and integers labelling the states of particle in box.

The fractionization can be understood in terms of multiple covering of $M^4$ by symmetry related $CP_2$ points formed in the phase transition increasing $\hbar$ [A9]. The covering is characterized by $G_b \subset SU(2) \subset SU(3)$ and fixed points correspond to orbifold points. The copies of imbedding space with different $G$ are glued with each other along $M^4$ factors at orbifold point, representing origin of $CP_2$.

An interesting implication of spin fractionization is that for $n_a$ and $n_b = 1$ the unit of spin would become $n_a$ standard units. This might be interpreted by saying that minimum size of a Bose Einstein condensate consisting of spin 1 Cooper pairs is $n_b/2$ Cooper pairs with spin 1. On the other hand charge could be fractionized to $e/n_b$ in this case. A possible interpretation is that electron is delocalized to $n_a$ separate $G_a$ related sheets of the $M^4$ covering of $CP_2$ projection such that each of them carries a fractional charge $e/n_a$. Geometrically this would correspond to a ring consisting of $n_a$ discrete points.

**Quantum critical super-conductors in TGD framework**

For quantum critical super-conductivity in heavy fermions systems, a small variation of pressure near quantum criticality can destroy ferromagnetic (anti-ferromagnetic) order so that Curie (Neel) temperature goes to zero. The prevailing spin fluctuation theory [31] assumes that these transitions are induced by long ranged and slow spin fluctuations at critical pressure $P_c$. These fluctuations make and break Cooper pairs so that the idea of super-conductivity restricted around critical point is indeed conceivable.

Heavy fermion systems, such as cerium-indium alloy $CeIn_3$ are very sensitive to pressures and a tiny variation of density can drastically modify the low temperature properties of the systems. Also other systems of this kind, such as $CeCu_2Ge_2$, $CeIn_3$, $CePd_2Si_2$ are known [28, 30]. In these cases super-conductivity appears around anti-ferromagnetic quantum critical point.

The last experimental breakthrough in quantum critical super-conductivity was made in Grenoble [29]. URhGe alloy becomes super-conducting at $T_c = .280$ K, loses its super-conductivity at $H_c = 2$ Tesla, and becomes again super-conducting at $H_c = 12$ Tesla and loses its super-conductivity again at $H = 13$ Tesla. The interpretation is in terms of a phase transition changing the magnetic order inducing the long range spin fluctuations.

TGD based models of atomic nucleus [F8] and condensed matter [F9] assume that weak gauge bosons with Compton length of order atomic radius play an essential role in the nuclear and condensed matter physics. The assumption that condensed matter nuclei possess anomalous weak charges explains the repulsive core of potential in van der Waals equation and the very low compressibility of condensed matter phase as well as various anomalous properties of water phase, provide a mechanism of cold fusion and sono-fusion, etc. [F9, J6]. The pressure sensitivity of these systems would directly reflect the physics of exotic quarks and electro-weak gauge bosons. A possible mechanism behind the phase transition to super-conductivity could be the scaling up of the sizes of the space-time sheets of nuclei.

Also the electrons of Cooper pair (and only these) could make a transition to large $\hbar$ phase. This transition would induce quantum overlap having geometric overlap as a space-time correlate. The formation of join along boundaries bonds between neighboring atoms would be part of the mechanism. For instance, the criticality condition $4n^2\alpha = 1$ for BE condensate of $n$ Cooper pairs would give $n = 6$ for the size of a higher level quantum unit possibly formed formed from Cooper pairs. If one does not assume invariance of energies obtained by fractionization of principal quantum number, this transition has dramatic effects on the spectrum of atomic binding energies scaling as $1/\hbar^2$ and practically universal spectrum of atomic energies would result [J6] not depending much on nuclear charge. It seems that this prediction is non-physical.

Quantum critical super-conductors resemble superconductors of type I with $\lambda \ll \xi$ for which defects near thermodynamical criticality are complex structures looking locally like stripes of thickness $\lambda$. These structure are however dynamical in super-conducting phase. Quite generally, long range quantum fluctuations due to the presence of two competing phases would manifest as complex dynamical structures consisting of stripes and their boundaries. These patterns are dynamical rather than static as in the case of ordinary spin glass phase so that quantum spin glass or 4-D spin glass is a more appropriate term.

The breaking of classical non-determinism for vacuum extremals indeed makes possible space-time correlates for quantum non-determinism and this makes TGD Universe a 4-dimensional quantum spin glass. The model for high $T_c$ super-conductors leads to the conclusion that the boundaries between the two phases are the carriers of the supra currents. Wormhole contacts appear naturally at boundaries and the mere assumption that $q\overline{q}$ type wormhole contacts feed the em gauge flux of electrons from the space-time sheet of Cooper pair to a larger space-time sheet predicts correctly the properties of high $T_c$ Cooper pairs.

### Could quantum criticality make possible new kinds of high $T_c$ super-conductors?

The transition to large $\hbar$ phase increases various length scales by $n/v_0$ and makes possible long range correlations even at high temperatures. Hence the question is whether large $\hbar$ phase could correspond to ordinary high $T_c$ super-conductivity. If this were the case in the case of ordinary high $T_c$ super-conductors, the actual value of coherence length $\xi$ would vary in the range $5-20$ Angstrom scaled up by a factor $n/v_0$ to $n - 40n$ $\mu$m to be compared with the range $.2-2$ $\mu$m for low $T_c$ super-conductors. The density of Cooper pairs would be scaled down by an immensely small factor $2^{-33}/n^3$ from its value deduced from Fermi energy so that neither high $T_c$ nor ordinary super-conductors can correspond to larger $\hbar$ phase for electrons.

Large $\hbar$ phase for some nuclei might be involved and make possible large space-time sheets of size at least of order of $\xi$ at which conduction electrons forming Cooper pairs would topologically condense like quarks around hadronic space-time sheets (in [F9] a model of water as a partially dark matter with one fourth of hydrogen ions in large $\hbar$ phase is developed).

Consider for a moment the science fictive possibility that super conducting electrons for some quantum critical super-conductors to be discovered or already discovered correspond to large $\hbar$ phase with $\hbar(k) = n_F\hbar_0$ keeping in mind that this affects only quantum corrections in perturbative approach but not the lowest order classical predictions of quantum theory. For $n_F = n/v_0 \simeq n2^{k11}$ with $k = 1, n = 1$ the size of magnetic body would be $L(149) = 5$ nm, the thickness of the lipid layer of cell membrane. For $k = 2, n = 1$ the size would be $L(171) = 10$ $\mu$m, cell size. If the density of Cooper pairs is of same order of magnitude as in case of ordinary super conductors, the critical temperature is scaled up by $2^{k11}$. Already for $k = 1$ the critical temperature of 1 K would be scaled up to $4n^2 \times 10^6$

K if $n_c$ is not changed. This assumption is not consistent with the assumption that Fermi energy remains non-relativistic. For $n = 1$ $T_c = 400$ K would be achieved for $n_c \rightarrow 10^{-6}n_c$, which looks rather reasonable since Fermi energy transforms as $E_F \rightarrow 8 \times 10^3 E_F$ and remains non-relativistic. $H_c$ would scale down as $1/\hbar$ and for $H_c = .1$ Tesla the scaled down critical field would be $H_c = .5 \times 10^{-4}$ Tesla, which corresponds to the nominal value of the Earth's magnetic field.

Quantum critical super-conductors become especially interesting if one accepts the identification of living matter as ordinary matter quantum controlled by macroscopically quantum coherent dark matter. One of the basic hypothesis of TGD inspired theory of living matter is that the magnetic flux tubes of the Earth's magnetic field carry a super-conducting phase and the spin triplet Cooper pairs of electrons in large $\hbar$ phase might realize this dream. That the value of Earth's magnetic field is near to its critical value could have also biological implications.

### 3.2.4 Space-time description of the mechanisms of super-conductivity

The application of ideas about dark matter to nuclear physics and condensed matter suggests that dark color and weak forces should be an essential element of chemistry and condensed matter physics. The continual discovery of new super-conductors, in particular of quantum critical superconductors, suggests that super-conductivity is not well understood. Hence super-conductivity provides an obvious test for these ideas. In particular, the idea that wormhole contacts regarded as parton pairs living at two space-time sheets simultaneously, provides an attractive universal mechanism for the formation of Cooper pairs and is not so far-fetched as it might sound first.

#### Leading questions

It is good to begin with a series of leading questions.

1. The work of Rabinowitch [26] suggests that that the basic parameters of super-conductors might be rather universal and depend on $T_c$ and conduction electron density only and be to a high degree independent of the mechanism of super-conductivity. This is in a sharp contrast to the complexity of even BCS model with its somewhat misty description of the phonon exchange mechanism.
   Questions: Could this mean that there exists a simple universal description of various kinds of super-conductivities? Could this mechanism involve large $\hbar$ phase for nuclei in case of quantum critical super-conductivity? Could wormhole contacts or their Bose-Einstein condensate play some role. Are the Cooper pairs of quantum critical super-conductors at the boundaries of the competing phases?

2. The effective masses of electrons in ferromagnetic super-conductors are in the range of 10-100 electron masses [28] and this forces to question the idea that ordinary Cooper pairs are current carriers. Quantum classical correspondence requires that bound states involve formation of join along boundaries bonds between bound particles. In the case of Cooper pairs in ordinary superconductors the length of join along boundaries bonds between electrons should be of order $10^3 - 10^4$ Angstroms. This looks rather strange.

   Questions: Could quantum classical correspondence help to identify the mechanism giving rise to Cooper pairs? The simplest model of pair is as a space-time sheet with size of order $\xi$ so that the electrons are "outside" the background space-time. Could the Coulomb interaction energy of electrons with positively charged wormhole throats carrying parton numbers and feeding em gauge flux to the large space-time sheet be responsible for the gap energy? Could wormhole throats carry also quark quantum numbers and form color singlet like structures connected by long color flux tubes so that color force would be ultimately responsible for the stability of Cooper pair? In case of single electron condensed to single space-time sheet the em flux could be indeed feeded by $u$ and $\overline{d}$ type wormhole contacts to larger space-time sheet. Or could electrons be free-travellers bound to structures involving also other particles?

3. Quantum classical correspondence forces to ask for the space-time correlates for the existing quantum description of phonons.
   Questions: What are the space-time sheets associated with phonons? Could the microscopic

description of phonons in atomic length scales rely on the oscillations of wormhole contact Bose-Einstein condensates at the boundaries of nucleon space-time sheets with size scale of order atom size? Could the dark weak length scale which is of order atomic size replace lattice constant in the expression of sound velocity? What is the space-time correlate for sound velocity?

4. The new super-conductors possess relatively complex chemistry and lattice structure. Questions: Could it be that complex chemistry and lattice structure makes possible something very simple which is a transition to dark nuclear phase so that size of dark quarks involved would be scaled up to $L(k \rightarrow k+22 \rightarrow k+44)$, say $k = 113 \rightarrow 135 \rightarrow 157)$, and the size of hadronic space-time sheets would be scaled up as $k = 107 \rightarrow 129 \rightarrow 151$? Could it be that also other p-adic primes are possible as suggested by the p-adic mass calculations of hadron masses predicting that hadronic quarks can correspond to several values of $k$? Could it be that the Gaussian Mersennes $(1+i)^k - 1$, $k = 151, 157, 163, 167$ spanning the p-adic length scale range 10 nm-2.5 $\mu$m correspond to p-adic length especially relevant for super-conductivity.

#### Photon massivation, coherent states of Cooper pairs, and wormhole contacts

The existence of wormhole contacts have been one of the most exotic predictions of TGD. The realization that wormhole contacts can be regarded as parton-antiparton pairs with parton and antiparton assignable to the light-like causal horizons accompanying wormhole contacts, and that Higgs particle corresponds to wormhole contact [F2], opens the doors for more concrete models of also super-conductivity involving massivation of photons.

The formation of a coherent state of wormhole contacts would be the counterpart for the vacuum expectation value of Higgs. The notions of coherent states of Cooper pairs and of charged Higgs challenge the conservation of electromagnetic charge. The following argument however suggests that coherent states of wormhole contacts form only a part of the description of ordinary super-conductivity. The basic observation is that wormhole contacts with vanishing fermion number define space-time correlates for Higgs type particle with fermion and antifermion numbers at light-like throats of the contact.

The ideas that a genuine Higgs type photon massivation is involved with super-conductivity and that coherent states of Cooper pairs really make sense are somewhat questionable since the conservation of charge and fermion number is lost. A further questionable feature is that a quantum superposition of many-particle states with widely different masses would be in question. The interpretational problems could be resolved elegantly in zero energy ontology [C2] in which the total conserved quantum numbers of quantum state are vanishing. In this picture the energy, fermion number, and total charge of any positive energy state are compensated by opposite quantum numbers of the negative energy state in geometric future. This makes possible to speak about superpositions of Cooper pairs and charged Higgs bosons separately in positive energy sector.

Rather remarkably, if this picture is taken seriously, super-conductivity can be seen as providing a direct support for both the hierarchy of scaled variants of standard model physics and for the zero energy ontology.

#### Phonon exchange mechanism

Sound waves correspond to density variations of condensed matter. If dark gluons and exotic weak bosons with weak scale of order atomic radius explain the low compressibility of condensed matter [F9] then these forces should be essential for the description of what happens for sound waves below the atomic length scale. In particular, the lattice length appearing in Debye frequency should be expressible in terms of dark weak length scale.

Quantum classical correspondence requires that phonons should have identification as space-time sheets and that sound velocity is coded in the geometry of the space-time sheet. This interpretation of course makes sense only if the space-time sheet of phonon is in contact with atoms so that atomic oscillations induce oscillations of the induced gauge fields inside it.

The obvious objection against this picture is that one can imagine the possibility of free phonons analogous to photons connecting nuclei with say distance of micrometer and having no contact with the nuclei in between. One can of course turn the situation around and ask whether free phonons are the hen and lattice oscillations the egg. Could free photons exist and induce resonant oscillations of atomic nuclei if their velocity is consistent with the sound velocity deducible from the lattice constant and elastic constant for the interactions between atoms?

The existence of warped vacuum extremals, and in general the huge vacuum degeneracy of field equations, suggest how this space-time representation of phonons might occur. The simplest warped extremal corresponds to the mapping $M^4 \rightarrow CP_2$ defined as $\Phi = \omega m^0$, where $\Phi$ is coordinate of the geodesic circle of $CP_2$ with other coordinates being constant. The induced metric is $g_{m^0m^0} = 1 - R^2\omega^2/4$, $g_{ij} = -\delta_{ij}$. Light velocity with respect to $M^4$ coordinates, which are physically preferred coordinates, is reduced to $v = \sqrt{1 - R^2\omega^2/4}$. The crazy guess would be that the reduced signal velocity could have interpretation as sound velocity with the previous prerequisites.

For small perturbations of vacuum extremals the term coming from the variation with respect to the induced metric vanishes, and the only contribution comes from the variation of the induced Kähler form. As a consequence, the field equations reduce to empty space Maxwell's equations $j_K^\alpha = 0$ for the induced Kähler form in the induced metric of determined by vacuum extremal in the lowest non-trivial order. This means that the maximal signal velocity is in general reduced and the reduction can be very large as the case of warped vacuum extremals demonstrates. The longitudinal Kähler electric field associated with phonons would serve as a correlate for the longitudinal sound waves.

In higher orders the solution develops a non-vanishing Kähler current $j_K^\alpha$ and this relates naturally to the fact that the phonon exchange involves dissipation. In the case of the simplest warped vacuum extremals the relevant parameter for the perturbation theory is $\omega R$ which is near to unity so that perturbative effects can be quite sizable if the phonons are representable in the proposed manner. The non-vanishing of the vacuum Lorentz force $j_K^\alpha J_{\alpha\beta}$ serves as a space-time correlate for the presence of dissipative effects. For the known solutions of field equations the Lorentz force vanishes and the interpretation is that they represent asymptotic self-organization patters. Phonons would be different and represent transient phenomena.

If this interpretation is correct, the phonon mechanism for the formation of Cooper pairs could have a description in terms of the topological condensation of electrons at space-time sheets representing phonons connecting atomic nuclei. The essential point would be that electrons of Cooper pair would be outside the space-time in well-defined sense. Also now wormhole contacts would be involved but the Coulomb interaction energy of delocalized electrons with charged wormhole throats would be negligible as compared to the interaction energy with nuclei.

**Space-time correlate for quantum critical superconductivity**

The series of leading questions has probably given reader a hunch about what the mechanism of super-conductivity could be in the quantum critical case.

*1. Exotic Cooper pair as a pair of space-time sheets of scaled up electrons feeding their gauge fluxes to a larger space-time sheet via $q\overline{q}$ type wormhole contacts*

Quantum critical electronic super-conductivity requires new kind of Cooper pairs which are responsible for supra currents in the temperature range $[T_c, T_{c_1}]$ inside stripe like regions (flux tubes). These Cooper pairs are quantum critical against decay to ordinary electrons so that in time scale characterizing quantum criticality so that super-conductivity is reduced to conductivity whose temperature dependence is characterized by scaling laws. Below $T_c$ large $\hbar$ variants of BCS Cooper pairs are good candidates for supra current carriers and would result from exotic Cooper pairs. A model for the exotic Cooper pairs is considered in the sequel. Boundary plays an essential role in that the Cooper pairs at boundary must be in quantum critical phase also below $T_c$ since otherwise the transformation of ordinary electrons to large $\hbar$ BCS type Cooper pairs and vice versa is not possible.

If wormhole contact for large $\hbar$ electron corresponds to $e^+e^-$ pairs, one ends up with a stability problem since the annihilation of electron and $e^+$ at wormhole throat can lead to the disappearance of the space-time sheet. If there are two wormhole contacts corresponding to quark anti-quark pairs the situation changes. The requirement that the net charge of wormhole throats is +2e implies $u\overline{d}$ configuration for upper wormhole throats and its conjugate for the lower wormhole throats. If the wormhole throats of each electron carry net color quantum numbers the binding of electrons by color confining force would guarantee the stability of the exotic Cooper pair. This would require that wormhole throats form a color singlet not reducible to product of pion type $u\overline{d}$ type color singlets.

BCS type Cooper pair results when both electrons end up at same space-time sheet of exotic Cooper pair via a join along boundaries bond. This hopping would also drag the wormhole contacts with it and the second space-time sheet could contract. These Cooper pairs can in principle transform to pairs involving only two join along boundaries contacts carrying $e^+e^-$ pairs at their throats. For these Cooper pairs case the binding of electrons would be due to phonon mechanism.

*2. General comments*

Some general comments about the model are in order.

1. High $T_c$ super conductors are Mott insulators and antiferromagnets in their ground state, which would suggest that the notion of non-interacting Fermi gas crucial for BCS type description is not useful. Situation is however not so simple if antiferromagnetic phase and magnetically disordered phase with large $\hbar$ for nuclei compete at quantum criticality. Large $\hbar$ makes possible high $T_c$ variant of BCS type superconductivity in magnetically disordered phase in interior of rivulets but it is possible to get to this phase only via a phase consisting of exotic Cooper pairs and this is possible only in finite temperature range below $T_c$.

2. For both exotic and phonon mediated super-conductivity Cooper pair can be said to be outside the space-time sheet containing matter. Assuming a complete delocalization in the exotic case, the interaction energy is the expectation value of the sum of kinetic and Coulombic interaction energies between electrons and between electrons and wormhole throats. In the case of phonon space-time sheets situation is different due to the much larger size of Cooper pair space-time sheet so that Coulomb interaction with wormhole throats provides the dominating contribution to the binding energy.

3. The explicit model for high $T_c$ super-conductivity relies on quantum criticality involving long ranged quantum fluctuations. The mechanism seems could apply in all cases where quantum critical fluctuations can be said to be carriers of supra currents and exotic super-conductivity vanishes when either phase dominates completely. In the case of high $T_c$ super-conductors quantum criticality corresponds to a quite wide temperature range, which provides support for the quantum criticality of TGD Universe.

### 3.2.5 Super-conductivity at magnetic flux tubes

Super-conductivity at magnetic flux tubes of magnetic flux quanta is one the basic hypothesis of the TGD based model of living matter. There is also evidence for magnetically mediated super-conductivity in extremely pure samples [32]. The magnetic coupling was only observed at lattice densities close to the critical density at which long-range magnetic order is suppressed. Quantum criticality suggests that the super-conductivity appears at the boundaries of two competing phases and that Cooper pairs correspond to space-time sheets feeding their em gauge charge via $q\overline{q}$ type wormhole contacts to larger space-time sheet.

Almost the same model as in the case of high $T_c$ and quantum critical super-conductivity applies to magnetic flux tubes. Now the flux quantum contains BE condensate of exotic Cooper pairs interacting with wormhole contacts feeding the gauge flux of Cooper pairs from the magnetic flux quantum to a larger space-time sheet. The interaction of spin 1 Cooper pairs with the magnetic field of flux quantum orients their spins in the same direction. Large value of $\hbar$ guarantees thermal stability even in the case that different space-time sheets are not thermally isolated.

#### Superconductors at the flux quanta of the Earth's magnetic field

Magnetic flux tubes and magnetic walls are the most natural candidates for super-conducting structures with spin triplet Cooper pairs. Indeed, experimental evidence relating to the interaction of ELF em radiation with living matter suggests that bio-super-conductors are effectively 1- or 2-dimensional. $D \leq 2$-dimensionality is guaranteed by the presence of the flux tubes or flux walls of, say, the magnetic field of Earth in which charge carries form bound states and the system is equivalent with a harmonic oscillator in transversal degrees of freedom.

The effect of Earth's magnetic field is completely negligible at the atomic space-time sheets and cannot make super conductor 1-dimensional. At cellular sized space-time sheets magnetic field makes possible the confinement of the electron Cooper pairs in harmonic oscillator states. The critical temperature is however extremely low for ordinary value of $\hbar$ and either thermal isolation between space-time sheets or large value of $\hbar$ can save the situation.

An essential element of the picture is that topological quantization of the magnetic flux tubes occurs. In fact, the flux tubes of Earth's magnetic field have thickness of order cell size from the quantization of magnetic flux. The observations about the effects of ELF em fields on bio-matter [77, 59] suggest that similar mechanism is at work also for ions and in fact give very strong support for bio-super conductivity based on the proposed mechanism.

### Energy gaps for superconducting magnetic flux tubes and walls

Besides the formation of Cooper pairs also Bose-Einstein condensation to the ground state occurs and the stability of Bose-Einstein condensate requires an energy gap which must be larger than the temperature at the magnetic flux tube.

There are several energies to be considered.

1. The Coulombic binding energy of Cooper pairs with the wormhole contacts feeding the em flux from magnetic flux tube to a larger space-time sheet defines an energy gap which is expected to be of order $E_g = \alpha/L(k)$ giving $E_g \sim 10^{-3}$ eV for $L(167) = 2.5\ \mu$m giving a rough estimate for the thickness of the magnetic flux tube of the Earth's magnetic field $B = .5 \times 10^{-4}$ Tesla.

2. In longitudinal degrees of freedom of the flux tube Cooper pairs can be described as particles in a one-dimensional box and the gap is characterized by the length $L$ of the magnetic flux tube and the value of $\hbar$. In longitudinal degrees of freedom the difference between $n = 2$ and $n = 1$ states is given by $E_0(k_2) = 3h^2/4m_eL^2(k_2)$. Translational energy gap $E_g = 3E_0(k_2) = 3h^2/4m_eL^2(k_2)$ is smaller than the effective energy gap $E_0(k_1) - E_0(k_2) = h^2/4m_eL^2(k_1) - h^2/4m_eL^2(k_2)$ for $k_1 > k_2 + 2$ and identical with it for $k_1 = k_2 + 2$. For $L(k_2 = 151)$ the zero point kinetic energy is given by $E_0(151) = 20.8$ meV so that $E_g$ corresponds roughly to a temperature of 180 K. For magnetic walls the corresponding temperature would be scaled by a factor of two to 360 K and is above room temperature.

3. Second troublesome energy gap relates to the interaction energy with the magnetic field. The magnetic interaction energy $E_m$ of Cooper pair with the magnetic field consists of cyclotron term $E_c = n\hbar eB/m_e$ and spin-interaction term which is present only for spin triplet case and is given by $E_s = \pm\hbar eB/m_e$ depending on the orientation of the net spin with magnetic field. In the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field) explaining the effects of ELF em fields on vertebrate brain, this energy scale is $\sim 10^{-9}$ eV for ordinary value of $\hbar$ and $\sim 2n \times 10^{-6}$ eV for $\hbar = n2^{11} \times \hbar(1)$. At the next level of dark hierarchy the energy would be $4n^2 \times 10^{-3}$ eV and would still correspond to a temperature $4n^2$ K.

The smallness of translational and magnetic energy gaps in the case of Cooper pairs at Earth's magnetic field could be seen as a serious obstacle.

1. Thermal isolation between different space-time sheets provides one possible resolution of the problem. The stability of the Bose-Einstein condensation is guaranteed by the thermal isolation of space-time if the temperature at the magnetic flux tube is below $E_m$. This can be achieved in all length scales if the temperature scales as the zero point kinetic energy in transversal degrees of freedom since it scales in the same manner as magnetic interaction energy.

2. The transition to large $\hbar$ phase could provide a more elegant way out of the difficulty. The criterion for a sequence of transitions to a large $\hbar$ phase could be easily satisfied if there is a large number of charge Cooper pairs at the magnetic flux tube. Kinetic energy gap remains invariant if the length of the flux tube scales as $\hbar$. If magnetic flux is quantized as a multiple of $\hbar$ and flux tube thickness scales as $\hbar^2$, $B$ must scale as $1/\hbar$ so that also magnetic energy remains invariant under the scaling. This would allow to have stability without assuming low temperature at magnetic flux tubes.

## 3.3 TGD based model for high $T_c$ super conductors

The model of exotic Cooper pairs has been already described and since high $T_c$ superconductors are quantum critical, they provide an attractive application of the model.

### 3.3.1 Some properties of high $T_c$ super conductors

Quite generally, high $T_c$ super-conductors are cuprates with CuO layers carrying the supra current. The highest known critical temperature for high $T_c$ superconductors is 164 K and is achieved under huge pressure of $3.1 \times 10^5$ atm for LaBaCuO. High $T_c$ super-conductors are known to be super conductors of type II.

This is however a theoretical deduction following from the assumption that the value of Planck constant is ordinary. For $\hbar = 2^{11}\hbar_0$ $\xi$ would be scaled up accordingly and type I super-conductor would be in question. These super-conductors are characterized by very complex patterns of penetrating magnetic field near criticality since the surface area of the magnetic defects is maximized. For high $T_c$ super-conductors the ferromagnetic phase could be regarded as an analogous defect and would indeed have very complex structure. Since quantum criticality would be in question the stripe structure would fluctuate with time too in accordance with 4-D spin glass character.

The mechanism of high $T_c$ super conductivity is still poorly understood [41, 51]. It is agreed that electronic Cooper pairs are charge carriers. It is widely accepted that electrons are in relative d-wave state rather than in s-wave (see [40] and the references mentioned in [41]). Cooper pairs are believed to be in spin triplet state and electrons combine to form $L = 2$ angular momentum state. The usual phonon exchange mechanism does not generate the attractive interaction between the members of the Cooper pair having spin. There is also a considerable evidence for BCS type Cooper pairs and two kinds of Cooper pairs could be present.

High $T_c$ super conductors have spin glass like character [39]. High $T_c$ superconductors have anomalous properties also above $T_c$ suggesting quantum criticality implying fractal scaling of various observable quantities such as resistivity. At high temperatures cuprates are anti-ferromagnets and Mott insulators meaning freezing of the electrons. Superconductivity and conductivity is known to occur along dynamical stripes which are antiferromagnetic defects.

These findings encourage to consider the interpretation in terms of quantum criticality in which some new form of super conductivity which is not based on quasiparticles is involved. This superconductivity is assignable with the quantum fluctuations destroying antiferromagnetic order and replacing it with magnetically disordered phase possibly allowing phonon induced super-conductivity.

The doping of the super-conductor with electron holes is essential for high $T_c$ superconductivity and the there is a critical doping fraction $p = .14$ at which $T_c$ is highest. There is considerable evidence that holes gather on one-dimensional stripes with thickness of order few atom sizes and lengths in the range 1-10 nm [51], which are fluctuating in time scale of $10^{-12}$ seconds. These stripes are also present in non-conductong and non-superconducting state but in this case they do not fluctuate. One interpretation for the fluctuations is as oscillations analogous to acoustic wave and essential for the binding of Cooper pairs. Quantum criticality suggests an alternative interpretation.

$T_c$ is inversely proportional to the distance $L$ between the stripes. One interpretation is in terms of generalization of the Debye frequency to 2-dimensional case. One could also consider phonons with wavelength equal to the distance between the stripes. A further interpretation would be that full super-conductivity requires delocalization of electrons also with respect to stripes so that $T_c$ would be proportional to the hopping probability of electron between neighboring stripes expected to be proportional to $1/L$ [51]. Later a TGD based interpretation will be discussed.

#### From free fermion gas to Fermi liquids to quantum critical systems

The article of Jan Zaanen [47] gives an excellent non-technical discussion of various features of high $T_c$ super-conductors distinguishing them from BCS super-conductors. After having constructed a color flux tube model of Cooper pairs I found it especially amusing to learn that the analogy of high $T_c$ super-conductivity as a quantum critical phenomenon involving formation of dynamical stripes to QCD in the vicinity of the transition to the confined phase leading to the generation of string like hadronic objects was emphasized also by Zaanen.

BCS super-conductor behaves in a good approximation like quantum gas of non-interacting electrons. This approximation works well for long ranged interactions and the reason is Fermi statistics plus the fact that Fermi energy is much larger than Coulomb interaction energy at atomic length scales.

For strongly interacting fermions the description as Fermi liquid (a notion introduced by Landau) has been dominating phenomenological approach. $^3$He provides a basic example of Fermi liquid and already here a paradox is encountered since low temperature collective physics is that of Fermi gas without interactions with effective masses of atoms about 6 times heavier than those of real atoms whereas short distance physics is that of a classical fluid at high temperatures meaning a highly correlated collective behavior.

Many-sheeted space-time provides a possible explanation of the paradox. Space-time sheets containing join along boundaries blocks of $^3He$ atoms behave like gas whereas the $^3He$ atoms inside these blocks form a liquid. An interesting question is whether the $^3He$ atoms combine to form larger units with same spin as $^3He$ atom or whether the increase of effective mass by a factor of order six means that $\hbar$ as a unit of spin is increased by this factor forcing the basic units to consist of Bose-Einstein condensate of 3 Cooper pairs.

High Tc super conductors are neither Fermi gases nor Fermi liquids. Cuprate superconductors correspond at high temperatures to doped Mott insulators for which Coulomb interactions dominate meaning that electrons are localized and frozen. Electron spin can however move and the system can be regarded as an anti-ferromagnet. CuO planes are separated by highly oxidic layers and become super-conducting when doped. The charge transfer between the two kinds of layers is what controls the degree of doping. Doping induces somehow a delocalization of charge carriers accompanied by a local melting of anti-ferromagnet.

Collective behavior emerges for high enough doping. Highest $T_c$ results with 15 per cent doping by holes. Current flows along electron stripes. Stripes themselves are dynamical and this is essential for both conductivity and superconductivity. For completely static stripes super-conductivity disappears and quasi-insulating electron crystal results.

Dynamical stripes appear in mesoscopic time and length scales corresponding to 1-10 nm length scale and picosecond time scale. The stripes are in a well-defined sense dual to the magnetized stipe like structures in type I super-conductor near criticality, which suggests type I super-conductivity: as found large $\hbar$ Cooper pairs would make it possible. The stripes are anti-ferromagnetic defects at which neighboring spins fail to be antiparallel. It has been found that stripes are a very general phenomenon appearing in insulators, metals, and superconducting compounds [50].

### Quantum criticality is present also above $T_c$

Also the physics of Mott insulators above $T_c$ reflects quantum criticality. Typically scaling laws hold true for observables. In particular, resistivity increases linearly rather than transforming from $T^2$ behavior to constant as would be implied by quasi-particles as current carriers. The appearance of so called pseudo-gap [48] at $T_{c1} > T_c$ conforms with this interpretation. In particular, the fact pseudo-gap is non-vanishing already at $T_{c_1}$ and stays constant rather than starting from zero as for quasi-particles conforms with the flux tube interpretation.

### Results from optical measurements and neutron scattering

Optical measurements and neutron scattering have provided especially valuable microscopic information about high $T_c$ superconductors allowing to fix the details of TGD based quantitative model.

Optical measurements of copper oxides in non-super-conducting state have demonstrated that optical conductivity $\sigma(\omega)$ is surprisingly featureless as a function of photon frequency. Below the critical temperature there is however a sharp absorption onset at energy of about 50 meV [42]. The origin of this special feature has been a longstanding puzzle. It has been proposed that this absorption onset corresponds to a direct generation of an electron-hole pair. Momentum conservation implies that the threshold for this process is $E_g + E$, where $E$ is the energy of the 'gluon' which binds electrons of Cooper pair together. In case of ordinary super-conductivity $E$ would be phonon energy.

Soon after measurements, it was proposed that in absence of lattice excitations photon must generate two electron-hole pairs such that electrons possess opposite momenta [42]. Hence the energy of the photon would be $2E_g$. Calculations however predicted soft rather than sharp onset of absorption since pairs of electron-hole pairs have continuous energy spectrum. There is something wrong with this picture.

Second peculiar characteristic [43, 44, 45] of high $T_c$ super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor. This scattering occurs only below the critical temperature, in spin-flip channel and for for favored momentum exchange $(\pi/a, \pi/a))$, where $a$ denotes the size of the lattice cube [43, 44, 45]. The transferred energy is concentrated in a remarkably narrow range around $E_w$ rather than forming a continuum.

In [34] is is suggested that e-e resonance with spin one gives rise to this excitation. This resonance is assumed to play the same role as phonon in ordinary super conductivity and ee resonance is treated like phonon. It is found that one can understand the dependence of the second derivative of the photon conductivity $\sigma(\omega)$ on frequency and that consistency with neutron scattering data is achieved. The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV. This would suggest that the energy of the excitations generating the binding between the members of the Cooper pair is indeed 41 meV, that two electron-hole pairs and excitation of the super conductor are generated in photon absorption above threshold, and that the gap energy of the Cooper pair is 27 meV. Of course, the theory of Carbotte *et al* does not force the 'gluon' to be triplet excitation of electron pair: also other possibilities can be considered.

### 3.3.2 Vision about high $T_c$ superconductivity

The following general view about high $T_c$ super-conductivity as quantum critical phenomenon suggests itself.

#### Interpretation of critical temperatures

The two critical temperatures $T_c$ and $T_{c_1} > T_c$ are interpreted as critical temperatures. $T_{c_1}$ is the temperature for the formation of a quantum critical phase consisting of ordinary electrons and exotic Cooper pairs with large value of Planck constant. Quantum criticality of exotic Cooper pairs prevails for temperatures below $T_{c_1}$ in the case that one has conductivity. For completely static stripes there is no conductivity. The absence of fluctuations suggests the loss of quantum criticality. One interpretation could be that exotic Cooper pairs are there but there can be no conductivity since the necessary transition of incoming ordinary electrons to large $\hbar$ dark electrons and back is not possible. $T_c$ is the temperature at which BCS type Cooper pairs with large Planck constant become possible and exotic Cooper pairs can decay to the ordinary Cooper pairs.

#### Model for exotic and BCS type Cooper pairs

Exotic Cooper pair is modelled as a pair of large $\hbar$ electrons with zoomed up size at space-time sheets $X_c^4$ topologically condensed to the background space-time sheet $Y^4$ of condensed matter system. The Coulombic binding energy of charged particles with the quarks and antiquarks assignable to the two wormhole throats feeding the em gauge flux to $Y^4$ could be responsible for the energy gap. Color force would bind the two space-time sheets to exotic Cooper pair.

Electrons of exotic Cooper pair can also end up a to same space-time sheet and possibly but not necessarily feed their em fluxes via two wormhole contacts carrying electron-positron pairs. In this case they are bound by the usual phonon interaction and form ordinary Cooper pair with large value of Planck constant.

The origin of the large $\hbar$ electrons must somehow relate to the breaking of antiferromagnetic phase by stripes. The neighboring electrons in stripe possess parallel spins and could therefore form a pair transforming to a large $\hbar$ Cooper pair bound by color force. This mechanism would be the TGD counterpart for the mechanism allowing the superconducting phases at different stripes to fuse to a single super-conducting phase at longer length scales.

Various lattice effects such as superconductivity-induced phonon shifts and broadenings, isotope effects in $T_c$, the penetration depth, infrared and photoemission spectra have been observed in the cuprates [49]. This would support the view that quantum criticality involves the competition between exotic and large $\hbar$ variant of BCS type super-conductivity and the proposed mechanism transforming exotic Cooper pair to BCS type pairs. The loss of antiferromagnetic order for higher dopings would make possible BCS type phonon induced super-conductivity with spin singlet Cooper pairs.

**What is the value of $\hbar$?**

The observed stripes would carry large $\hbar_{eff}$ electrons attracted to them by hole charge. The basic question concerns the value of $\hbar_{eff}$ which in the general case is given by $\hbar_{eff} = n_a/n_b$ where $n_i$ is the order of the maximal cyclic subgroup of $G_i$.

1. The thickness of stripes is few atomic sizes and the first guess is that scaled up electrons have atomic size. The requirement that the integer $n_a$ defining the value of $M^4$ Planck constant correspond to a n-polygon constructible using only ruler and compass gives strong constraints. An even stronger requirement would be that subgroup $G_a \subset SU(2)$ characterizes the Jones inclusion involved and thus the covering of $CP_2$ by $M^4$ points, corresponds to exceptional group via McKay correspondence, leaves only one possibility: $N(G_b) = 120$ which corresponds to $E_8$ Dynkin diagram having $Z_5$ as maximal cyclic subgroup and involving Golden Mean. The p-adic length scale of electron would be scaled up: $L(127) \rightarrow 5L(127) \simeq L(127+12) = L(139) \simeq 1.6$ Angstrom. This picture is not consistent with the model involving cell membrane length scale and the appearance of 50 meV energy scale which can be interpreted in terms of Josephson energy for cell membrane at criticality for nerve pulse generation is too intriguing signal to be dismissed.

2. The length of stripes is in the range 1-10 nm and defines second length scale in the system. If the Compton wavelength of scaled up electron corresponds to this length then $n_a = n_F = 2^{11}$ whose powers are encountered in the quantum model of living matter would suggest itself, and would predict the effective p-adic length scale electron to be $L(127+22) = L(149) = 5$ nm, the thickness of the lipid layer of the cell membrane which brings in mind cell membrane and bio-superconductivity. It will be found that simple stability arguments favor this size scale for scaled up electrons and size $L(151)$ for the exotic Cooper pairs. The minimum option is that only the exotic Cooper pairs making possible super-conductivity above $T_c$ and broken by quantum criticality against transition to ordinary electron need have size of order $L(151) = 10$ nm.

3. The coherence length for high $T_c$ super conductors is reported to 5-20 Angstroms. The naive interpretation would be as the size of BCS type Cooper pair which would suggest that scaled up electrons have at most atomic size. There is however a loophole involved. The estimate for coherence length in terms of gap energy is given by $\xi = \frac{4\hbar v_F}{E_{gap}}$. If coherence length is estimated from the gap energy, as it seems to be the case, then the scaling up of Planck constant would increase coherence length by a factor $n_F$ and give coherence length in the range $1-4$ $\mu m$.

4. The dependence $T_c \propto 1/L$, where $L$ is the distance between stripes is a challenge for the model since it would seem to suggest that stripe-stripe interaction is important for the energy gap of BCS type Cooper pairs. One can however understand this formula solely in terms of 2-dimensional character of high $T_c$ super-conductors. To see this, consider generalization of the 3-D formula

$$\begin{aligned} E_{gap} &= \hbar\omega_c exp(-1/X) \\ \omega_D &= (6\pi^2)^{1/3} c_s n_n^{1/3} \end{aligned}$$

   for the gap energy to 2-dimensional case. Since only the nuclei inside stripes contribute to high $T_c$ super-conductivity it is natural to replace 3-dimensional formula for Debye frequency in 2-dimensional case with

$$\omega_D = k c_s n_h^{1/2} \quad ,$$

   where $n_h$ is the 2-dimensional density of holes and $k$ a numerical constant. Since one has $n_h \propto 1/L^2$ this indeed predicts $E_{gap} \propto 1/L$.

**Quantum criticality below $T_{c_1}$**

Exotic Cooper pairs would be present below the higher critical temperature $T_{c_1}$ associated with high $T_c$ super-conductors and start to transform to BCS type Cooper pairs at $T_c$. Also the reverse process occurs. In the intermediate temperature range they would be unstable against transition changing the value of Planck constant to ordinary ones and this instability would break the exotic super-conductivity to ordinary conductivity with resistance obeying scaling law as a function of temperature typical for quantum critical systems. The complete stability of stripes would indicate that the exotic Cooper pairs are present but conductivity is not possible since ordinary electrons entering to the system cannot transformed to exotic Cooper pairs.

### Why doping by holes is necessary?

In high $T_c$ super-conductivity doping by holes plays a crucial role. What is known that holes gather to the stripes and that there is a critical doping at which $T_c$ is maximum. Cusp catastrophe as a general model for phase transition suggests that that super-conductivity is possible only in finite range for the hole concentration. This is indeed the case.

The holes form a positive charge density and this inspires the idea that Coulomb attraction between exotic Cooper pairs of electrons and holes leads to the formation of stripes. Stripes provide also electrons with parallel spins which can transform to exotic large $\hbar$ Cooper pairs at quantum criticality with respect to $\hbar$.

One should also understand the upper limit for the hole concentration.

1. The first explanation is that super-conductivity is not preserved above critical hole concentration due to the loss of fractal stripe structure. Part of the explanation could be that beyond critical hole concentrations it is not possible to arrange the stripes to a fractal lattice formed by a lattice of "super-stripes" which are lattices of stripes of thickness $L(151)$ containing the observed stripes such that super-stripes have separation $d \geq L(151)$. Doping fraction $p$ gives an estimate for the distance $d$ between super-stripes as $d = xL(151)$, $x = r/p - 1$, where $r$ is the fraction of atoms belonging to stripe inside super-stripe and $p$ is doping fraction. $x = 2/5$ and $p = .15$ gives $d = 5L(151)/3$. Note that ideal fractality would require $x/(1+x) = r$ giving $r \simeq p/2$.

2. One could also consider the possibility that large $\hbar$ BCS super-conductivity is not lost above critical hole concentration but is useless since the transformation of ordinary current carrying electrons to large $\hbar$ exotic Cooper pairs would not be possible. Thus a quantum critical interface allowing to transform ordinary current to supra current is necessary.

### Zeros of Riemann $\zeta$ and quantum critical super conductors

A long standing heuristic hypothesis has been that the radial conformal weights $\Delta$ assignable to the functions $(r_M/r_0)^\Delta$ of the radial lightlike coordinate $r_M$ of $\delta M^4_+/-$ of lightcone boundary in super-canonical algebra consisting of functions in $\delta M^4_\pm \times CP_2$ are expressible as linear combinations of zeros of Riemann Zeta. Quantum classical correspondence in turn inspires the hypothesis that these conformal weights can be mapped to the points of a geodesic sphere of $CP_2$ playing the role of conformal heavenly sphere.

The arguments of [C1] suggest that radial conformal weight $\Delta$ in fact depends on the point of geodesic sphere $S^2$ in $CP_2$ and is given in terms of the inverse $\zeta^{-1}(z)$ of Riemann $\zeta$ having the natural complex coordinate $z$ of $S^2$ as argument. This implies a mapping of the radial conformal weights to the points of the geodesic sphere $CP_2$. Linear combinations of zeros correspond to algebraic points in the intersections of real and p-adic space-time sheets and are thus in a unique role from the point of view of p-adicization. This if one believes the basic conjecture that the numbers $p^s$, $p$ prime and $s$ zero of Riemann Zeta are algebraic numbers.

Zeros of Riemann Zeta have been for long time speculated to closely relate to fractal and critical systems. If the proposed general ansatz for super-canonical radial conformal weights holds true, these speculations find a mathematical justification.

Geometrically the transition changing the value of $\hbar(M^4)$ correspond to a leakage of partonic 2-surfaces between different copies of $M^4 \times CP_2$ with same $CP_2$ factor and thus same value of $\hbar(CP_2)$ but different scaling factor of $CP_2$ metric. $M^4$ metrics have the same scaling factor given by $n_b^2$.

Critical 2-surfaces can be regarded as belonging to either factor which means that points of critical 2-surfaces must correspond to the $CP_2$ orbifold points, in particular, $z = \xi^1/\xi^2 = 0$ and $z = \xi^1/\xi^2 = \infty$ remaining invariant under the group $G \subset SU(2) \subset SU(3)$ defining the Jones inclusion, that is the north and south poles of homologically non-trivial geodesic sphere $S^2 \subset CP_2$ playing the role of heavenly sphere for super-canonical conformal weights. If the hypothesis $\Delta = \zeta^{-1}(z)$ is accepted, the radial conformal weight corresponds to a zero of Riemann Zeta: $\Delta = s_k$ at quantum criticality.

At quantum level a necessary prerequisite for the transition to occur is that radial conformal weights, which are conserved quantum numbers for the partonic time evolution, satisfy the constraint $\Delta = s_k$. The partonic 2-surfaces appearing in the vertices defining S-matrix elements for the phase transitions in question need not be of the required kind. It is enough that $\Delta = s_k$ condition allows their evolution to any sector of $H$ in question. An analogous argument applies also to the phase transitions changing $CP_2$ Planck constant: in this case however leakage occurs through a partonic 2-surface having single point as $M^4$ projection (the tip of $M^4_\pm$).

Quantum criticality for high temperature super-conductivity could provide an application for this vision. The super conducting stripe like regions are assumed to carry Cooper pairs with a large value of $M^4$ Planck constant corresponding to $n_a = 2^{11}$. The boundary region of the stripe is assumed to carry Cooper pairs in critical phase so that super-canonical conformal weights of electrons should satisfy $\Delta = s_k$ in this region. If the members of Cooper pair have conjugate conformal weights, the reality of super-canonical conformal weight is guaranteed. The model predicts that the critical region has thickness $L(151)$ whereas scaled electron with $n = 2^{11}$ effectively correspond to $L(127+22) = L(149)$, the thickness of the lipid layer of cell membrane. This picture would suggests that the formation and stability of the critical region is essential for the formation of phase characterized by high $T_c$ super-conductivity with large value of Planck constant and forces temperature to a finite critical interval. In this framework surface super-conductivity would be critical and interior super-conductivity stable.

These observations in turn lead to the hypothesis that cell interior corresponds to a phase with large $M^4$ Planck constant $\hbar(M^4) = 2^{11}\hbar_0$ and cell membrane to a quantum critical region where the above mentioned condition $\Delta = s_k$ is satisfied. Thus it would seem that the possibility of ordinary electron pairs to transform to large $\hbar$ Cooper pairs is essential in living matter and that the transition takes place as the electron pairs traverse cell membrane. The quantum criticality of cell membrane might prevail only in a narrow temperature range around T=37 C. Note that critical temperature range can also depend on the group $G$ having $C_n$, $n = 2^{11}$ cyclic group as maximal cyclic group ($C_n$ and $D_n$ are the options).

### 3.3.3 A detailed model for the exotic Cooper pair

#### Qualitative aspects of the model

High $T_c$ superconductivity suggests that the Cooper pairs are stripe like structures of length 1-10 nm. The length of color magnetic flux tube is characterized by the p-adic length scale in question and $L(151) = nm$ is highly suggestive for high $T_c$ superconductors.

These observations inspire the following model.

1. The space-time sheet of the exotic Cooper pair is obtained in the following manner. Take two cylindrical space-time sheets which have radius of order $L(149)$. One could of course argue that flux tubes can have this radius only along CuO plane and must flattened in the direction orthogonal to the super-conducting plane with thickness of few atomic units in this direction. The assumption about flattening leads however to a very large electronic zero point kinetic energy. Furthermore, in the absence of flattening supra phases belonging to different CuO planes combine to form single quantum coherent phase so that coherence length can be longer than the thickness of CuO layer also in orthogonal direction.

2. Assume that the cylinders they contain electrons with $u$ wormhole throat at top and $\overline{d}$ wormhole throat at bottom feeding the em gauge flux to the larger space-time sheet. Connect these parallel flux tubes with color magnetic bonds. If the $u\overline{d}$ states associated with the flux tubes are not in color singlet states, color confinement between wormhole quarks binds the electronic space-time sheets together and electrons are "free-travellers". These exotic Cooper pairs are energy minima for electrons are in large $\hbar$ phase if the electron kinetic energy remains invariant in $\hbar$ changing phase transition. This is achieved by fractionization of quantum numbers characterizing the kinetic energy of electron.

3. If the flux tubes carry magnetic flux electron spins are parallel to the magnetic field in minimum energy state. If the magnetic flux rotates around the resulting singlet sheeted structure the spin

directions of electrons are opposite and only $S = 0$ state is possible as a minimum energy state since putting electrons to the same flux tube would give rise to a repulsive Coulomb interaction and also Fermi statistics would tend to increase the energy.

4. The homological magnetic monopoles made possible by the topology of $CP_2$ allows the electrons to feed their magnetic fluxes to a larger space-time sheet via $u$ throat where it returns back via $\overline{d}$ throat. A 2-sheeted monopole field is in question. The directions of the magnetic fluxes for the two electrons are independent. By connecting the flux tubes by color bonds one obtains color bound electrons. In this kind of situation it is possible to have $S = 1$ state even when electrons are at different flux tubes portions so that energies are degenerate in various cases. The resulting four combinations give $S_z = \pm 1$ states and two $S_z = 0$ states which means spin triplet and singlet. Interestingly, the first 23 year old model of color confinement was based on the identification of color hyper charge as homological charge. In the recent conceptual framework the the space-time correlate for color hyper charge $Y$ of quark could be homological magnetic charge $Q_m = 3Y$ so that color confinement for quarks would have purely homological interpretation at space-time level.

5. One can also understand how electrons of Cooper pair can have angular momentum ($L = 2$ in case of high $T_c$ Cooper pairs and $L = 0$ in case of $^3$He Cooper pairs) as well as correlation between angular momentum and spin. The generation of radial color electric field determined by the mechanical equilibrium condition $E + v \times B = 0$ inside give portion of flux tube implies that electrons rotate in same direction with velocity $v$. A non-vanishing radial vacuum $E$ requires that flux tube portion contains cylindrical hole inside it. Without hole only $v = 0$ is possible. Assume that the directions of radial $E$ and thus $v$ can be freely chosen inside the vertical portions of flux tube. Assume that also $v = 0$ is possible in either or both portions. This allows to realize $L_z$ values corresponding to $L = 0, 1, 2$ states.

6. Since quarks in this model appear only as parton pairs associated with wormhole contacts, one expects that the corresponding p-adic mass scale is automatically determined by the relevant p-adic length scale, which would be $L(151)$ in case of high $T_c$ superconductors. This would mean that the mass scale of inertial mass of wormhole contact would be $10^2$ eV even in the case that p-adic temperature is $T_p = 1$. For $T_p = 2$ the masses would be extremely small. The fact that the effective masses of electrons can be as high as $100m_e$ [28] means that the mass of wormhole contact does not pose strong constraints on the effective mass of the Cooper pair.

7. The decay of Cooper pair results if electrons are thrown out from 2e space-time sheet. The gap energy would be simply the net binding energy of the system. This assumption can make sense for high $T_c$ super-conductors but does not conform with the proportionality of the gap energy to Debye frequency $\omega_D = v_s/a$ in the case of ordinary super-conductors for which phonon space-time sheets should replace color flux tubes.

8. Both the assumption that electrons condensed at $k = 149$ space-time sheets result from scaled up large $\hbar$ electrons and minimization of energy imply the the scales $L(149)$ and $L(151)$ for the space-time sheets involved so that there is remarkable internal consistency. The model explains the spins of the exotic Cooper pairs and their angular momenta. The dark BSC type Cooper pairs are expected to have $S = 0$ and $L = 0$.

### Quantitative definition of the model

There are several poorly understood energies involved with high $T_c$ super-conductors below $T_c$. These are $E_g = 27$ meV, $E_1 = 50$ meV, $E_w = 41$ meV, and $E_2 = 68$ meV. These numbers allow to fix the wormholy model for quantum critical super-conductors to a high degree.

Consider now a quantitative definition of the model.

1. p-Adic length scale hypothesis combined with the ideas about high $T_c$ super-conductivity in living matter plus the fact that the stripe like defects in high $T_c$ superconductors have lengths 1-10 nm suggests that the length scales $L(151) = 10$ nm corresponding to cell membrane thickness and $L(149) = 5$ nm corresponding to the thickness of its lipid layer are the most important p-adic length scales. Of course, also $L(145 = 5 \times 29) = 1.25$ nm could be important. $L(151)$ would be associated with the structure consisting of two flux tubes connected by color bonds.

2. The kicking of electrons from $k = 151$ to $k = 149$ space-time sheet should define one possible excitation of the system. For wormhole contacts kicking of electron to smaller space-time sheet is accompanied by the kicking of wormhole contacts from the pair $(151, 157)$ to a pair $(149, 151)$ of smaller space-time sheets. This can be achieved via a flow along JABs $157 \rightarrow 151$ and $151 \rightarrow 149$. Also the dropping of electrons from color flux tube to larger space-time sheet defines a possible transition.

3. Assume that given electrons reside inside electronic flux tubes connected having $u$ and $\overline{d}$ at their ends and connected by color bonds. Assume that electrons are completely delocalized and consider also the configuration in which both electrons are in the same electronic flux tube. The total energy of the system is the sum of zero point kinetic energies of electrons plus attractive Coulomb interaction energies with $u$ and $\overline{d}$ plus a repulsive interaction energy between electrons which contributes only when electrons are in the same flux tube. Minimum energy state is obviously the one in which electrons are at different flux tubes.

   By effective one-dimensionality the Coulomb potential can be written as $V(z) = \alpha Qz/S$, where $S$ is the thickness of the flux tube. It is assumed that $S$ scales $L(k)^2/y$, $y > 1$, so that Coulomb potential scales as $1/L(k)$. The average values of Coulomb potential for electron quark interaction ($Q(u) = 2/3$ and $Q(\overline{d}) = 1/3$) and ee interaction are

$$\begin{aligned} V_{eq} &= \frac{y}{2}V(k) \ , \\ V_{ee} &= \frac{y}{3}V(k) \ , \\ V(k) &= \frac{\alpha}{L(k)} \ . \end{aligned} \tag{3.3.1}$$

   One can introduce a multiplicative parameter $x$ to zero point kinetic energy to take into account the possibility that electrons are not in the minimum of kinetic energy. The color interactions of wormhole throats can of course affect the situation.

   With these assumptions the estimate for the energy of the 2e space-time sheet is

$$\begin{aligned} E_{2e}(k) &= 2xT(k) - 2V_{eq} + \epsilon V_{ee} = 2xT(k) - y(1 - \frac{\epsilon}{3})V(k) \ , \\ T(k) &= \frac{D}{2}\frac{\pi^2}{2m_eL^2(k)} \ , \\ V(k) &= \frac{\alpha}{L(k)} \ . \end{aligned} \tag{3.3.2}$$

   Here $\epsilon = 1/0$ corresponds to the situation in which electrons are/are not in the same flux tube. One has $x \geq 1$ and $x = 1$ corresponds to the minimum of electron's kinetic energy. If the maximum area of the tube is $\pi L(151)^2$, one should have $y \leq \pi$. The effective dimension is $D = 1$ for flux tube. $k = 151$ and $k = 149$ define the most interesting p-adic length scales now.

4. By p-adic scaling one has

$$E_{2e}(k) = 2^{151-k} \times 2xT(151) - 2^{(151-k)/2} \times y(1 - \frac{\epsilon}{3})V(151) \ . \tag{3.3.3}$$

   The general form of the binding energy implies that it has maximum for some value of $k$ and the maximum turns out to correspond to $k = 151$ with a rather reasonable choice of parameters $x$ and $y$.

   One could also require a stability against the transition $151 \rightarrow 149$. Here a difficulty is posed by the fact that color interaction energy of wormhole contacts probably also changes. One can however neglect this difficulty and look what one obtains. In this approximation stability condition reads as

$$E_{2e}(149) - E_{2e}(151) = 6xT(151) - y(1 - \frac{\epsilon}{3})V(151) > 0 \ . \tag{3.3.4}$$

One obtains

$$\frac{y}{x} \leq \frac{6T(151)}{V(151)} = \frac{6}{\alpha}\frac{\pi^2}{2m_eL(151)} \simeq 3.54 \ . \tag{3.3.5}$$

For $k > 151$ the binding energy decreases so fast that maximum of the binding energies at $k = 151$ might be guaranteed by rather reasonable conditions on parameters.

5. The general formula $\lambda$ is expected to make sense and gives rather large $\lambda$. The BCS formula for $\xi$ need not make sense since the notion of free electron gas does not apply. A good guess is that longitudinal $\xi$ is given by the height $L(151) = 10$ nm of the stripe. Transversal $\xi$, which is in the range 4-20 Angstroms, would correspond to the thickness of the color magnetic flux tube containing electrons. Hence the scale for $\xi$ should be smaller than the thickness of the stripe.

**Estimation of the parameters of the model**

It turns out to be possible to understand the energies $E_2$, $E_1$, $E_w$ and $E_g$ in terms of transitions possible for wormhole contact option. The values of the parameters $x$ and $y$ can be fitted from the following conditions.

1. The largest energy $E_2 = 68$ meV is identified as the binding energy in the situation in which electrons are at different flux tubes. Hence one has $E_{2e}(\epsilon = 0) = -E_2$ giving

$$-2xT(151) + yV(151) = E_2 \ . \tag{3.3.6}$$

The peak in photo-absorption cross section would correspond to the dropping of both electrons from the flux tube to a much larger space-time sheet.

2. The energy $E_g = 27$ meV is identified as the binding energy in the situation that electrons are at the same flux tube so that $E_g$ represents the energy needed to kick electrons to a much larger space-time sheet. This gives

$$-2xT(151) + \frac{2}{3}yV(151) = E_g \ . \tag{3.3.7}$$

3. $E_w$ corresponds to the difference $E_2 - E_g$ and has an interpretation as the energy needed to induce a transition from state with $\epsilon = 0$ (electrons at different flux tubes) to the state with $\epsilon = 1$ (electrons at the same flux tube).

$$E_{2e}(151, \epsilon = 1) - E(2e)(151, \epsilon = 0) = \frac{y}{3}V(151) = E_w \ . \tag{3.3.8}$$

This condition allows to fix the value of the parameter $y$ as

$$y = \frac{3E_w}{V(151)} \quad . \tag{3.3.9}$$

Condition a) fixes the value of the parameter $x$ as

$$x = \frac{E_w}{T(151)} \quad . \tag{3.3.10}$$

Using $V(151) \simeq 144$ meV and $T(151) = 20.8$ meV this gives $y = .8539 < \pi$ and $x = 1.97$. The area of the color flux tube is .27 per cent about $S_{max} = \pi L^2(151)$ so that its radius equals in a good approximation $L(149)$, which looks rather large as compared to the estimated thickness of the visible stripe. $x = 1.97$ means that the electron's kinetic energy is roughly twice the minimal one. $y/x = .43$ satisfies the bound $y/x < 6T(151)/V(151) = .87$ guaranteing that the binding energy is maximum for $k = 151$. This result is rather remarkable.

4. The model should explain also the energy $E_1 \simeq 50$ meV at which sharp photon absorption sets on. The basic observation is that for neuronal membrane 50 mV corresponds to the critical voltage for the generation of nerve pulse. In super-conductor model of cell membrane 50 meV is identified as the energy of Josephson photon emitted or absorbed when Cooper pair moves from cell interior to exterior of vice versa. Thus 50 meV energy *might* correspond to the energy of Josephson photon and kick BCS type Cooper pair between the two layers of the double-layered super stripe.

   Note that 50 meV corresponds to a thermal energy of 3-D system at T= 333 K (60 C). This is not far from 37 C, which would also suggest that high $T_c$ super-conductivity is possible at room temperatures. In the case of cell membrane quantum criticality could among other things make possible the kicking of the large $\hbar$ BCS type Cooper pairs between lipid layers of cell membrane. If so, neurons would be quantum critical only during nerve pulse generation.

   One can consider also alternative explanation. 50 meV is not much higher than 41 meV so that it could relate to the $\epsilon = 0 \rightarrow 1$ transition. Recoil effects are negligible. Perhaps $m = 1$ rotational excitation of electron of 2e system residing at the same flux tube and having energy $E = 9$ meV is in question. This excitation would receive the spin of photon. The energy scale of electronic rotational excitations is $\hbar^2/2m_eL^2(149) \sim 8.4$ meV if the radius of the flux tube is $L(149)$.

To sum up, the model allows to understand the four energies assuming natural values for adjustable parameters and predicts that $k = 151$ corresponds to stable Cooper pairs. It seems that the model could apply to a large class of quantum critical super-conductors and scaled up electrons might be involved with all condensed matter phenomena involving stripes.

### Model for the resonance in neutron scattering

The resonance in neutron scattering is usually understood as a resonance in the scattering from the modification of the lattice induced by the formation of stripes and this scattering gives the crucial information about cross-like structure of Fermi surface of holes suggesting crossed stripes. One can also consider the possibility that the scattering is on exotic Cooper pairs which could always accompany stripes but as such need not give rise to super-conductivity or not even conductivity unless they are in quantum critical state.

Consider now the TGD based model for neutron scattering based on the proposed model for Cooper pairs.

1. Neutrons couple naturally to the magnetic field accompanying color magnetic field at the space-time sheet of Cooper pair by magnetic moment coupling. As found, $E_w = 41$ meV can be interpreted as the energy needed to induce the $\epsilon = 0 \rightarrow 1$ transition. Spin flip necessarily occurs if the electron is kicked between the vertical flux tubes.

2. Resonance would result from the coherent coupling to the wormhole BE condensate making scattering rate proportional to $N^2$, where $N$ denotes the number of wormhole contacts, which is actually identical with the total number of super conducting electrons. Therefore the prediction of the TGD based model is very similar to the prediction of [34]. The absence of the resonance above critical temperature suggests that exotic Cooper pairs are not present above $T_c$. The presence of quantum criticality also above $T_c$ suggests that Cooper pairs decay to wormholy space-time sheets containing single electron plus wormholy pion $u\overline{d}$ responsible for the ordinary conductivity. The transition is possible also for these space-time sheets but they do not form Bose-Einstein condensate so that the resonance in neutron scattering is predicted to be much weaker for temperatures above the critical temperature. For overcritical doping the resonance should be absent if exotic Cooper pairs are possible only at the boundaries of two phases disappearing at critical doping.

3. The momentum transfer associated with the resonance is located around the momentum $(\pi/a, \pi/a)$ in resiprocal lattice [46], where $a$ denotes the length for the side of the lattice cell. The only possible conclusion is that in the scattering neutron momentum is transferred to the lattice whereas the remaining small momentum is transferred to the momentum of wormhole BE condensate. Thus the situation is analogous to that occurring in Mössbauer effect.

#### What is the origin of picosecond time scale

The model should also predict correctly the picosecond and 1-10 nm length scales. Quantum criticality suggests that picosecond time scale relates directly to the 10 nm length scale via p-adic length scale hypothesis. $L(151) = 10$ nm defining the size for color flux tubes containing electrons of Cooper pair and lower limit for the distance between predicted super-stripes would correspond to a p-adic time scale $T(151) \sim 10^{-16}/3$ seconds for ordinary Planck constant. For $\hbar = 2^{22}\hbar_0$ this time scale would be scaled up to about $.15n$ picoseconds. This kind of length scale corresponds for electron to $n_F = 2^{22}$ rather than $n_F = 2^{11}$. One could however argue that by the very definition of quantum quantum criticality several values of $n_F$ must be involved. The quantum model of EEG indeed assumes this kind of hierarchy. Note that $n_F = 3 \times 2^{12}$ would give picosecond scale as also (157).

Just for fun one can also consider the possibility that this time scale is due to the large $\hbar$ phase for nuclei and hadrons. Large $\hbar$ for nuclei and quarks would means gigantic Compton lengths and makes possible macroscopic quantum phase competing with ordinary phase. If one accepts TGD based model for atomic nuclei where $k = 129$ corresponds to the size of the magnetic body of ordinary nuclei [F8], the super-stripes could involve also the color magnetic bodies of dark hadrons. The size of color magnetic body for ordinary hadrons is $L(k_{eff} = 107 + 22 = 129)$ and therefore $L(k_{eff} = 129 + 22 = 151)$ for dark hadrons. This of course forces the question whether the nuclei along stripes correspond to dark nuclei. Large $\hbar$ phase for hadrons means also scaling up of the basic purely hadronic time scales. Notice that neutral pion lifetime $\sim 2 \times 10^{-16}$ seconds would be scaled up by a factor $2^{11}$ to .2 picoseconds.

#### Why copper and what about other elements?

The properties of copper are somehow crucial for high $T_c$ superconductivity since cuprates are the only known high $T_c$ superconductors. Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages to think that the doping by holes needed to achieve superconductivity induces the dropping of these electrons to $k = 151$ space-time sheets and gives rise to Cooper pairs.

More generally, elements having one electron in $s$ state plus full electronic shells are good candidates for doped high $T_c$ superconductors. If the atom in question is also a boson the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Superfluid would be in question. Thus elements with odd value of $A$ and $Z$ possessing full shells plus single $s$ wave valence electron are of special interest. The six stable elements satisfying these conditions are $^{5}$Li, $^{39}$K, $^{63}$Cu, $^{85}$Rb, $^{133}$Cs, and $^{197}$Au. Partially dark Au for which dark nuclei form a superfluid could correspond to what Hudson calls White Gold [116] and the model for high $T_c$ superconductivity indeed explains the properties of White Gold.

### 3.3.4 Speculations

#### 21-Micrometer mystery

21 micrometer radiation from certain red giant stars have perplexed astronomers for more than a decade. Emission forms a wide band (with width about 4 micrometers) in the infrared spectrum which suggests that it comes form a large complex molecule or a solid or simple molecules found around starts. Small molecules are ruled out since they produce narrow emission lines. The feature can be only observed in very precise evolutionary state, in the transition between red giant phase and planetary nebular state, in which star blows off dust that is rich in carbon compounds. There is no generally accepted explanation for 21-micrometer radiation.

One can consider several explanations based on p-adic length scale hypothesis and some explanations might relate to the wormhole based super-conductivity.

1. 21 micrometers corresponds to the photon energy of 59 meV which is quite near to the zero point point kinetic energy 61.5 meV of proton Cooper pair at $k = 139$ space-time sheet estimated from the formula

$$\Delta E(2m_p, 139) = \frac{1}{2}\frac{\pi^2}{(2m_p)L(169)^2} = \frac{1}{8}\Delta E(m_p, 137) \simeq 61.5\ meV \quad .$$

   Here the binding energy of the Cooper pair tending to reduce this estimate is neglected, and this estimate makes sense only apart from a numerical factor of order unity. This energy is liberated when a Cooper pair of protons at $k = 139$ space-time sheet drops to the magnetic flux tube of Earth's magnetic field (or some other sufficiently large space-time sheet). This energy is rather near to the threshold value about 55 meV of the membrane potential. This observation and the presence of the carbon compounds leads to ask whether bio-superconductors and perhaps even some primitive forms of life might be involved.

2. 21 micrometer radiation could also result when electrons at $k = 151$ space-time sheet drop to a large enough space-time sheet and liberate their zero point kinetic energy. Scaling argument gives for the zero point kinetic energy of electron at $k = 151$ space-time sheet the value $\Delta(e, 151) \simeq$ 57.5 meV which is also quite near to the observed value. If electron is bound to wormhole with quantum numbers of $\overline{d}$ Coulombic binding energy changes the situation.

3. A possible explanation is as radiation associated with the transition to high $T_c$ super conducting phase. There are two sources of photons. Radiation could perhaps result from the de-excitations of wormhole BE condensate by photon emission. $\lambda = 20.48$ micrometers is precisely what one expects if the space-time sheet corresponds to $p \simeq 2^k$, $k = 173$ and assumes that excitation energies are given as multiples of $E_w(k) = 2\pi/L(k)$. This predicts excitation energy $E_w(173) \simeq$ 61.5 meV. Unfortunately, this radiation should correspond to a sharp emission line and cannot explain the wide spectrum.

#### Ionic high $T_c$ superconductivity and high $T_c$ super-fluidity

The model of electronic superconductivity generalizes to the case of fermionic ions in almost trivial manner. The stability condition determining the p-adic length scale in question is obtained by replacing electron mass with the mass $Am_p$ of ion and electron charge with the charge $Ze$ of the ion. The expression of binding energy as sum of kinetic energy and Coulombic interaction energy has the general form

$$T_e + V_{ee} + V_{eq} = \frac{a_e}{L^2(k)} - \frac{b_e}{L(k)} \ , \qquad (3.3.11)$$

and gives maximum binding energy for

$$L = \frac{2a_e}{b_e} \simeq L(151) \ . \qquad (3.3.12)$$

The replacement of electrons with ions of charge $Z$ induces the replacements

$$\begin{aligned} a_e &\rightarrow \frac{m_e}{Am_p}a_e \ , \\ b_e &\rightarrow Z^2 b_e \ , \\ L &\rightarrow \frac{m_e}{AZ^2m_p}L_e \simeq \frac{1}{AZ^2}L(129) \ . \end{aligned} \tag{3.3.13}$$

This scale would be too short for ordinary value of $\hbar$ but if the nuclei are in large $\hbar$ phase, $L$ is scaled up by a factor $\simeq n\times 2^{11}$ to $L(k_{eff}) = nL(k+22)$. This gives

$$L(k) \simeq \frac{n}{AZ^2}L(151) \ . \tag{3.3.14}$$

This length scale is above $L(137)$ for $AZ^2 < 2^7 n = 128n$: $n = 3$ allows all physical values of $A$. If $L(135)$ is taken as lower bound, one has $AZ^2 < 2^9 n$ and $n = 1$ is enough.

Second constraint comes from the requirement that the gap temperature defined by the stability against transition $k \rightarrow k-2$ is above room temperature.

$$3\times \frac{\pi^2\hbar^2}{2Am_pL^2(k)} \simeq 2^{-k+137}\frac{.5}{A} \quad \mathrm{eV} \geq T_{room} \simeq .03 \quad \mathrm{eV} \ . \tag{3.3.15}$$

Since the critical temperature scales as zero point kinetic energy, it is scaled down by a factor $m_e/Am_p$. $k\geq 137$ would give $A\leq 16$, $k = 135$ would give $A\leq 64$, and $k = 131$ allows all values of $A$.

The Bose-Einstein condensates of bosonic atoms giving rise to high $T_c$ super fluidity are also possible in principle. The mechanism would be the dropping of atoms to the space-time sheets of electronic Cooper pairs. Thermal stability is achieved if nuclei are in doubly dark nuclear phase and electrons correspond to large $\hbar$ phase. Electronic Cooper pairs would correspond to $k_{eff} = 151+22 = 173$ space-time sheets with size about 20 $\mu$m. This is also the size scale of the Bohr radius of dark atoms [J6]. The claimed properties of so called ORMEs [116] make them a possible candidate for this kind of phase.

### Are living systems high $T_c$ superconductors?

The idea about cells and axons as superconductors has been one of the main driving forces in development of the vision about many-sheeted space-time. Despite this the realization that the supra currents in high $T_c$ superconductors flow along structure similar to axon and having same crucial length scales came as a surprise. Axonal radius which is typically of order $r = .5$ $\mu$m. $\lambda = 2^{11}$ would predict $r = .2$ $\mu$m. The fact that water is liquid could explain why the radius differs from that predicted in case of high $T_c$ superconductors.

Interestingly, Cu is one of the biologically most important trace elements [37]. For instance, copper is found in a variety of enzymes, including the copper centers of cytochrome c-oxidase, the Cu-Zn containing enzyme superoxide dismutase, and copper is the central metal in the oxygen carrying pigment hemocyanin. The blood of the horseshoe crab, Limulus polyphemus uses copper rather than iron for oxygen transport. Hence there are excellent reasons to ask whether living matter might be able to build high $T_c$ superconductors based on copper oxide.

### Neuronal axon as a geometric model for current carrying "rivers"

Neuronal axons, which are bounded by cell membranes of thickness $L(151)$ consisting of two lipid layers of thickness $L(149)$ are high $T_c$ superconductors (this was not the starting point but something which popped out naturally). The interior of this structure is in large $\hbar$ nuclear phase, which is partially dark. Since the thickness of the tube should be smaller than the quantum size of the dark nuclei, a lower limit for the the radius $r$ of the corresponding nuclear space-time sheets is obtained by scaling up the weak length scale $L_w(113) = 2^{(11-89)/2}L_w(89)$ defined by W boson Compton length by a factor $2^{22}$ to doubly dark weak length scale $L_w = 2^{22}L_w(113) = .2$ $\mu$m.

These flux tubes with radius $r > L_w$ define "rivers" along which conduction electrons and various kinds of Cooper pairs flow. Scaled up electrons have size $L(k_{eff} = 149)$ corresponding to 5 nm, the thickness of the lipid layer of cell membrane. The observed quantum fluctuating stripes of length 1-10 nm might relate very closely to scaled up electrons with Compton length 5 nm, perhaps actually representing zoomed up electrons!

According to the model of dark Cooper pairs the $k = 149$ flux tubes at which electrons are condensed should be hollow. What comes in mind first is that a cylinder with radius $L(149)$ is in question having a hollow interior with say atomic radius.

The original assumption that exotic *resp.* BCS type Cooper pairs reside at boundaries *resp.* interior of the super-conducting rivulet. It would however seem that the most natural option is that the hollow cylindrical shells carry all supra currents and there are no Cooper pairs in the interior. If exotic Cooper pairs reside only at the boundary of the rivulet or the Cooper pairs at boundary remain critical against exotic-BCS transition also below $T_c$, the time dependent fluctuations of the shapes of stripes accompanying high $T_c$ super-conductivity can be understood as being induced by the fluctuations of membrane like structures. Quantum criticality at some part of the boundary is necessary in order to transform ordinary electron currents to super currents at the ends of rivulets. In biology this quantum criticality would correspond to that of cell membrane.

## 3.4 Models for ionic superconductivity and topological condensation at the magnetic flux quanta of endogenous magnetic field

In this section the model for ionic superconductivity is constructed as a straightforward generalization of the model of high $T_c$ electronic superconductivity: the basic prediction is that only ions with $A < 4$ (in practice protons) can form stable Cooper pairs at room temperature. There is however a loophole involved. TGD based model of atomic nucleus predicts that fermionic ions can have bosonic chemical equivalents for which one of the color bonds connecting nucleons to nuclear string is charged. Dark fermionic ions like $Na^+$, $K^+$, and $Cl^-$ could be actually exotic ions of this kind having different mass number and be able to form Bose-Einstein condensates. This is required by the recent model for nerve pulse [M2]. The prediction can be tested.

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field differs radically from the earlier model and allows to understand that effects of ELF em fields on brain. Bose-Einstein condensates of bosonic ions are predicted to be of special importance for the functioning of living systems. Also a quantitative understanding of the effects of Schumann resonances and EEG emerges.

### 3.4.1 Model for ionic superconductivity based on Cooper pairs

The model of ionic super-conductivity is a direct generalization of corresponding model for high $T_c$ electronic super conductivity.

1. Electron is topologically condensed at a cylindrical space-time sheets of radius $L(k = 149) = 5$ nm and length $L(151) = 10$ nm and carrying magnetic monopole flux flowing through the wormhole throat at the upper end of the cylindrical sheet to the larger space-time sheet and returning back through the throat at the lower end of the sheet. Magnetic monopole flux made possible by the topology of $CP_2$ is necessary in order to have spin 1 Cooper pairs.

2. The two causal horizons associated with each wormhole contact carry quantum numbers of quark and antiquark and the charges of quark and antiquark at electron space-time sheet sum up to the negative of electron charge. The two flux tubes of this kind are connected by color bonds such that the state does not reduce to a product of color singlets. Hence color confinement is responsible for the formation of Cooper pair.

3. The requirement that the binding energy is maximum as a function of p-adic length scale implies that $k = 151$ corresponds to the length of the electronic flux tube and $k = 149$ to its radius.

Exactly the same mechanism works also in the case of ions and the only differences come from the different mass and charge of ion.

1. The weak length scale $L_w = .2$ $\mu$m associated with doubly dark $k = 113$ weak bosons gives an upper bound for the size of the Cooper pair. The requirement that the binding energy is minimum forces this length for the Cooper pair if one assumes that the diameter of ionic flux tube equals to its length.

2. For proton regarded as a particle in 1-D box the scale of excitation energy inside flux tube is $\Delta E \sim 3\pi^2\hbar^2/2m_pL_w^2 = .31$ eV for $\hbar = 2^{11}\hbar_0$ and safely above the maximum photon energy $E_{th} = 2.882T = .086$ eV of black body radiation at room temperature $T = 300$ K. For $A \geq 4$ nuclei this energy scale is below $E_{th}$ ($A = 4$ gives $E = .078$ eV). Thus it would seem that only protonic Cooper pairs are relevant for living systems at $k_d = 1$ level of dark matter hierarchy. For $^7\mathrm{Li}_+$ ion this energy corresponds to .04 eV. One cannot exclude the possibility that for effectively 2- or 1-D systems lithium Cooper pairs might be marginally stable. In the case of electronic Cooper pairs one has $\Delta E \sim 3 = .06$ eV ($E_{th} = \Delta E$ corresponds to $T = 219$ K) so that thermal stability criterion is marginally satisfied at room temperature.

### 3.4.2 Super conductors of exotic bosonic counterparts of fermionic ions

If ion is boson, no Cooper pairs is needed in order to have a super conductor, and $Ca^{++}$ and $Mg^{++}$ ions at dark magnetic flux tubes with large value of Planck constant could give rise to high $T_c$ superconductors in this manner. Fermionic ions ($\mathrm{Na}^+$, $\mathrm{K}^+$,$\mathrm{Cl}^-$,..) would not define supra currents. The explanation of the effects of ELF em fields on vertebrate brain however suggests cyclotron Bose-Einstein condensates of also ions behaving chemically like fermionic ions. Also the model of nerve pulse requires Josephson currents of ions which are chemical equivalents of fermionic ions.

TGD based nuclear physics [F9] allows this kind of ions. The model indeed predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation. The table below describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation $Mg_-^{++}$ tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.

$$\begin{array}{llll} Ion & f_c/Hz & Pseudo-ion & f_c/Hz \\ ^{23}Na^+ & 13.1 & ^{19}Ne_+ & 15.7 \\ ^{23}Na^+ & 13.1 & ^{24}Mg_-^{++} & 12.5 \\ ^{39}K^+ & 7.7 & ^{40}A_+ & 7.5 \\ ^{39}K^+ & 7.7 & ^{40}Ca_-^{++} & 7.5 \\ ^{35}Cl^- & 8.6 & ^{40}A_- & 7.5 \end{array} \tag{3.4.1}$$

$f_c(K+)$ and $f_c(Cl^-)$ are replaced with the frequency 7.5 Hz and one can do only using the cyclotron frequencies $f(Ca^{++})/2 = 7.5$ Hz, $f_c(Mg^{++}) = 12.5$ Hz, and $f(Ca^{++}) = 15$ Hz. The nominal values of the lowest Schumann frequencies are 7.8 Hz and 14.3 Hz. All ions with relevance for nerve pulse and EEG could be bosonic ions or bosonic pseudo-ions. I do not know how well the needed ionization mechanisms are understood in the standard framework.

### 3.4.3 Model for Bose-Einstein condensation in endogenous magnetic field

The effects of ELF em fields on living matter suggest that quantal cyclotron transitions are involved. This does not conform with intuitive expectations since cyclotron energy scale is ridiculously as compared to the thermal energy at room temperature.

The earlier model based on ordinary $\hbar$ assumed thermal isolation between space-time sheets and that large space-time sheets are cold so that BE condensates are possible. Thermal stability in fractal sense requires that temperature scales like cyclotron energy as a function of p-adic length scale. Flux quantization implies that $T$ scales like zero point kinetic energy: $T(k) \propto 1/L^2(k)$.

One can criticize the assumption about thermal isolation. Second criticism concerns the assumed flux quantization. The flux tubes of the endogenous magnetic field have radius which is at most

$5L(167) = 8\ \mu$m. This however suggests that ions and atoms can be in two states depending on whether they are condensed at magnetic flux tubes or not. In the absence of topological condensation to magnetic flux tubes no cyclotron transitions or spin flips should occur. The states in which ions do not respond to magnetic field have not been however observed. Usually it is assumed that no flux quantization occurs in macroscopic length scales but this assumption is in conflict with the idea that there are no preferred length scales. The scaling up of flux quantum by scaling of $\hbar$ could resolve this problem.

### A model for the condensation of ordinary ion to dark magnetic flux tube

One particular set of preferred values of $\hbar_{eff} = n_a/n_b$ suggested by the model of living matter is as powers of $\lambda = 2^{11}$. Dark ions at space-time sheets having $(n_a = \lambda^k, n_b = 1)$, $k > 1$, are thermally unstable at room temperature since the atomic energy scale would be $\lambda^{-k}E_0$. The only possibility is that ion itself has small enough a value of $n_a/n_b$. The simplest possibility is $(n_a = 1, n_b = 1)$.

The next question concerns the magnetic interaction between ion and dark magnetic flux tube. The magnetic flux from the dark flux quantum must be feeded to the space-time sheet of ion and return back. This is indeed possible since it is $M^4_+$ projection which is zero-dimensional and corresponds to the tip of $M^4_+$ at the 2-surface which corresponds to parton just intermediate between two sectors. The 2-dimensionality of $CP_2$ projection allows non-vanishing magnetic flux. That magnetic flux cannot flow between sectors with different value of $n_b$ might relate to Meissner effect. If so, the values of $n_b$ for super-conductor and its environment would be different.

Since $n_a$ sheets fuse to single one at the leakage point, the magnetic flux feeded to the ordinary space-time sheet of ion is $n_a$-fold so that cyclotron energy is $n_a$-fold too. One can equally well consider the situation also by assuming that the magnetic flux of ion is shared by the $N(G_a)$ flux sheets of the dark magnetic field and returns back to ion. The total magnetic interaction energy summed over the $N(G_a)$ identical $G_a$-related sheets is scaled up by $n_a$ since the value of Planck constant is $n_a$ time larger.

If the dark magnetic flux sheets with $k > 1$ contain nuclei, they form a fully ionized plasma at room temperature, and have cyclotron energies which are $Z/A$ times the cyclotron energy of proton. For $B = .2$ Gauss this gives $f_c = (2Z/A)(f_p/2) = (2Z/A) \times 150$ Hz.

### Why the endogenous magnetic field corresponds to .2 Gauss?

For years I erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking $Ca^{++}$ cyclotron frequency as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for $Ca^{++}$ is .2 Gauss and thus slightly smaller than the minimum value .3 Gauss of $B_E$. This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic field. This field value corresponds roughly to the magnitude of $B_E$ at distance 1.4R, $R$ the radius of Earth.

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar_{eff}(k) = \lambda^k(p)\hbar_0$, $\lambda = 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, ...$. Each p-adic length scale corresponds to this kind of hierarchy. Number theoretical arguments suggest a general formula for the allowed values of $\lambda$ [A9] as $\lambda = n$ where $n$ characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [C6]. The values of $n$ for which quantum phase is expressible in terms of squared roots are number theoretically preferred and correspond to integers $n$ expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. $n = 2^{11}$ obviously satisfies this condition. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \rightarrow h = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L(k) \rightarrow nL(k)$ and $B \rightarrow B/n$.

$B_{end} = .2 = 2B_E/5$ with $k = 169$, $\hbar = 5\hbar_0$, with flux tubes of radius 25 $\mu$m carrying flux $2h_5$ is the most natural option since gives a direct connection with the Earth's magnetic field. Furthermore, the model for EEG forces to assume that also the presence of the magnetic field $B_{end}/2$ and this gives the minimal flux $h_5$. Note that $n = 5$ is the minimal value of $n$ making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [E9].

For a couple of years after writing this I realized that the value of $B_{end}$ could be understood in much more deeper level. The secondary p-adic length scale associated with Mersenne prime $M_{127}$ corresponds to a time scale of .1 seconds, the fundamental biorhythm. $M_{127}$ is the largest not completely super-astronomical p-adic length scale corresponding to Mersenne prime and can be assigned to both electron and gravitons and perhaps also exotic scaled variants of quarks and neutrino. This led for many years ago to the idea that memetic code corresponds to $M_{127}$ with the duration of memetic codon equal to .1 seconds and containing 126 bits of equal length.

The latest step in the progress of understanding the value of $B_{end}$ relates to the understanding of how p-adic length scale hypothesis emerges from quantum TGD: this has been already explained in the introduction. The amazing prediction is that one can assign to elementary particle secondary p-adic time scale as a fundamental time scale. It correspond to the temporal duration of the particle space-time time sheet carrying positive and negative energy states at its future and past boundaries. In the case of single particle state these states correspond particle and its negative energy variant. In the general case the interpretation for the detection of zero energy state is as a detection of initial and final states of particle reaction. Secondary p-adic time scale would be a concrete signature of zero energy ontology. The fundamental role of .1 seconds in biology and neuroscience could be interpreted in terms of the key role of Bose-Einstein condensates of electronic Cooper pairs. It would be rather natural for the cyclotron frequencies of biologically important ions to be as near as possible to 10 Hz. This would dictate the value of endogenous magnetic field to $B_{end} \simeq .2$ Gauss. If each ionic Bose-Einstein condensate lives at its own magnetic flux tubes, it is possible to fine tune the value of $B_{end}$ to achieve an exact resonance.

#### How to identify the personal magnetic body?

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body. If EEG corresponds to the purely personal aspects of consciousness, the magnetic body associated with human body should be of order Earth size. This however raises the question about how to distinguish between the magnetic bodies of Earth and of human body. As a matter fact, this problem turned out to be a pseudo problem due to calculational error. The value of the endogenous magnetic field is $B = .2$ Gauss from experiments of Blackman and others and corresponds to p-adic length scale $L(169)$ and $\hbar = 5\hbar_0$ level in dark matter hierarchy carrying two flux quanta $h_5$ whereas Earth's magnetic field would correspond to $L(169)$ and $n = 1$. What is nice is that $n = 5$ is the minimal value of $n$ making universal topological quantum computation possible [E9].

One can argue that it is the neuronal time scale of millisecond rather than EEG time scale which serves as a correlate for the conscious experiences assignable solely to our biological body and that EEG is associated with the social aspects of our behavior. The problem with this argument is that our conscious experience contains contributions from much longer time scales than millisecond. The following argument based on a simple model for magnetic flux quanta allows to discuss this problem more quantitatively.

There are several manners to achieve quantization of magnetic flux with dynamical $\hbar$.

1. One possibility is that the area $S$ of flux quantum scales as $\hbar^2$. In this case flux quantization implies that $B$ and cyclotron frequency scale as $1/\hbar$ whereas cyclotron energy is invariant under the scaling of $\hbar$.

2. Second possibility is that the value of magnetic field remains invariant and $S$ scales as $\hbar$. This is especially natural when flux quanta are magnetic flux walls. In this case cyclotron frequencies remain invariant but cyclotron energy scales as $\hbar$. The considerations of this chapter provide support for both quantizations in living matter.

For the latter option one can consider both tubular and sheet like flux quanta.

1. For tubular flux quanta $k_d = 4$ level of dark matter hierarchy the radii of tubular flux quanta would be about $2^{22} \times L(169) = L(169 + 44 = 213) = 20$ m for the Earth's magnetic field $B_E$. For the endogenous magnetic field $B_{end} = .2$ Gauss the radii of fundamental flux tubes would

be $5L(169)$, the size of a large neuron. Using the above described identifications the radii of flux tubes would be scaled up by a factor 5 to about $2^{22} \times 5 \times L(169) = 100$ m. This length scale would define the size scale for the quantum coherence regions of the Bose-Einstein condensates of bosonic ions. This scale is enough to guarantee that the behavior of ions in $B_{end}$ is consistent with the model based on single-sheeted space-time.

2. For $B_{end} = .2$ Gauss one can consider flux sheets with a total transversal length $5 \times L(169 + 4 \times 22) = 5L(257) = 4 \times 10^5$ km, which corresponds to about 62 Earth radii. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure. The photon frequency corresponding to the wavelength $5L(257)$ is 1 Hz and characterizes delta band. One can however argue that DNA thickness which happens to be $\simeq 5L(169)/\lambda \simeq 12.5$ nm, slightly above cell membrane thickness of 10 nm, defines a more natural thickness of the flux sheet. In this case the width of the flux sheet would be scaled up by a factor $\lambda$ to $8.9 \times 10^8$ km about $1.4 \times 10^5$ Earth radii: note that the length scale of the plasma sheet at night side extending to about 1000 Earth radii. Let us refer to these alternatives as option I and II respectively.

The question is whether one can assign a convoluted flux sheet of this width to a single human body or brain. Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux sheet arrives to the human body through a string of cortical neurons. This means that the flux quantum traverses neuronal nuclei such that they are arranged like text lines of a book page along the flux sheet. This structure could closely correlate with the organization of central nervous system and give rise to what might be called super genes.

The total length of DNA in single human cell is about one meter. The DNA of about $8 \times 10^7$ neurons ($1.6 \times 10^{10}$) neutrons would be required for option I (II) *if the contribution of DNA length dominates the width*. The italics are absolutely essential here! If the number of cortical neurons in single layer is about $8 \times 10^7$ which corresponds roughly to an average neuron radius of $10^{-5}$ meters then the flux sheet should go through all neurons in the uppermost neuron layer for option I. This cannot be the case and $k_d = 4$ flux sheets must traverse through several organisms so that they necessarily correspond to collective aspects of consciousness: the mind of Mother Gaia. Also the estimate $\lambda^4 L(151) < L < \lambda^4 L(169)$ for the over all size $L$ of scaled up dark variant of cell nucleus suggests that single magnetic flux sheet traverses cells of organisms in an area of size $L > 180$ km.

If one assumes that the text lines on flux sheet are fully written, a more realistic candidate for the personal magnetic body would correspond to $k_d = 3$ with $B = \lambda B_{end}$ to achieve thermal stability. 1 Hz DNA cyclotron band would for $Z = 2$ flux quantization scale up to kHz band possibly involved with neuronal synchrony and defining the time scale of the nerve pulse. Flux quantization requires flux sheets with width scaled down by $\lambda^{-2}$ to 40 km. This requires neuronal strings traversing at least $4 \times 10^4$ neuronal nuclei which the highly convoluted cortex can easily accommodate. If the personal magnetic body can be regarded as a fractally scaled up cell nucleus, the estimate 80 m $< L <$ 176 km for the size of the personal magnetic body emerges for $\lambda = 2^{11}$.

The fact is however that our consciousness involves contributions from much longer time scales than millisecond. This raises difficult questions about our identity. Do I correspond to a single flux quantum of $B_{end}$ after all: could it be that only a small fraction of these flux sheets corresponds to neuronal DNA and the empty parts of text lines are waiting for the evolution of larger brain to be fully written? How much of the contents of my conscious experience is from my own biological body? Why my sensory experience is dictated by my this particular biological body and why I possess intentional control only over it.

### The definition of the model

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B_{end} = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the value of $\hbar(k) = \lambda^{k_d}\hbar_0$, $\lambda = 2^{11}$.

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

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

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

#### Schumann resonances, EEG and large $k_d = 4$ level of dark matter hierarchy

The photon frequency corresponding to the wavelength $5 \times L(256)$ (size scale of magnetic flux quanta assignable to living matter) is 1.5 Hz and defines delta band. The corresponding energy is $E = .238$ eV which is above than the maximum photon energy $E_{th} = .085$ eV of black body radiation at T=300 K. The frequency $f = 10$ Hz, which corresponds to secondary p-adic length scale associated with Mersenne prime $M_{127}$ characterizing electron, and defines fundamental biological rhythm, corresponds to $E = .67$ eV.

The nominal value 7.8 Hz of the lowest Schumann resonance frequency [19] corresponds to .52 eV which is in the range of energies assignable to the metabolic energy quantum. $A \leq 233Z$ corresponds to $f_{min} = 1.29$ Hz which corresponds to delta band. The higher Schumann frequencies 14, 20, 26, 33, 39, and 45 Hz correspond to energies .9, 1.3, 1.7, 2.2, 2.6, and 3.0 eV. The corresponding photon energies belong to infrared and visible range in the case of ordinary photons. The Schumann frequencies 26, 33, and 39 Hz correspond to red, green, and blue light.

These observations suggest that EEG corresponds to $k_d = 4$ space-time sheets and that EEG frequencies correspond to dark photon energies above the thermal energy at body temperature. The dominance of theta and delta bands during sleep state could be due to the fact that the EEG photons at these energies are not able to induce metabolic effects. The reported strong effects of the lowest Schumann resonance frequency on human brain could be interpreted in terms of a metabolic resonance. Lowest Schumann resonance could also serve as a biological clock synchronizing the behavior of living matter in Earth length scale. Higher Schumann resonance frequencies could define a global reference for the representation of visible colors.

#### Bose-Einstein condensates of bosonic ionized atoms

The number of elements for which ions are bosons is not very large. The following table lists the cyclotron frequencies of bosonic ions which are biologically important for $B_{end} = .2 \times 10^{-4}$ Tesla.

| Ion | $f_1/Hz$ | $E_1/eV$ |
|---|---|---|
| $^6Li^+$ | 50.1 | 3.3 |
| $^{24}Mg^{2+}$ | 25.0 | 1.65 |
| $^{16}O^{2-}$ | 37.6 | 2.48 |
| $^{32}S^{2-}$ | 18.8 | 1.24 |
| $^{40}Ca^{2+}$ | 15.0 | .99 |
| $^{55}Mn^{2+}$ | 11.4 | .75 |
| $^{56}Fe^{2+}$ | 10.8 | .71 |
| $^{59}Co^{2+}$ | 10.0 | .66 |
| $^{64}Zn^{2+}$ | 9.4 | .62 |
| $^{80}Se^{2-}$ | 7.6 | .5 |

Table 1. The first columns give the cyclotron frequencies and cyclotron energies for biologically relevant bosonic ions in $B_{end} = .2 \times 10^{-4}$ Tesla. The third column gives cyclotron energy.

The table inspires some comments.

1. For $Li^+$ the dominating isotope $^7Li^+$ is fermion. $^6Li^+$ is boson and its abundance is 5 per cent. $Li^+$ ions are used as medications in mania and represents mood stabilizer [75]. A possible explanation is that the cyclotron oscillations of Bose-Einstein condensate of $^6Li^+$ ions serve as a biological clock helping to stabilize the mood. The cyclotron frequency is however 50 Hz and higher than thalamocortical resonance frequency having nominal value 40 Hz.

   An alternative explanation for the effect of $Li^+$ is based on the observation that $^7Li_+$ has cyclotron frequency equal to 42.9 Hz for $B_{end} = .2 \times 10^{-4}$ Tesla, which is at the upper limit of the 40 Hz resonance band. The presence of lithium ions or their Cooper pairs could enhance thalamocortical resonance.

   These hypothesis could be tested by looking whether the use of pure $A = 6$ ($A = 7$) isotope of $Li^+$ amplifies the beneficial effect and the use of $A = 7$ ($A = 6$) isotope nullifies it.

2. For $Mg^{2+}$ cyclotron energy corresponds to the energy of photon of green light. Chlorophyll is not able to convert nutrients to sugar without magnesium, which suggests that cyclotron transitions of Mg BE condensate are at least partially responsible for the green color of plants. Mg BE condensate could control the coherent occurrence of photosynthesis in the size scale of plant.

3. For oxygen ion the cyclotron frequency is 37.6 Hz and rather near to $\sim 40$ Hz thalamocortical resonance frequency, which suggests that the cyclotron transitions of oxygen ions might play key role in inducing coherent firing of neurons at this frequency. This would mean that oxygen would be much more than a mere provider of metabolic energy. Note also that $\Delta n = 3$ cyclotron transition of $Na^+$ ion corresponds to frequency 39 Hz and might be involved with the synchronous firing.

4. $Ca^{2+}$ ions play a unique role in the functioning of living matter. In particular, calcium waves appearing in a wide range of time scales are known to serve a crucial role in nervous system [20]. $Ca^{2+}$ corresponds to .99 eV cyclotron energy scale, which is twice the energy of metabolic energy quantum. Hence one can ask whether the cyclotron transitions of $Ca^{2+}$ BE condensate could induce a collective emission of metabolic energy quanta and in this manner induce coherent metabolic activity in the scale of entire body.

5. The cyclotron frequencies Mn, Fe, Co, Cu, and Zn are in alpha band and corresponding cyclotron energies are somewhat above metabolic energy quantum. These energy quanta could drive protons from larger space-time sheet to $k = 137$ atomic space-time sheet. 10 Hz frequency is known to define an important biological clock and Co ions could be essential for the functioning of this clock. $n = 3$ multiple of $Co^{2+}$ cyclotron frequency corresponds to the 30 Hz threshold of gamma band known to be important for cognition. Also $3f_c(Fe^{2+}) = 32.2$ Hz and $3f_c(Mn^{2+}) = 34.2$ belong to gamma band. The presence of Bose-Einstein condensates of these ions in length scale of $5L(212) = 141$ km could mean that these bio-rhythms are shared by different organisms inside regions of this size.

6. The fact that the cyclotron frequency of $Se^{2-}$ ion, which is known to be a biologically important trace element, corresponds to the nominal value of the metabolic energy quantum, raises the question whether Selenium BE condensate might act as a metabolic synchronizer.

**Cyclotron frequencies and Schumann frequencies**

Even in the case that Cooper pairs of fermionic ions are not thermally stable, the cyclotron transitions of fermionic ions like $K^+$, $Cl^-$, and $Na^+$ are expected to be important. In the following table cyclotron frequencies and energies of some fermionic ions are given. Notice that the cyclotron energy of $K^+$ ion corresponds to metabolic energy quantum. Quite generally fermionic ions cannot be involved with the generation of Josephson part of EEG.

| Ion | $f/Hz$ | $E_c/eV$ |
|---|---|---|
| $^7Li_+$ | 42.9 | |
| $F^-$ | 15.8 | 1.04 |
| $Na^+$ | 13 | .86 |
| $Al^+$ | 11.1 | .73 |
| $Cl^-$ | 8.5 | .56 |
| $K^+$ | 7.5 | .50 |
| $Cu^+$ | 4.8 | 333.9 |
| $Ag^+$ | 2.8 | .18 |
| $I^+$ | 2.4 | .16 |
| $Au^+$ | 1.5 | .10 |

Table 2. The first columns give cyclotron frequencies and corresponding cyclotron energies for some ions in $B_{end} = .2 \times 10^{-4}$ Tesla for some fermionic ions.

The first thing to notice is the close relationship of cyclotron frequencies with the lowest resonance frequencies in the spectrum of geo-electromagnetic field starting from 5 Hz, so called Schumann frequencies [19], are $7.8, 14, 20, 26, 33, 39$ and 45 Hz. 5 Hz corresponds roughly to the threshold 4 Hz of theta frequency range below which EEG spectrum lies during sleep which suggests that wake-up state involves the coupling of brain with geo-electro-magnetic activity. 7.8 Hz corresponds to the threshold for alpha waves associated with wake-up state without cognition; 14 Hz corresponds to threshold of 13 Hz for beta waves accompanying cognitive activities, and 33 Hz is quite near to the threshold 30 Hz for gamma waves known to be important in the temporal coding of sensory data.

Consider now examples of cyclotron frequencies keeping in mind that Schumann frequencies vary typically within 1 Hz interval around their mean values [19].

1. As already noticed, the frequencies, which are multiples of 15 Hz can be assigned to $Ca^{2+}$ ion. The excitations $n = 3, 5, 7, ..$ correspond to the frequencies $45, 75, 105, ...$ Hz. All these frequencies have been observed. The two lowest frequencies correspond to Schumann frequencies 14 and 45 Hz with accuracy of 1 Hz.

2. $Na_+$ has $A = 23$ and gives $f = 13$ Hz. This is the lower bound for the frequency of beta EEG waves which are associated with conscious cognition. This would suggest that the presence of em field of 13 Hz frequency correlates with large fluxes of $Na_+$ ions through the axonal cell membrane during nerve pulse generation. This could result from increased amplitude of $Na_+$ Josephson current facilitating the emission of nerve pulses at the second half of the EEG cycle. Silencing of mind by meditation or closing eyes reduces amplitudes associated with EEG frequencies below 13 Hz and conscious cognition disappears.

   $n = 3$ excitation of $Na_+$ corresponds to 39 Hz, which is one of the Schumann frequencies and quite near to the 40 Hz resonant frequency associated with the thalamocortical circuit. This could correspond to jumping of $Na_+$ ions from ground state to $n = 3$ state or vice versa. $n = 5$ quantum jumps correspond to 65 Hz which is average EEG frequency during REM sleep! Thus 13, 39 and 65 Hz frequencies correspond to the basic signatures of conscious cognition. The two lowest transition frequencies correspond to Schumann frequencies 14 and 45 Hz within accuracy of 1 Hz.

3. $K_+$ has $A = 39$ and gives $f = 7.5$ Hz, which is theta frequency rather near to the lowest Schumann resonance frequency 7.8 Hz. $K_+$ ion flux could correlate with em fields in the range of the alpha frequencies creating cyclotron resonance. Theta activity dominates during sleep and Adey's observations [77] demonstrate that 7 Hz ELF field increases reaction times. Second and third transition frequencies are within 1.5 Hz Schumann frequencies 20 and 37.5 Hz.

4. $Cl_-$ ion has $A = 35$ and gives $f = 8.5$ Hz. Chloride ion has inhibitory effect. $n = 3, 7, ..$ excitations correspond to 25.5, 42.5 Hz,... Rather interestingly, frequencies rather near to 40 Hz associated with thalamo-cortical loops appear as excitations for all ions relevant to nerve pulse activity. Note that 39 Hz is also Schumann frequency. Two lowest transition frequencies of $Cl_-$ are quite near to Schumann frequencies 7.8 and 25 Hz.

5. $Fe^{2+}$ has $A = 56$ and corresponds to 10.7 Hz. $3f_c(Fe^{2+}) = 32.2$ Hz is rather near to Schumann frequency 33 Hz whereas $Co^{2+}$ corresponds to 10 Hz in excellent accuracy. $Co$ has especially large nuclear magnetic moment and serves as a natural magnet. $Fe^{2+}$ and/or $Co^{2+}$ could be present in magnetic sensory organ possessed also by humans making it possible to navigate using magnetic fields. Yarrow suggests that $Co$ makes $B_{12}$ magnetic vitamin [77] so that it can serve as fundamental biological clock at frequency very precisely equal to 10 Hz. $Co$ is carried by $B_{12}$ vitamin and is known to be important for normal consciousness: among other things the lack of $B_{12}$ causes fatigue, blurred vision and cognitive problems.

6. $Mg^{2+}$ has A=24 and $f = 25$ Hz which is near to Schumann frequency: $n = 3$ corresponds 75 Hz. Charged polypeptides could also form BE condensates and be involved with cyclotron mechanism: they are rather heavy and their cyclotron frequencies are in Hz range. Negatively charged organic molecules are indeed known to be present in neurons.

To sum up, surprisingly many magnetic transition frequencies are near to Schumann frequencies which suggests strong resonant interaction between brain and geo-electromagnetic fields.

#### What about proton's cyclotron frequency?

There are good reasons to expect that the cyclotron frequency of proton and its odd harmonics play an important role in brain functioning. The cyclotron frequency of proton in $B_{end} = .2$ Gauss is $f(p) = 300$ Hz. The frequency associated with $n = 3$ transition would be $3f(p) = 900$ Hz. Third harmonics of cyclotron frequencies of many ions with $f_c$ in alpha band belong to gamma band known to relate to cognition. Perhaps this is true also in the case of proton.

The duration of single bit of the memetic codeword consisting of 127 bits and having total duration defined by the p-adic timescale $T^{(2)}_{M_{127}} = .1$ seconds corresponds to the frequency $f_m = 1027$ Hz. This frequency is by 10 per cent higher than the cyclotron frequency of proton for $B_{end} = .2$ Gauss. If magnetic homeostasis is realized, as will be discussed later, and if it allows 10 per cent variation of the strength of magnetic field as the width 1 Hz of alpha band suggests, it is possible to realize this frequency as proton's cyclotron transition frequency.

The frequency of neuronal synchronization, which is obviously associated with cognitive processing, is $\simeq 1$ kHz and might well be identifiable with $f_m$. The maximum rate of neuronal firing is slightly below kHz: this rate however corresponds to the rate of quantum jumps rather than oscillation frequency at space-time level.

#### Bose-Einstein condensates of bosonic molecular ions

Also biologically relevant bosonic molecular ions such $SO_4^{2-}$, $CO_3^{2-}$, $NO_3^-$, $NO_2^-$ could form Bose-Einstein condensates. The cyclotron frequencies for bosonic molecular ions satisfying the thermal stability condition $A \leq 233 \times Z$ at room temperature are typically in theta and delta band and above $f_{min} = 1.29$ Hz.

DNA is negatively charged and an interesting question is whether DNA satisfies the stability condition. The molecular weights of DNA nucleotides A,T,C,G are 132,126,96,149. The molecular weight of deoxyribose sugar attached to the nucleotide is 100 and that of phosphate group $PO_4^{2-}$ is 95. Altogether this makes molecular weights 327, 321, 291, 344. Since phosphate group is doubly charged this structure has cyclotron energy which is higher than thermal energy. Also DNA sequences satisfy the thermal stability condition. The presence of DNA Bose-Einstein condensates at magnetic flux quanta could mean that DNA can be transferred between different organisms along these space-time sheets and that DNAs of different organisms of same species could form quantum coherent systems inside regions where magnetic field can be regarded as a constant.

## 3.5 Magnetic genome, magnetic homeostasis, and magnetic circulation?

The view about the interaction of magnetic flux sheets with DNA leads to a rather far reaching vision about what genetic code really is. The notions of magnetic homeostasis and magnetic circulation are also highly suggestive.

### 3.5.1 The new view about genetic code

The concrete realization of the personal magnetic body or actually hierarchy of them labelled by $k_d = 0, 1, ..., 7$ was already discussed in section discussing the difference between personal magnetic body and that of Earth. The cautious proposal was that the personal magnetic body corresponds to $k = 169$ and to $\hbar = 5\hbar_0$ for $\lambda = 1$ with $B_{end} = .2$ Gauss carrying two units $h_5 = nh$ of magnetic flux. In the simplest situation the flux sheets have thickness $5L(169) \simeq 25$ $\mu$m and width which scales as $\lambda^{k_d}$, $\lambda = 2^{11}$. If the folded flux sheet goes through genomes such single cell or neutron contributes a length $5L(169)$ to the flux sheet, the number of cells traversed is $N = \lambda^k \times 5L(169)/L(DNA) = 2.5 \times 10^{-5}\lambda^k \simeq 5 \times 2^{k-1} \times 10^{3k-5}$, where $L(DNA) \sim 1$ m is the estimate for the total length of human DNA strand inside genome.

| k | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| N | 105 | 2.1E+5 | 4.4E+8 | 9E+11 | 1.8E+15 | 3.8E+18 |

Table 3. The table gives a rough estimate for the number of neurons of radius 25 $\mu$m traversed by the folded magnetic flux sheets and assumed to contain 1 meter of DNA in the case that the density of genes along the flux sheet is maximal.

$k_d = 6$ would give a total width of about $1.8 \times 10^{12}$ km, which could correspond to the size of magnetosphere of Sun. The number of neurons traversed would be about $2 \times 10^15$. $k_d = 7$ would give a total width of about 400 light years defining size scale for the galactic nucleus. The assignment of cosmic consciousness with crown chakra would be really well justified. This width of flux sheet would require that it traverses through about $4 \times 10^{18}$ neuronal nuclei to be compared with the number $\sim 10^{12}$ of neurons in human brain. The cells of human body would not be enough in the case that the lines of text defined by gene sequences are not almost empty. For $k_d = 5$ the number of genomes traversed would be of order $N \sim 10^{12}$. The number of neurons in human brain is estimated to be $\sim 10^{12}$. For $k_d \geq 6$ also other cells or neurons in other organisms must be added to the necklace unless the text lines defined by genomes are almost empty.

For $k_d < 4$ level the cyclotron frequencies in $B_{end} = 0.2$ Gauss do not correspond to cyclotron energies above thermal threshold so that stronger magnetic fields associated with $k < 169$ are necessary if cyclotron energies are to be of biological significance. It would seem that $k_d = 3$ defines upper bound in this respect: in this case $L(151)$ corresponds to cyclotron energies above thermal threshold for $A \leq 55Z$.

Those for whom pictures about mitosis are familiar might have had the feeling that the chromosomes are indeed bound to threads and that division of a dipole magnetic field to two occurs during cell division. This encourages to speculate about the possible implications of the proposed realization of magnetic bodies corresponding to $k_d \geq 3$ levels of dark matter hierarchy.

1. The flux tube with given value of $k_d$ need not go through every gene. It is also possible that same gene topologically condenses at flux sheets characterized by several values of $k_d$. These assignments are in principle dynamical. The flux sheets would obviously define a functional hierarchy such that at each level quite different structures or functions are coded. A natural guess would be that dark genes at level $k_d$ code structure and functions related to dark matter at level $k_d$. This increases dramatically the representative power of genome and would explain why the amount of human genome differs only little from that of much more primitive organisms such as wheat or fishes.

   The emergence of dark matter hierarchy would be the manner to make genes multi-functional and bring in a hierarchy of increasingly refined abstraction hierarchy. In vertebrates the really significant evolution would take place at this level. This also allows a new perspective to the mysterious introns, the 95 per cent portion of DNA christened as "junk DNA" by materialistic biologists, as a part of genome codes mostly for functions associated with dark matter levels and culture rather than biology.

2. For $k_d \geq 2$ single human genome with a total length $\sim 1$ m of DNA cannot correspond to entire width of the magnetic flux sheet which is about 40 km for $k_d = 3$. This means that the flux sheet must traverse through a large number of genes and bind them to single super gene (this would occur even in the case that the flux sheet is branched).

These super genes would be very literally light highly convoluted pages of book containing sequences of nucleons as text lines. The pages of this book would be dynamical and the evolution of individual would presumably be like writing this enormous body book and expressing it in various manners. They would provide an exponentially explosive representational power and the relation of genome itself to super-genome would be like that of bit to a large collection of computer programs. This would also mean that brain would have use quantum computational capacity (for TGD based model for topological quantum computation see [E9]).

3. Even more dramatic generalization of genome can be considered. There is in principle no reason why magnetic flux sheets could not pass through several organisms so that kind of hyper-genes would result. These hyper-genes could make possible the emergence of complex social structures with individuals obeying rules making possible complex behavioral patterns. In this case there is practically no upper bound for $k_d$. Hyper genes could have introns as building blocks and could express themselves electromagnetically via memetic code as discussed in [L1]. Very probably hypergenome would be highly dynamical unlike the hardwired ordinary genome.

4. Super genome would distinguish between man and wheat whereas hyper genome would explain the difference between monkeys and men having almost identical genomes. A dramatic boost in the evolution of hyper-genome probably occurred when humans started to emigrate from Africa. The evolution of spoken language occurred in parallel with this evolution. The emergence of the written language as a direct projection of the pages of the genetic book to the external world meant also a great leap forward in this evolution and led to the development of art and science and complex social structures. One could even consider the possibility of explaining cultural diseases like the emergence of Nazi Germany and global market economy (to take an example nearer to us) as the emergence of collective conscious entity with pathological hyper genome.

### 3.5.2 Magnetic homeostasis and magnetic circulation?

The possible importance of the precise value of the local magnetic field for say memetic code [L1] suggests that living matter has learned to control local magnetic field inside magnetic flux tubes just as it controls salt level of biological water.

In particular, $B_{end}$ could have slightly different values at different levels $k_d$ of dark hierarchy (cyclotron energies can be above thermal threshold only for $k_d \geq 4$). Cell differentiation could lead to the differentiation of the local value of $B_{end}$ and the value could vary even inside single cell nucleus, and be slightly different for genes characterized by different value of $k_d$ (that is, topologically condensed at flux sheet with this value of $k_d$).

There is rather precise analogy with blood flow since both incompressible velocity field of blood and magnetic field are divergence-free: one can imagine magnetic flux to flow along 'B-veins' (magnetic flux tubes) along organism or at least CNS. Variation of the magnetic field strength would be forced by the variation of the thickness of the flux tube since magnetic flux is conserved just as the variation of the thickness of blood veins affects blood flow. Artificial small alteration of local magnetic from outside would only interfere with this control.

For instance, alpha peak drifts in Hz range and this could be due the variation of the value of local magnetic field varies as much as 10 per cent. If this variation is due to the homeostatic variation of the local magnetic field, absolute variation should increase for higher frequencies: at the upper end of gamma band it would be 9 Hz. An alternative explanation for drifting is in terms of amplitude modulation: amplitude modulation of frequency $f_1$ by frequency $f$ implies that original frequency is split to frequencies $f_1 \pm f$. In this case the amplitude of drifting does not depend on frequency.

#### Magnetic circulation

The analogy with blood flow suggests that one could speak about $B$-circulation completely analogous to blood circulation: $B$-circulation could be crucial for bio-system to act as macroscopic quantum system. $B$-circulation would naturally accompany neural circuitry. It could be also accompany ordinary blood circulation physically or could form an independent system. The association with blood circulation would provide prerequisites for quantum control of also blood circulation and metabolism.

The control could be based on MW frequency Josephson currents associated with ELF em fields inducing conformational changes of proteins coherently in large regions in turn giving rise to needed synchronous biochemical self-organization processes. Also $Z^0$ magnetic circulation system is plausible.

#### Temperature dependence of the local magnetic field strength

EEG frequencies are known to change with temperature [55]. The assumption that the thickness of the magnetic flux tubes depends on temperature implies that EEG frequency scale varies with temperature. One might think that this kind of mechanism could partially explain why a serious hibernation leads to a lower level of arousal. The results of Blackman [86] suggesting that ELF effects with given frequency disappear when body temperature is not in the range $36-37$ C inspires the hypothesis that quantum critical high $T_c$ superconductivity is possible only in the range 36-37 C. This obviously provides a more plausible explanation for the effect of hibernation. In this picture the extreme importance of temperature regulation for the functioning of organism could be seen as a prerequisite for continual quantum control by magnetic transition frequencies from $k_d = 4$ magnetic body.

Circadial temperature variation can be something like 20 Kelvins , which means relative variation about 10 per cent for poikilotherms, which is of same order as alpha frequency drifting. The relative width of the cyclotron resonance would be from this about 7 per cent ($\Delta f/f = \Delta B/B \propto \Delta T/T$).

The observation that widely separated brain regions tend to fluctuate in unisono [54] is not easy to understand if one imagines brain as consisting of independent oscillators. If important EEG frequencies correspond to magnetic transition frequencies, the fluctuations can be understood as induced from fluctuations of the local magnetic field possibly induced by the organism itself.

#### Why the increase of the local magnetic field strength by factor of ten does not raise alpha band to heaven?

The increase of the local magnetic field strength by a factor $10-20$ is known to induce stress [77] and confuse biological timekeeper mechanisms but it certainly cannot raise alpha band above 100 Hz. The resolution of the this objection is simple. The size of the volume in which artificially generated magnetic field prevails determines the value of $k_d$ and p-adic length scale $L(k)$ in question. $k_d$ is definitely smaller than $k_d = 4$ associated with the flux sheets corresponding to $B_{end}$. Secondly, the ability to perturb the magnetic field at $k_d = 4$ flux sheets associated with DNA would presumably require a refined technology. If organism has developed magnetic homeostasis, it tends to keep the magnetic field constant inside the flux sheets just as cell tends to keep the salt concentration constant. Thirdly, if $B_{end} = .2$ Gauss indeed corresponds to $\hbar = 5\hbar_0$, the coupling to the variations of Earth's magnetic field might be rather weak. This would also resolve the problem posed by the fact that astronauts have survived in magnetic fields much weaker than the Earth's magnetic field.

Assuming that $k_d$ is fixed, p-adic length scale hypothesis suggests that the increase of local field strength of flux quantum by a factor four would cause change of p-adic scale since $p \simeq 2^k$, $k = 167$ is the next p-adic length scale below $k = 169$: this scale is by a factor 2 shorter so that magnetic field scales up by a factor of 4. Of course, it could be also that the increase of the local magnetic field with strength defined macroscopically by flux per area might only tend to thicken the flux tubes or increase their volume density rather than increasing the value of the magnetic field inside flux tube.

### 3.5.3 Some remarks and questions

#### Synchronizing effect of Earth's magnetic field

Magnetic homeostasis and the deviation of $B_{end}$ from $B_E$ does not prevent the effects due to the variation of the Earth's magnetic field on human consciousness, and Earth's magnetic field could act as a grand synchronizer of biorhythms or even separate organisms.

The close correlation of various cycles of biological and brain activity, in particular sleep-wake cycle, with periodic circadial variations of the geomagnetic field [77], is consistent with this. Magnetic storms change temporarily the value of the local magnetic field and also this should have effects on consciousness. The statistics about mental hospitals supports this view [77]. Also Persinger has proposed that the modulations of Earth's magnetic field caused by geomagnetic perturbations have effect on human consciousness [92, 77]. Michael Persinger has studied extensively the effects of

Schumann resonances on brain and has even explained religious and UFO experiences as correlates of this interaction [93, 94, 95].

Also the diurnal changes of magnetic field caused by Moon having period of 25 hours are known and this variation seems to provide fundamental biological clock which sets on in absence of the normal 24 rhythm regulated by sunlight. The diurnal variations of the geomagnetic field are also responsible for sleep-awake rhythm: the increased melatonin secretion during dark hours correlate with the variation of Earth's magnetic field.

It is also known that that the exposure to magnetic fields 10-20 times geomagnetic field induces stress in rabbits and slowed reaction time in humans; that the absence of geomagnetic field leads to a complete de-syncronization of biorhytms and that the synchorization of ELF biorhytms is coupled to ELF geomagnetic pulsations [77]. In particular, pineal gland serves as biological timekeeper with cyclotron frequency of $Co^{2+}$ ion defining the basic time unit of .1 seconds.

Dr. Phil Callahan [91] claims on basis of intensive experimental work that there is a tendency of political strifes and wars to concentrate on regions where Schumann resonances are weak. This would not be surprising since Schumann resonances act as collective bio-rhytms if vertebrate brains are connected to the magnetic body of Earth.

*3. What happens to astronaut's magnetic body*

There is an old objection against the notion of magnetic body. If the local value of Earth's magnetic field is crucial for the brain functioning, astronauts should experience grave difficulties or at least dramatic changes in the character of consciousness. A possible estimate for the weakening of the local magnetic field is based on the scaling law $B \propto 1/r^3$ for dipole field. In this case a rough estimate for the relative change of the EEG frequency scale is $\Delta f/f = 3\Delta R/R \sim 6$ per cent for satellites moving below the ionosphere. This should affect the state of consciousness.

As a matter fact, there is reported evidence [114, 113] that cosmonauts spending months in MIR had strange altered states of consciousness involving among other things precognition of the difficulties to be countered by MIR and receiving advices and identification experiences with other people and life forms, even dinosaurs of ancient Earth!

In the many-sheeted space-time the situation looks like following.

1. The endogenous magnetic field $B_{end} = .2$ Gauss which is most important for the function of living matter is associated with the personal magnetic body and is not affected. This alone might explain why astronauts are able to survive.

2. Astronauts could draw the magnetic flux sheets connecting them to the magnetic body of Earth and possibly existing higher level magnetic bodies with them. Only $k_d = 4$ level might be affected since for $k_d > 4$ the length scale involved, which corresponds to height of ionosphere, is shorter the than the distance travelled.

3. At the level of cell nuclei nothing dramatic need happen. Energetically the stretching magnetic flux sheets associated with DNA is not a problem since the energy densities involved are rather tiny. Furthermore, if the flux sheets carry homological monopole flux, they could highly stable against increase of length since they would have magnetic monopole wormhole contacts at their ends.

4. The question is what happens for the possibly existing Josephson junction associated with 180 km thick layer composed of litosphere and connecting brain to magnetic body of Earth? Could the Josephson current run still now but from litosphere to the magnetic sheets to the brain of astronaut and back to the ionosphere? A long period in space might change the situation and this could relate to the strange experiences of astronauts. If the contribution of $k_d = 4$ level weakens it might happen that $k_d > 4$ levels with longer time scale begin to dominate the consciousness.

5. The experiences are also consistent with TGD based view about geometric time and possibility of geometric memories extending beyond the duration of individual life cycle. If one takes seriously the report about dinosaurs, which lived for $\sim 10^8$ years ago, $k_d = 9$ level which corresponds to Josephson period of $5.44 \times 10^9$ years, could have contributed to the conscious experience of astronauts.

*5. What the reduction of Earth's magnetic field means?*

The strength of Earth's magnetic field has reduced 50 per cent during last 1.000 years. The fact that an exponential evolution of civilization has occurred during this period, might not be an accident. Surprisingly many magnetic transition frequencies for $B_{end} = .2$ Gauss happen to be near to Schumann resonance frequencies. During this period the weakening of $B_E$ has reduced cyclotron frequency spectrum of heavy ions in Earth's magnetic field from the range $[f_{l,E}, f_{u,E}] = [7.5, 20]$ Hz range to the range $[f_{l,E}, f_{u,E}] = [3.75, 10]$ Hz.

$B_{end}$ could have stayed constant through this period so that frequency interval would have remained $[f_{l,end}, f_{u,end}] = [1.5, 4]$ Hz for all the time. Interestingly, delta frequencies near 3 Hz, which correspond to a peak in the frequency spectrum of so called sferics associated with lightning activity [21], would have belonged to the endogenous range during the entire period in this case. The fast evolution might have related to the change of the character of the interaction between $B_E$ and $B_{end}$: indeed $f_{l,E} = 3.75$ Hz is slightly above $f_{lu,end} = 4$ Hz. If $B_{end}/B_E$ has been constant, then the cyclotron frequency interval for heavy ions in $B_{end}$ would have reduced from 3-8 Hz to 1.5-4 Hz.

These observations suggest the emergence of strong interaction between brain and higher levels of the self hierarchy based on spherics and Schumann resonances. Assuming temporal linearity, the reduction of Earth's magnetic field has been 25 per cent after Newton and 5 per cent during last 100 years. Perhaps an exponential development of mathematical consciousness made possible by the activation of cyclotron frequencies of heavy ions with high nuclear and electronic angular momenta and allowing large number of conscious-to-us magnetic transitions, and possibly also involving some kind of fine tuning is taking place.

The weakening of Earth's magnetic field probably relates to a forthcoming change in the polarity of Earth's magnetic field. One might guess that the personal magnetic bodies are not affected appreciably during this period but that the violent change of Earth's magnetic field induces dramatic effects on collective aspects of consciousness at $k_d = 4$ level as the findings of Callahan suggest.

### What about spin flips?

In the original scenario based assuming that cold space-time sheets are dark and $\hbar$ has the ordinary value, also Larmor frequencies were important: effects of em fields in living matter at Larmor frequencies have not been however reported. For some time I though that the Because spin is invariant under the scaling of $\hbar$ Larmor energy is negligible as compared to the cyclotron energy so that it seems that spin is thermalized in the most pessimistic scenario and spin does not play important role in the understanding of consciousness.

There is however a notable exception: cognitive neutrino pairs which correspond to wormhole contacts carrying quantum numbers of neutrino and antineutrino at their throats identified as light-like causal horizons. In condensed matter it is possible to achieve a situation in which cognitive neutrino pairs are created from vacuum and since they have zero energy the notion of thermalization does not make sense. If this heuristics is correct, the earlier quantum model for hearing and cognition can be saved and despite the dramatic modifications of basic assumptions makes essentially the same basic quantitative predictions.

### What about $Z^0$ magnetic transitions?

The idea that $Z^0$ magnetic magnetic transitions might be relevant for biomatter have been discussed already earlier. The identification of the sources of long ranged classical weak fields as dark matter forces however a profound modification of the earlier picture.

The TGD based models for atomic nuclei [F8] and condensed matter [F9] suggest strongly that the dark variant of $k = 113$ copy of $k = 89$ electro-weak physics is essential for understanding of not only the anomalies of water but also the basic properties of condensed matter. Also other copies of electro-weak physics with arbitrarily small weak mass scale are implied by the fact that long ranged classical weak fields are unavoidable in TGD Universe. Also the scaled down copies of color physics with arbitrarily low mass scales for quarks are a basic prediction of TGD.

If classical $Z^0$ magnetic field is present and if nuclei possess anomalous weak charges due to the presence of color bonds with quark and antiquark at their ends carrying non-vanishing net weak charges coupling to $k = 113$ dark weak bosons, one must consider also $Z^0$ cyclotron frequencies given by

$$\Omega = \frac{N(u\overline{d})}{A} \times Q_Z(u\overline{d}) \times \frac{g_Z B_Z}{eB} \times \Omega_p \ , \quad \Omega_p = \frac{eB}{m_p} \ ,$$
$$Q_Z(u\overline{d}) = \frac{1}{2} - sin^2(\theta_W) \ . \tag{3.5.1}$$

Here $N(u\overline{d})$ is anomalous $Z^0$ charge of the nucleus due to weakly charged color bonds connecting nucleons with quark and antiquark at their ends using $u\overline{d}$ $Z^0$ charge $Q(u\overline{d})$ as unit. $\Omega_p$ is proton cyclotron frequency, which is about 300 Hz for $B = B_{end} = .2$ Gauss. The dependence on the $Z^0$ magnetic transition frequencies on the mass of nucleus is same as in the electromagnetic case.

The doubly dark weak bosons with weak length scale $L_w = 2^{22}L_w(113) = .2\ \mu$m should be key actors in TGD based model of living matter. Since the quantization of magnetic flux uses $\hbar$ as unit the quantum of $Z^0$ flux over a given area is multiplied by a factor $2^{22}$ for doubly dark weak bosons. Also the energy $\hbar\omega_c$ associated with the cyclotron frequency is multiplied by a factor $2^{22}$ so that energies are by a factor $2^{44}$ higher for cyclotron transitions in flux quantized $Z^0$ magnetic field than one might expect. In the case of dark quarks it would be natural to use $2(Q_Z(u\overline{d})$ as unit of charge in the quantization of magnetic flux so that the flux quantization reads $2Q_Z(u\overline{d})\int B_Z dA = n2^{22}\hbar 2\pi$.

$Z^0$ flux quanta with radius $L_w = .2\ \mu$m are expected to be of special interest. Consider the field corresponding to single flux quantum in this case. Using the fact that $B_{end} = 2$ Gauss corresponds to a single quantum of flux through a disk of radius $5L(k = 168)$, one obtains that the $Z^0$ cyclotron frequency and energy in this case are given by

$$\begin{aligned} f_c(2^{22}\hbar(5), 168) &= 2^{22}\frac{N(u\overline{d})}{A} \times Q_Z(u\overline{d}) \times (\frac{5L(168)}{L_w})^2\omega_p(B_{end}) \\ &\simeq \frac{N(u\overline{d})}{A} \times 1.875\ \ THz \ , \\ E_c(2^{22}\hbar) &= 2^{44}\frac{5}{\sqrt{2}}E_c(\hbar) \simeq \frac{N(u\overline{d})}{A} \times 2.5 \times 10^4\ \ eV \ . \end{aligned} \tag{3.5.2}$$

Note that $\Omega_c$ and $E_c$ do not depend on the unit of flux quantization. Cyclotron frequencies are in GHz range but energies in $10^4$ eV range and corresponds to ordinary photon wavelength of about atomic length scale. In the earlier picture frequencies were in 10 Hz range. The energies involved are well above the thermal energy at room temperature. For the first level of dark matter hierarchy the frequency scale would be .9 GHz and energy scale 6 meV which is below the thermal energy at room temperature.

Also ordinary nuclei containing charged color bonds would couple to dark weak bosons with weak length scale having nominal value $L_w = 2^{11}L_w(113) = 1$ Angstrom. In this case $Z^0$ magnetic fields would have $2^{11}$ stronger strength that in previous case and cyclotron energies would be same.

## 3.6 Two models for the hierarchy of Josephson junctions

One can imagine two manners to realize the hierarchy of EEGs and Josephson junctions.

1. The original model was based on a too restricted view about the generalized imbedding space and led to a model of Josephson junctions assigned to a fractal hierarchy of cell membrane like structures with arbitrarily large thickness for the scaled up variant of cell membrane but possessing same membrane potential as ordinary cell membrane. This assumption is very strong and could quite well be unrealistic.

2. Few years later a further generalization of the imbedding space emerged allowing hierarchy of Josephson junctions assignable to cell membrane itself. This option looks much more realistic and will be discussed after a brief summary of the generalization of the notion imbedding space. The generalization of the imbedding space is discussed in more detail in Appendix.

### 3.6.1 Generalization of the notion of imbedding space

Quite generally, the hierarchy of Planck constant is realized by generalizing the notion of imbedding space such that one has a book like structure with various almost-copies of imbedding space glued together like pages of book. Each page of book correspond to a particular level of dark matter hierarchy and darkness means that there are no Feynman diagrams in which particles with different value of Planck constant would appear. The interactions between different levels of hierarchy involve the transfer of the particles mediating the interaction between different pages of the book. Physically this means a phase transition changing the value of Planck constant assignable to the particle so that particle's quantum size is scaled. At classical level the interactions correspond to the leakage of magnetic and electric fluxes and radiation fields between different pages of the book.

#### Original view about generalized imbedding space does not allow understanding of quantum Hall effect

The original generalization of the imbedding space was too restricted and the belief that the proposed generalization of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge turned out to be wrong. The idea was that a given page of the book like structure would correspond to an orbifold obtained from $H = M^4 \times CP_2$ by identifying the points of $H$ obtained from each other by the action of group $G_a \times G_b$, where the factors act in $M^4$ and $CP_2$ degrees of freedom. As a matter fact, this identification implies just the opposite of fractionization if these quantum numbers are assigned with the symmetries of the imbedding space. For instance, quantization unit for orbital angular momentum becomes $n_a$ where $Z_{n_a}$ is the maximal cyclic subgroup of $G_a$.

One can however imagine of obtaining fractionization at the level of imbedding space for space-time sheets, which are analogous to multi-sheeted Riemann surfaces (say Riemann surfaces associated with $z^{1/n}$ since the rotation by $2\pi$ understood as a homotopy of $M^4$ lifted to the space-time sheet is a non-closed curve. Continuity requirement indeed allows fractionization of the orbital quantum numbers and color in this kind of situation.

#### Extension of imbedding space by allowing coverings

This means an extension of the imbedding space by allowing also $G_a$ *resp.* $G_b$-fold coverings of $\hat{M}^2 = M^4 \backslash M^2$ *resp.* $\hat{CP}_2 = CP_2 \backslash S^2$, where $M^2$ corresponds to 2-D Minkowski space defined by the fixing of rest frame and direction of quantization axis of angular momentum and $S^2$ to a homologically trivial geodesic sphere of $CP_2$ which corresponds to a particular choice of group $SO(3) \subset SU(3)$ and thus fixing of quantization axes of color isospin. The surfaces $X^4 \subset M^4 \times S^2$ are vacuum extremals as required by internal consistency of the theory. The leakage between different pages of book occurs via manifolds $M^4 \times S^2$ and $M^2 \times CP_2$ which correspond to quantum criticality. The extreme form of quantum criticality corresponds to leakage through $M^2 \times S^2$.

The book has four kinds of pages:

1) $[\hat{M}^4/G_a] \times [\hat{CP}_2/G_b]$ with Planck constant $\hbar/\hbar_0 = n_a/n_b$: $n_i$ is the order of maximal cyclic subgroup of $G_i$. Only these pages were included in the original "book": the problem concerning biological applications is that large values of Planck constant require high rotational symmetries;

2) $[\hat{M}^4" \times "G_a] \times [\hat{CP}_2/G_b]$ with $\hbar/\hbar_0 = 1/(n_a n_b)$: " $\times$ "$G_i$ refers to $G_i$ covering. Note that Planck constant is always smaller than its standard value $\hbar_0$ ($n_a = n_b = 1$) in this case implying for instance that the binding energy scale of hydrogen atom is scaled up;

3) $[\hat{M}^4" \times "G_a] \times [\hat{CP}_2" \times "G_b]$ with $\hbar/\hbar_0 = n_b/n_a$;

4) $[\hat{M}^4/G_a] \times [\hat{CP}_2" \times "G_b]$ with $\hbar/\hbar_0 = n_a n_b$; note that in this case the Planck constant is maximal.

#### Maximimation of Planck constant in quantum control and communication in living matter

The pages of type 4) are the most promising candidates concerning the understanding of living matter, at least the quantum control of living matter.

1. $G_a$ symmetry is implied in $M^4$ degrees of freedom since the restriction to the orbifold $\hat{M}^4/G_a$ is equivalent to the $G_a$-invariance of quantum states. Molecular rotational symmetries correspond typically to small groups $G_a$.

2. $G_a = Z_n$, $n = 5,6$ are favored for molecules containing aromatic cycles. Also genuinely 3-dimensional tedrahedral, octahedral, and icosahedral symmetries appear in living matter. In this kind of situation one could have for given $G_a$ the hierarchy $n_b = 2^{11k}$) giving rise to large values of Planck constant. This hierarchy might be realized both at the level of DNA and cell membrane.

3. Also the hierarchy of EEGs could correspond to this hierarchy and one could assume that cell membrane gives rise to the entire hierarchy. Also other powers of 2 could occur in the hierarchy.

## 3.6.2 The new model for the hierarchy of Josephson junctions

The original model for EEG led was based on the generalization of imbedding space obtained by gluing together almost-copies of imbedding space such that copies where effectively orbifolds $H/G$ $G = G_a \times G_b$ the product of discrete subgroups of rotational group SO(3) and $SO(3) \subset SU(3)$. The model forced the admittedly weird looking assumption that cellular Josephson junctions are accompanied by their fractally scaled up variants with cell membrane thickness $2^{11k}$, $k = 0,1,2,...$ with very precisely same value of electric field. This means quite a strong assumption about the dark matter hierarchy.

After few of years after developing the first version of the model the obvious questions are whether one could avoid such a strong assumption about dark matter hierarchy and whether one could assume that Josephson junctions in hierarchy have the same thickness defined by cell membrane thickness. This seems to be possible.

The further generalization of imbedding space by allowing $G_a-$ *resp.* $G_b$-coverings of $M^4\backslash M^2$ *resp.* $CP_2\backslash S^2$ leads to a more general formula for Planck constant. If imbedding space corresponds to $n_b$-fold covering of $CP_2\backslash S^2$ then Planck constant is proportional to $n_b$. This means that besides $n_a$-fold symmetry in $M^4$ degrees of freedom also $n_b$-fold covering in $CP_2$ degrees of freedom makes possible to make Planck constant large.

This would suggest that cell membrane Josephson junctions for large values of Planck constant to $n_b$-fold $CP_2$-coverings of ordinary cell membrane Josephson junctions with electronic Cooper pairs at the sheets of covering. The value of Planck constant would be $n_a n_b$-fold for pages of type 4) discussed in previous subsection. If the thickness of Josephson junction is not changed one obtains only the scaling of photon wavelengths for a given photon energy.

Cyclotron frequency would remain invariant but Josephson frequency would be scaled down since one has $f_J = ZeV/\hbar$. This kind of slowing down of oscillation of the Josephson current should have interpretation in terms of the modified topology in $CP_2$ degrees of freedom. The simplest interpretation would be that covering means that oscillation corresponds to a closed orbit in $CP_2$ degrees of freedom which for $n_b$-fold covering closes only after $n_b$ cycles. It seems that this option is the more realistic one.

### p-Adic fractal hierarchy of Josephson junctions is possible also in the new model

The older model postulated a hierarchy of Josephson junctions which involved two hierarchies, dark matter hierarchy and p-adic hierarchy in a kind of resonance for living matter systems. The unrealistic looking assumption was that there exists a hierarchy of cell membrane like structures with increasing thickness scaled up by factor $2^{11k}$ acting as Josephson junctions and characterized by the same voltage as ordinary cell membrane.

In the new model the dark hierarchy of Josephson junctions is replaced with a hierarchy of layers of the onion-like magnetic body assignable to the ordinary cell membrane. It is of course still possible to have hierarchy of Josephson junctions at least in length scales regarded usually as biologically relevant. The voltage through the junction need not however be same as for the ordinary cell membrane anymore.

In particular, twin primes abundant in the p-adic length scale range assignable to living matter could define double layered structures acting as Josephson junctions.

| | | | | |
|---|---|---|---|---|
| $(k, k+2)$ | $(137, 139)$ | $(149, 151)$ | $(167, 169 = 13^2)$ | $(179, 181)$ |
| $L(k)$ | $.78\ A$ | $5\ nm$ | $2.5\mu m$ | $.32\ mm$ |
| $(k, k+2)$ | $(191, 193)$, | $(197, 199)$ | | |
| $L(k)$ | $1\ cm$ | $8\ cm$ | | |

Table 4. Twin primes define especially interesting candidates for double membrane like structures defining Josephson junctions. Also included the pair $(137, 13^2 = 169)$ although $k = 169$ is not prime. The two largest scales could relate to structures appearing in brain.

#### An objection against the older model for the fractal hierarchy of Josephson junctions

There is a counter argument against the hierarchy of cell membrane like structures with a scaled up thickness coming as powers of $2^11$. The electric field involved with the higher levels of Josephson junction hierarchy is very weak: something like $10^{-7}$ V/m for lito-ionospheric Josephson junctions (of thickness about 176 km from the scaling of the cell membrane thickness by $\lambda^4 = 2^{44}$) which might be responsible for EEG. The electric field of the Earth at space-time sheets corresponding to ordinary matter is much stronger: about $10^2 - 10^4$ V/m at the surface of Earth but decreasing rapidly as ionosphere is approached being about .3 V/m at 30 km height. The estimate for the voltage between ionosphere and Earth surface is about 200 kV [22].

The many-sheeted variant of Faraday law implies that on order to have a voltage of order .08 V over lito-ionospheric Josephson junction at dark matter space-time sheet, the voltage over ionospheric cavity must be almost completely compensated by an opposite voltage over litosphere so that lito-ionospheric double layer could be seen as a pair of capacitor plates in a radial electric field of order $10^{-7}$ V/m generated by the charge density in sub-litospheric part of Earth. This condition requires fine-tuning and therefore looks unrealistic.

A natural distance scale in which the electric field is reduced would correspond to 10-20 km thick layer in which whether phenomena are present. The mirror image of this layer would be Earth's crust. The cell membrane counterpart would be a dipole layer like charge density between the lipid layers of the cell membrane. Note that the electric field at dark matter space-time can be constant. However, as far as Josephson junction is considered, it is only the net voltage what matters.

The new model for EEG implies fractal onion-like hierarchy of dark magnetic bodies assignable to cell membrane labelled by the values $\hbar/\hbar_0 = 2^{11k}$. As already noticed, the older model differed from the new one in that it predicts similar hierarchy of cell membrane like structures defining Josephson junctions with same membrane potential.

### 3.6.3 The two hierarchies of Josephson junctions and generalized EEGs

Two hierarchies are possible. One can have a p-adic hierarchy of Josephson junctions with an increasing thickness of the corresponding membrane like structure and to each membrane like structure one can assign a dark hierarchy of generalized EEGs corresponding to powers of $2^{11}$.

#### The possibility of a p-adic hierarchy of membrane like structures accompanied by Josephson junctions

One can imagine the existence of fractally scaled up variants of cell membrane defining hierarchy of Josephson junctions possibly realized as magnetic flux tubes. The possible existence of this hierarchy is however not relevant for the model of EEG in its recent form.

The first hierarchy correspond to the p-adic length scales varying in the range of biologically relevant p-adic length scales $L(k)$ involving membrane like structures. Twin primes $(k, k+2)$ are good candidates here (Table 4). Second hierarchy corresponds to dark matter hierarchy for which length scales come in powers $2^{11k_d}L(k)$). The general prediction is that $\lambda$ is power of two and $k = 11$ is favored value because it corresponds to a fundamental constant in TGD. There are also other arguments supporting the exactness of this value.

The original restriction to just these values of Planck constant is not required by the recent view about the hierarchy of Planck constants and might well be too restrictive. The hierarchy could involve also the Planck constants $2^{11k_d}n$, $n$ small integer, possibly expressible in terms of Fermat primes. For instance, $n = 3$ with $k_d = 4$ would give 10 Hz EEG frequency for .08 eV resting potential.

Since 11 p-adic length scales combine naturally to form single block in this hierarchy, there is a strong temptation to assume that p-adic length scales $k = 151, 147, 163, 167, 169$ form the fundamental block. Same length scale can have interpretation as several different p-adic length scales belonging to different levels of dark hierarchy. This is expected to induce an interaction between various levels of dark matter hierarchy.

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

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

### Fractal hierarchy of magnetic bodies assignable to cell

Second hierarchy corresponds to a dark matter hierarchy involving powers $2^{11k}$ of given p-adic length scale assignable to biological membrane like structure.

The emergence of a genuinely new structure or function in evolution would correspond to the emergence of new level in this fractal hierarchy. Quantum criticality would be essential: phases corresponding $k_d$ and $k_d + 1$ levels would compete at quantum criticality.

The flux sheet or tubes through cell membranes should integrate to larger structures at the higher levels of dark matter hierarchy implying the integration of sensory inputs from a large number of cells to single coherent input at higher levels of dark matter hierarchy. One can think two options: the sensory inputs from cell membranes are communicated directly to the magnetic body or via cell nuclei. The second option would require that the flux sheets or tubes starting from cell membrane traverse also the DNA.

1. $k_e = 0$ would correspond to cell nucleus since electronic and possible neutrino superconductivity made possible by scaled up variant of weak interactions can correspond to ordinary $\hbar$. One could assume for definiteness that the magnetic body involved as size scale of cell membrane thickness at this level but could also consider some larger size which is scaled up at higher levels of the hierarchy by the scaling factor $2^{k11}$.

2. $k_d = 1$ would correspond to the emergence magnetic bodies with sizes below 4 cm. This size scale could be assigned to organs bounded by epithelial sheets (double cell layers) of thickness about 20 $\mu$m. Also in the new model these layers could define Josephson junctions but with some other voltage than that associated with the cell membrane.

3. $k_d = 2$ would correspond to layers of thickness 4 cm and structures with size smaller than 80 m. Obviously genuinely dark level is in question now. The layers of this Josephson junction could be assignable to left and right halves of central nervous system. The interpretation in terms of dark matter around the magnetic body of organs suggests also itself. $k_d = 3$ corresponds to the emergence of double layered dark matter structures of thickness 80 m and size scale below 160 km. Now dark matter condensed around magnetic bodies of magnetic bodies of organs could be in question.

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

It must be emphasized that also other values of $k$ besides $k = 168$ with $n = 5$ can be considered. In particular, the values $k = 151, 157, 163, 167$ corresponding to Gaussian Mersennes are especially promising candidates for characterizing endogenous magnetic fields. The model of EEG in turn leads to the conclusion that also $k = 169$ with $n = 5$ must be present. The relevant length scales vary accordingly.

**Dark hierarchy of EEGs**

The dark hierarchy of Josephson junctions with fixed size characterized by a p-adic length scale most naturally assignable to a member of twin prime pair defining a fractal hierarchy of EEGs is the basic element of the model of generalized EEG.

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

Each junction has a background voltage over it. The basic hierarchy involves the p-adic length scales $L(k)$, $k = 151, ..., 169$. One could consider the possibility that not only $k = 151$ but all these length scales and also twin primes define their own Josephson junctions with their own values of Josephson potential. Note however that if the Josephson voltage behaves like $1/L_(k)$ - as the naive scaling would suggest - then Josephson energy $E_J = ZeV$ is below the thermal energy for $k > 151$.

Josephson current can be written as

$$J \propto sin[(2eVt + 2e \int V_1 dt)/\hbar] \ ,$$

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

The model for nerve pulse [M2] supports strongly that $V$ actually corresponds to a propagating soliton sequence associated with Sine-Gordon equation. As described in the section about EEG, the situation is mathematically equivalent to a linear array of gravitational penduli coupling with each other and soliton sequence corresponds to a rotation of penduli with constant phase difference between neighbors so that a propagating wave would result. The analog of EEG would be associated also with ordinary cell membranes but the smaller value of $\hbar$ would imply that the frequencies involved are higher. Non-propagating EEG would accompany neuronal soma and possible propagating EEG waves with axons.

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

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

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

The reactions of the Josephson junctions corresponding to different p-adic length scales $k = 151, ..., 169$ (if really present!) to external electric field are different due to $V_1 \propto L(k) \propto 2^{(k-151)/2}$ proportionality and independence of $V$ on $k$.

*2. Thermodynamical considerations*

Josephson energy does not depend on the level of dark matter hierarchy and is thus above thermal energy since this holds true in the case of cell membrane. From the resting potential whose nominal value is often taken to be for .08 V, $f_J$ corresponds roughly to the energy .16 eV roughly twice the energy allowed by thermal stability. Thermal stability of drum beat would allow 140 °C temperature. The growth temperatures of thermophilic bacteria can be even higher than 100 °C.

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

*3. Josephson frequencies*

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

$f_J$ scales like $f_J \simeq \lambda^{-k_d}$ as a function of the level of the dark matter hierarchy. For $k_d = 4$ one obtains $f_J = 3.38$ Hz using $\lambda = 2^{11}$. This frequency belongs to delta band (defined as the the frequency range .25-5 Hz).

The original hypothesis about possible values of $\hbar$ must be taken with a grain of salt. There are reasons to argue that the most natural value for $f_J$ is 5 Hz. $\hbar/\hbar_0 = 5 \times 2^{42}$ would give this frequency in good approximation.

**Levels of dark matter hierarchy as a physical counterpart of chakras?**

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

The magnetic bodies involved include the magnetic body associated with biological body, presumably that associated with $k_{em} = 2$, magnetic body of Earth for $k_{em} = 4$, magnetic body associated with plasma sheet at night side of Earth's magnetosphere, the magnetic body of Sun for $k_{em} = 6$ and that of solar system for $k_{em} = 7$. Note however that the endogenous magnetic field is $B_{end} = .2$ Gauss and relates to $B_E = .5$ Gauss by a scaling factor. This suggests that personal magnetic bodies in the hierarchy interact with the astrophysical magnetic bodies but are not identical with them.

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

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

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

**What is the precise value of $\lambda$?**

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

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

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

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

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

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

#### Josephson frequencies for various levels of dark matter hierarchy

The following tables list the Josephson frequencies for doubly charged current carriers for the levels of dark matter hierarchy corresponding to $k_d = 0, ..., 7$ using the value .08 V/m for the resting potential for $\lambda = 2^{11}$.

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

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

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

| $k_d$ | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| $f_J(80\ mV)/Hz$ | 5.95e+13 | 2.91e+10 | 1.42e+07 | 6.93e+03 |
| $f_J(50\ mV)/Hz$ | 3.72e+13 | 1.82e+10 | 8.87e+06 | 4.33e+03 |

| $k_d$ | 4 | 5 | 6 | 7 |
|---|---|---|---|---|
| $f_J(80\ mV)/Hz$ | 3.38 | 6.18e-4 | 2.85e-7 | 1.31e-10 |
| $f_J(50\ mV)/Hz$ | 2.11 | 1.0e-3 | 5.04e-07 | 2.46e-10 |

Table 45. The Josephson frequencies $f_J = 2eV/2\pi\hbar$ of doubly charged particles for $\lambda = 2^{11}$ corresponding to the resting potential .08 V and threshold potential .05 V for nerve pulse generation for $\lambda = 2^{11}$.

### 3.6.4 A more precise identification of layers of magnetic body

By fractally scaling up from the case of cell membrane one can assign to a given level of dark matter hierarchy the p-adic length scales $L(k)$, $k = 151, ..., 169$ scaled by the power $2^{11k}$ as a sequence of onion like layers of the magnetic body at given level of dark matter hierarchy in the newer model. In the older model the onion layers of magnetic body scaled by $2^{11k}$ would correspond to Josephson junctions having key properties of the scale up cell membrane. The discussion below relies on the newer model.

#### $k_d = 0$ level

In the new model Josephson junctions involved with EEG are assigned with cell membrane. Note that electronic and exotic neutrino super-conductivities correspond to the ordinary value of $\hbar$. The Josephson frequency is 29.8 THz and corresponds to infrared photons. The observation of photons with spectrum having characteristics of coherent photon state generated by Josephson current is a testable experimental prediction.

An interesting question is whether membrane proteins acting as receptors and possibly also as channels and pumps correspond to a concrete realization of Josephson junctions and could be seen as being analogous to living organisms populating the cell membrane. Josephson junction would correspond to the protein magnetic body connecting cell interior to the magnetic body of cell. Second question is where the magnetic flux tube of the personal magnetic body flows in the cell interior and exterior. As a matter fact, the radius 18 $\mu$m of flux quanta for $B_{end} = .2$ Gauss resolves this question and suggests that large neurons of vertebrate brain are essential concerning the effects of ELF fields on brain.

If topological magnetic monopole flux flowing to a larger space-time sheet through wormhole contacts and returning back at the other end of the junction in the similar manner is in question, this question is avoided. The Josephson junctions identifiable as protein magnetic bodies can be associated with also other membrane bounded structures, in particular organelles inside cell, say cell nucleus.

With inspiration coming from the experiments of Gariaev [64] I have proposed that EEG has fractally scaled-up counterparts such that ordinary EEG would correspond to $k = 169$ level and scaled up variants to primes $k = 151, 157, 163, 167$ (at least). The model worked assuming that magnetic field scales like $B \propto 1/L(k)$: this is consistent with highly convoluted flux sheets. This scaling is just the reversal for the scaling of Josephson frequencies of external voltage perturbations as $f_J \propto L(k)$. These magnetic flux quanta can be associated with the coiling hierarchy of DNA.

### $k_d = 1$ level

In this case one has $L(151) \rightarrow L(151 + 22 = 173) = 40\ \mu$m. The upper bound for the size of layers of magnetic body would be $\lambda \times L(173) \simeq 4$ cm. Epithelial sheets consisting of double cell layer and surrounding organs correspond to size scale $L(173)$.

Josephson frequency is 29 GHz and corresponds to the time scale for the conformational dynamics of proteins. Josephson junctions could define a pacemaker for this dynamics and perturbations of the resting potential would serve a control purpose.

### $k_d = 2$ level

The scale assignable to the corresponding layer of magnetic body is $\lambda = 2^{11}\ L(195) = 4$ cm. The upper bound for these structures is 80 m and $L(169)$ corresponds now to 20 m length scale. This would require that magnetic flux sheets traverse through cell nuclei of a large number of organisms and thus define hyper-genes responsible for the social aspects of the behavior. At least the interiors of these structures must correspond to dark matter. The proposal that the magnetic flux sheets of $k_d = 4$ magnetic body flow through DNA of neurons generalizes to the proposal that flux sheets of $k_d = 2$ magnetic body flow through the DNA of cells which are at a lower level in the differentiation hierarchy. Josephson frequency would be 14 MHz.

### $k_d = 3$ level

In this case the layer of magnetic body would have thickness $L(217) = 80$ m. The Josephson frequency would be 6.9 kHz. The length of DNA needed to guarantee minimal flux quantum width would be $\lambda^3 L(169) \simeq 40$ km so that roughly $4 \times 10^4$ cell nuclei are needed if most of the width of flux sheet corresponds to DNA. Thus supergenes would necessarily emerge at this level and involve organisms in a region of size scale 176 km. $k_d = 3$ layer of magnetic body defined by the magnetic flux sheet going through cell nuclei have size scale characterizing litosphere and ionospheric cavity.

### $k_d = 4$ level

As already proposed, $k_d = 4$ level could correspond to that level in the hierarchy of personal magnetic bodies which connects organism to the magnetic body of Earth.

The length scale $\lambda^4 L(151)$ equals to 176 km for $\lambda = 2^{11}$. The cavity between ionosphere and Earth surface is about 100 km thick whereas litosphere plate has thickness about 80 km [23]. The layer responsible for atmospheric phenomena is about 10 km thick. 180 km thickness is consistent with 176 km thickness predicted by $\lambda = 2^{11}$. Litosphere plate + atmosphere and ionosphere above atmosphere could thus form the counterpart of bilayered cell membrane. This hypothesis makes sense since its is dark matter which is involved with the Josephson junction in question. If this where the case living organisms would be analogous to the proteins defining receptors, ionic channels, and pumps at the cell membrane. For this option the convoluted magnetic flux tubes defining Josephson junctions could carry monopole flux which returns back at the larger space-time sheet. In this hyper-genes would involve organisms in the scale of entire Earth.

In this picture vertebrates would be like magnetic plants extending from the bottom of litosphere to the ionosphere. These Josephson junctions would presumably connect parts of the magnetic body of Earth to each other. Josephson frequency is 3.4 Hz and belongs to theta band in EEG. The frequency is somewhat higher than the 3 Hz frequency associated with absence seizures. 3-4 Hz posterior rhythm is established in EEG of 3 months old child in awake state. 5 Hz rhythm is established at the age of 6 months. A possible interpretation is that perturbing oscillatory voltage is superposed on the 3.4 Hz drum beat.

$k_d > 4$ **levels**

$k_d = 5$ corresponds to the length scale $L(151 + 5 \times 22 = 261) = .32$ Mkm to be compared with the solar radius $R = .7$ Mkm and Earth radius $6.3 \times 10^3$ km. Earth's rotating inner magnetosphere extends at night side to about 100 Earth radii which is of same order of magnitude as $L(261)$. The rather remarkable finding that equatorial plasma sheet is self-organizing system [24] which seems to represent in electron distributions patterns resembling "flowers", "eyes", etc... might have deeper meaning if plasma sheet corresponds to $k_d = 5$ level of dark matter hierarchy. I have indeed suggested the interpretation of these patterns as magnetospheric sensory representations [M1, N1].

Because of its size Sun could correspond to $k_d = 5$ level naturally. A possible interpretation is that all planets are accompanied by dark matter hierarchy involving also this size scale but that only in case of Sun there is considerable density of visible matter associated with this dark matter. In the case of Earth only plasma sheet would be associated to this level.

$k_d = 6$ corresponds to the length scale .64 Gkm and is of the same order of magnitude as the size of the planetary system (the distance to Sun about $AU = .146$ Gkm). $k_d = 7$ corresponds to the length scale 1.28 Tkm and could correspond to the size of solar magnetosphere. This size scale is .14 light years. The distance of nearest star is about 4 light years.

One can argue that a flux tube of thickness $L = 5L(169)/\sqrt{2}$ cannot follow every twist and turn of the highly convoluted DNA double strand. Many-sheeted space-time might save the situation. On the other hand, if the thickness of flux sheet is $L/\lambda = 8.8$ nm, it has almost the thickness of cell membrane and could adopt the shape of the convoluted DNA strand. The transversal dimension of base pair is indeed about 1.2 nm meaning that the thickness of the double strand is about 2.5 nm. Note that $k = 167$ could correspond to flux sheets traversing only single strand.

In this case the width of the flux sheet would be about 136 light years so that $k_d = 7$ level would indeed conform with the assignment of cosmic consciousness with the crown chakra. In this case the flux sheet should flow through $\sim 10^{15}$ neurons or cells and bind them to single string defining kind of super genome. The total number of cells in human body is estimated to be around $10^{14}$ so that hyper genes involving large number of different organisms should appear at this level if most of the flux sheet cross section contains DNA. As already noticed the estimate for the size of the scaled up version of nucleus implies that hyper-genes should appear already at $k_d = 2$ level.

### 3.6.5 Relation with the structure of CNS

Page of a book is rather precise metaphor for the magnetic flux sheet going through a linear array of strings of nuclei. This raises several questions. Do the lines of the text of this book correspond to axons in neural circuits? Do the pages correspond to larger structures formed by the axons? This might hold true for sufficiently large values of $k_d$, say $k_d \geq 2$.

Books are made for reading and one can thus ask whether the book metaphor extends. Could the observed moving brain waves scanning cortex relate to the "reading" of the information associated with these sheets of book by the magnetic body and does our internal speech correspond to this "reading"? One is also forced to ask whether these brain waves are induced by waves propagating along magnetic flux quanta of the magnetic body of Earth or personal magnetic body in the case that it has components other than magnetic flux sheets serving as Josephson junctions.

## 3.7 The effects of ELF fields on brain and high $T_c$ ionic super conductivity

The article 'Spin the tale on the dragon' by David Jarron [77] gives excellent popular review about the history of the bio-electromagnetic research and about the frequencies for which electromagnetic fields have special effects on living matter and brain. The material from this article led to the realization of how brain manages to be a macroscopic quantum system in TGD Universe. A more technical view about the effects can be found from review articles of Adey and Blackman [78, 59]. The online review article of Cherry [58] provides a good technical representation about various effects of weak ELF em fields and ELF modulated radiofrequency em fields on brain and an extensive list of references.

### 3.7.1 Summary about effects of ELF em fields on brain

The work by pioneers of bio-electromagnetism (Wertheimer, Milham, Marino, Becker, Adey, Blackman and many others) which began already at sixties led to amazing discoveries about ELF fields on brain. The article of Blackman [59] provides a detailed summary of these developments. The results of the work of Bawin, Adey, Blackman and others can be summarized by saying that radio frequency em fields amplitude modulated by ELF frequencies affect in certain frequency and amplitude windows brain tissue [80, 82, 84]. The function of the radio frequency carrier wave is to facilitate the penetration of em field into tissue and its frequency is not essential for the occurrence of the effect. Presumably nonlinear effects give rise to a secondary wave with modulation frequency which is the primary source of effects.

#### Basic effects

The effects of ELF em fields on brain include chemical, physiological and behavioral changes within windows in frequency and field intensity. It is essential that the effects have been observed only in vertebrates which thus possess EEG. A good summary is the online review article of Cherry [58].

The well documented and established non-thermal biological effects of EMR include significant alteration of cellular calcium ion homeostasis, reduction of melatonin, and the detection of Schumann Resonances by human and avian brains. A key effect is change in $Ca^{2+}$ homeostasis: $Ca^{2+}$ it is involved with both pre- and postsynaptic steps of nerve pulse transmission and also with intracellular communication. For instance, $Ca^{2+}$ is involved with gene expression, the development and plasticity of nervous system, modulation of synaptic strengths, and with $Ca^{2+} - c$AMP signal transduction process.

Change in $Ca^{2+}$ homeostasis has harmful effects in central nervous system, endocrine system and immune system. At the level of CNS this means changes of reaction time and behavioral alternations. At the level of neuro-endocrine system a good example is the reduction of the melatonin production in pineal gland having wide variety of harmful effects since melatonin serves as effective scavenger of free radicals: among the effects are DNA strand breakage, chromosome aberrations and problems with gap junction communications. Melatonin is also crucial for healthy sleep and for the reduction of cholesterol and blood pressure. In case of immune system an example is provided by the change of functioning of lymphosytes in turn reducing the competence of immune system making the subject more vulnerable to allergens, toxins and viruses.

#### Amplitude windows

Two main amplitude windows have been seen. For the first window ELF em fields have values of electric field in tissue around $10^{-7}$ V/m. The effects are high level effects and associated with navigation and prey detection in marine vertebrates and with the control of human biological rhythms. For ELF modulated radio frequency fields (RF) and microwaves (MW) the intensities are around $1-10$ V/m. In this case the effects are neurophysiological effects are lower level effects at the level of the brain tissue. In case of brain tissue maximal sensitivity to electromagnetic fields occurs between 6 and 20 Hz.

In order to get grasp about orders of magnitude, it is good to notice that cell membrane electric field has a strength about $10^7$ V/m whereas EEG electric fields in the range $5-10$ V/m. The fact that the second intensity window corresponds to $1-10$ V/m suggests that the em field simulates the em field associated with EEG: a valuable guideline in attempts to understand what is involved. For Schumann resonances electric field is of order .6 mV/m. For sferics (em perturbations associated with lightnings) magnetic field strength is not above nTesla: this corresponds to electric field strength 10 V/m associated also with EEG waves [21]. Field strength of V/m corresponds roughly to energy flux $\mu W/m^2$.

The presence of windows and weak intensities implies that the effects cannot be thermal. A good metaphor is the effect of radio noise on radio receiver: it occurs at definite frequency and destroys the information content of the original transmission.

### The effects occur at harmonics of cyclotron resonance frequencies

Blackman also discovered that odd multiples 15, 45, 75, 105... of 15 Hz had much stronger effect on tissue than even multiples 30, 60, 90... Hz and realized a possible role of Earth's magnetic field [83]: it must be however emphasized that the value of magnetic field in question is $B_{end} = .2$ Gauss and smaller than $B_E = .5$ Gauss. A possible interpretation is that harmonics of cyclotron frequencies might be the information carrying frequencies in EEG.

In response to the results and speculations of Blackman, Liboff formulated ionic cyclotron resonance (ICR) model [89] based on the realization that the frequencies in question correspond to multiples of the cyclotron frequencies of $Ca^{2+}$ ion in a magnetic field $B_{end} = .2$ Gauss. This model was classical. Later Blanchard and Blackman proposed so called ionic parametric resonance model (IPR) [87]. This phenomenological model combines ICR model with ideas about atomic physics. There are several objections against ICR model; classical orbits of ions in Earth's magnetic field have radius of order meters; dissipative effects and Brownian forces do not allow cyclotron orbits; charge-to mass ratios appearing in cyclotron frequencies correspond to vacuum rather than water environment characterized by a large value of dielectric constant; it is difficult to understand why odd multiples of cyclotron frequencies give rise to stronger effects [59]. Some of these objections apply also to IPR model.

The pattern of data seems to suggest that the interaction occurs at quantum level. This is in dramatic conflict with the predictions of the standard quantum theory and with the standard view about space-time.

### Are quantal effects in question?

The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field having same strength as Earth's magnetic field, is supported by the following observations.

1. The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron frequency of $Ca^{2+}$ ion in magnetic field $B_{end} = .2$ Gauss. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

2. Even multiples of 15 Hz have a weak but non-vanishing effect. Transitions are not possible at all in the lowest order of perturbation theory since the interaction Hamiltonian describing the transitions in question has non-vanishing matrix elements only between states of opposite parities in the dipole approximation applying when the wavelength of the radiation is much larger than the size of the radiating system [25]. Odd and even values of $n$ for cyclotron states have opposite parities so that $\Delta n$ odd rule results. In higher orders of perturbation theory also transitions for which transition frequency is even multiple of the cyclotron frequency are possible. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

There are however also objections.

1. The cyclotron energy scale is about $10^{-14}$ eV and ridiculously small as compared to the energy scale .086 eV defined by room temperature so that quantal effects should be masked completely by thermal noise.

2. Also ELF em fields at spin flip frequencies (Larmor frequencies) should induce transitions. To my best knowledge these have not been reported.

3. The wave functions of ions in magnetic field are confined in a region of size of order

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

which is of the order of cell size: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the p-adic length scale $L(169) = 5$

$\mu$m rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ ($S$ denotes the area of the flux tube) and $Z = 2$. If one requires quantum classical correspondence, very large values of $n$ are required and cyclotron radii would be much larger than flux tube radius.

A common resolution of all these objections is provided by large $\hbar$ phases and hierarchy of magnetic flux sheets with $B$ scaling like $1/hbar$ meaning that cyclotron frequencies scale down similarly and cyclotron energies remain invariant. Same applies to spin flip energies scaling in the same manner as cyclotron energies (for some time I thought that the scaling behaviors are different). By the quantization of the magnetic flux, predicted by TGD also classically, the minimal radius of the magnetic flux tube for the magnetic field of Earth of cell size for ordinary value of $\hbar$ but scales like $\hbar$ if magnetic field remains invariant and flux quantization $BS = n2\pi\hbar$ implying $S \propto \hbar$ holds true. This implies consistency with classical theory for large values of $\hbar = \lambda^{k_d}\hbar_0$, $\lambda \simeq 2^{11}$.

### A brief summary of the model

Some work is required to end up with the following interpretation based on a model for how the different levels of dark matter hierarchy communicate and control.

1. Ions with charge $Z$, mass $m$ and spin $S$ in the external magnetic field behave quantum mechanically like harmonic oscillator with energies quantized as

$$E = E_c + E_L \ , \quad E_c = (n + \frac{1}{2})\hbar\omega_c \ , \quad E_L = S_z\frac{g\omega_c}{2} \ , \quad \omega_c = \frac{ZeB}{m} \ \ (c = 1) \ . \tag{3.7.1}$$

   The first contribution corresponds to cyclotron contribution. For a given value of $n$ the component of angular momentum in the direction of $B$ has $n+1$ values $n, n-2, ..., -n$. $E_L$ denotes spin (Larmor) contribution. $g$ is so called Lande factor which for free elementary fermions equals to $g = 2$. Since $S_z$ is invariant under the scalings of $\hbar$, Larmor contribution is negligible as compared to cyclotron contribution for large values of $\hbar$. The contribution to energy coming from the free motion in the direction of magnetic field has not been written.

2. The model for high $T_c$ superconductivity involving competition of two superconductivities, one associated with cell interior and second with cell membrane is the starting point. These phases coexist in a narrow range around critical temperature and 36-37 C range where the effects are observed is a good candidate for this range.

3. Experimental findings suggests strongly that external em field induces resonant transitions between cyclotron states: these transitions are identified as transitions inside the cell/nucleus or its fractally scaled up variant. For $k_d = 4$ level of dark matter hierarchy cyclotron energy scale turns out to be above the thermal energy $2.88T$ of photons at maximum intensity of black body radiation at room temperature for $A \leq 223Z$. Cyclotron radiation can drive charged particles to smaller space-time sheets and this is essential for the metabolism and this process is expected to be part of the interaction of ELF em fields with cell nucleus. The scale of cyclotron energies for $k_d = 4$ level of dark matter hierarchy is indeed turns out to be consistent with this assumption.

4. The ELF em field used in the experiments have electric fields strengths in two windows: one around $10^{-7}$ V/m and second corresponding to $1 - 10$ V/m. Even in the latter case the field is by a factor of order million weaker than membrane potential: the notion of many-sheeted space-time allows to understand why so weak fields can have effects on biomatter. Amplitude windows are a further mystery related with the interaction of ELF em fields with brain tissue: if ELF em field defines potential difference $eV$ associated with a Josephson junction, one might understand this effect in terms of quantum jumps induced by Josephson current with frequency $f = ZeV/2\pi$.

5. Dark matter hierarchy leads to the hypothesis that there is entire hierarchy of EEGs generated as coherent photon states by Josephson currents associated with the Josephson junctions whose thickness scales as $\hbar$ and frequency scales as $1/\hbar$ so that cyclotron energy remains invariant and is above the thermal threshold. For each value of $\hbar$ there is also p-adic hierarchy corresponding to $k = 151, ...., 169$ with same Josephson frequency: these levels combine to form single block for dark matter hierarchy formed from the scaled up variants of this block. At least the magnetic flux tube structure of DNA and membrane structure appear as scaled up copies. The lowest level corresponds to cellular or nuclear membrane and ordinary value of $\hbar$.

6. Josephson current is of form $J \propto sin(2eVt + 2e\int V_1 dt)$ and its amplitude does not depend on the strength of the perturbation $V_1$. $V_1$ is same for all values of $\hbar$ but scales like $L(k)$ as function of p-adic length scale for given value of $\hbar$. Perturbation is represent as EEG pattern communicated to the magnetic body of fractally scaled up variant of cell or cell nucleus, which reacts appropriately. At the limit when the Josephson frequency $f_J^1 = 2eV_1/2\pi\hbar$ of perturbation satisfies $f_J^1 \gg f_c$, the amplitude of perturbation is coded to frequencies $f_\pm = f_J^1 \pm f_J$ in the EEG in a good approximation.

7. The response of the system is that of AND gate. $V_1$ induces in the neuronal nucleus or its scaled up counterpart cyclotron transitions if the frequency is correct. If this the case, cell nucleus opens up communication line receiving possible control signals from the magnetic body at higher level of hierarchy. $V_1$ induces in Josephson junctions effects if the amplitude is in the amplitude window guaranteing that the frequencies $f_\pm$ belong to EEG resonance bands (or their scaled up variants. In this case magnetic body receives representation of $V_1$ as coherent photons and responds. If communication line is open the response induces in the cell nucleus gene translation and other activities necessary for the biological response. The model implies that cyclotron frequencies code for the biologically relevant information carried out by classical electric fields so that noise is eliminated very effectively.

### 3.7.2 Interpretation of the temperature window

The effects of ELF em fields on matter have been observed only in a temperature window 36-37 C around body temperature. The model of high $T_c$ super-conductivity as a quantum critical phenomenon predicts that there is a narrow interval around $T_c$ around which two competing phases corresponding to ordinary value and scaled up value of $\hbar$ compete. More generally, dark matter hierarchy should correspond to a hierarchy of quantum criticalities. A fractal hierarchy of cusp catastrophes such that the next cusp is inside the critical line of the previous cusp would be a convenient manner to visualize the situation. Each big leap in the evolution corresponds to the emergence of a new level $k_d$ in the dark matter hierarchy made possible by the external conditions allowing co-presence and competition of phases corresponding to $k_d - 1$ and $k_d$.

Quantum critical high $T_c$ super-conductivity for electrons and protons (at least) is the essential prerequisite for the existence of Josephson currents through the cell membrane and its scaled up variants, and thus the hierarchy of generalized EEGs. Electronic super-conductivity is expected to be possible in a very limited temperature range usually idealized with single critical temperature. Quantum critical phase is analogous spin glass phase possible in a finite interval around critical temperature, and one can indeed speak of quantum spin glass phase for which the analogs of regions with fixed direction of magnetization are 4-dimensional rather than 3-dimensional and static. This relates to the breaking of the strict classical determinism of the basic variational principle of TGD having interpretation in terms of space-time correlate for quantum non-determinism in long time and length scales. Quantum coherence and quantum nondeterminism in long scales is obviously what makes system living. An educated guess is that the critical range of temperatures allowing quantum criticality and high $T_c$ super-conductivity is just 36-37 C: this in turn implies that the effects of ELF em fields occur only in this temperature range.

### 3.7.3 Interpretation of amplitude windows in terms of resonance bands of generalized EEGs

**Basic observations**

The first amplitude window corresponds to $E \in [1, 10]$ V/m. Second window is around $E = 10^{-7}$ V/m. The following observations are crucial in attempt to understand what these windows correspond to.

1. The ratio of average electric fields for amplitude windows is $\sim 5 \times 10^7$. This is not too far from $\lambda^2 \simeq 4 \times 10^6$. This would suggest that the two windows correspond to levels $k$ and $k+2$ of dark matter hierarchy.

2. In Josephson junctions electric field is converted to voltage which in turn defines Josephson frequency. The voltage over junction is represented as a Josephson current generating coherent state of photons. The electric field is thus represented as biological actions induced by the absorption of coherent (dark photons) photons. Also the decoherence of these photons to ordinary photons would be involved.

These observations allow to construct a model for amplitude based on the idea that they correspond to resonance bands for generalized EEGs associated with p-adic and dark matter hierarchies.

**Could amplitude windows correspond to the resonant EEG bands for the generalized EEGs?**

In the proposed model of EEG the amplitude of oscillatory perturbation $V_1 sin(2\pi f t)$ of the voltage of Josephson junction is coded to Josephson frequency $f_J^1 = 2eV_1/2\pi\hbar$ and for $f_J^1 \gg f$, the frequencies $f_\pm = f_J \pm f_J^1$ appear in the generalized EEG spectrum as fundamental frequencies so that amplitude is coded to frequency. The frequency $f$ itself defines the duration of the periodically occurring modulation of Josephson current. This would suggest that the amplitude windows correspond to frequencies $f_J \pm f_J^1$ belonging to the resonant bands in the generalized EEG.

The requirement $f_J^1 > f_c$, the condition that $f_J^1$ and $f_J$ are of same order of magnitude, and the condition that the scaled down counterpart of $f_\pm = f_J \pm f_J^1$ in ordinary EEG belongs to the range of EEG frequencies, fix uniquely the selection of $k$ and $k_d$ for both $E \in [1-10]$ V/m and $E = 10^{-7}$ V/m.

**Josephson frequencies associated with amplitude windows**

In the table below the Josephson frequencies associated with the perturbations $E = 1$ V/m, $E = 10$ V/m and $E = 10^{-7}$ V/m as a function of p-adic length scale. There is no dependence on the level of dark matter hierarchy.

| k | 151 | 157 | 163 | 167 | 169 |
|---|---|---|---|---|---|
| $f_J^1/MHz(1\ V/m)$ | 3.72 | 29.8 | 238 | 952 | 1905 |
| $f_J^1/MHz(10\ V/m)$ | 37.2 | 298 | 2380 | 9520 | 19050 |
| $f_J^1/Hz(10^{-7}\ V/m)$ | 0.37 | 2.98 | 23.8 | 95.2 | 190.5 |

Table 6. Josephson frequencies $f_J^1$ having relevance for periodic perturbations satisfying $f_J^1/f \gg 1$ as a function of p-adic length scale. The frequencies are given for $E = 1V/m$, $E = 10$ V/m and $E = 10^{-7}$ V/m.

It is quite possible that also other values of $k$ in the range $151, ...., 172$ are possible and this is indeed suggested with the experience with p-adic mass calculations which favor also other values of $k$ besides integers.

**Amplitude window $1-10$ V/m**

In this case $f_J^1 \gg f_c$ condition is trivially satisfied. $k_d = 2$ is the only possible choice for dark matter level and corresponds to 2+2 cm Josephson junctions. $k = 151$ and $k = 157$ are the only possible candidates for the p-adic length scale in question. For $k = 157$ the upper limit for $f_J^1$ however corresponds to a frequency above the range 1-100 Hz of EEG frequencies so that this option looks implausible.

In order to utilize the intuition about ordinary EEG, one can translate scaled down the frequencies by a factor $\lambda^{-2}$. For $k = 151$ the scaled down frequencies satisfy

1. $f_+ \in [4.48, 12.85]$ Hz and $f_- \in [2.62, 5.75]$ Hz for $\lambda = 2^{11}$,

2. $f_+ \in [4.08, 12.45]$ Hz and $f_- \in [2.22, 6.15]$ Hz for $\lambda = 2.17 \times 10^3$.

   $f_+$ and $f_-$ cover delta, theta, and alpha bands and part of beta band. If the proposed interpretation is correct, the detailed dependence of the effect on $V_1$ should reflect the resonance band structure of EEG in this region.

**Amplitude window around $E = 10^{-7}$ V/m**

The condition $f_J^1 > f_c$ allows $f_\pm$ type EEG resonance only for $k = 163$ and $k_d = 4$ level of dark matter hierarchy.

1. For $\lambda = 2^{11}$ one has $f_+ = 27.1$ Hz and $f_- = f_J^1 - f_J = 20.4$ Hz. 27 Hz frequency corresponds to a resonance frequency in the EEG of dog induced by stimulation with monochromatic light [47]. $f_- = 20.4$ is very near to the second harmonic of the fundamental 10 Hz alpha peak and Schumann frequency 20 Hz.

2. $\lambda = 2.17 \times 10^3$ gives $f_+ = 26.4$ Hz and $f_- = 21.1$ Hz. $f_+$ is between Schumann resonance 26 Hz and 27 Hz resonance.

   $\lambda = 2^{11}$ is favored by the following observation. $f \sim 3$ Hz peak in EEG correlates with spike activity accompanying absence of seizures. For $k = 151$ one has $f_- = f_J(151) - f_J^1 = 3.38 - .37$ Hz $= 3.01$ Hz for $\lambda = 2^{11}$. Slowly varying perturbations with frequency $f < f_J^1(157)$, perhaps some cyclotron frequency, could induce resonant oscillation with frequency $\simeq 3$ Hz, which corresponds to A=100 ($^{99}Ru$).

### 3.7.4 Why it is necessary to have both cyclotron frequency and amplitude in the window?

The explanation of amplitude windows leaves for cyclotron frequencies a very passive role and there seems to be no special reason for why the frequency of $V_1$ should correspond to cyclotron frequency. What seems to be the simplest interpretation for the situation is that there is a kind of AND gate involved. A non-vanishing net effect requires too separate effects which can be assigned with the membrane and interior of the structure involved, most naturally cell nucleus or its scaled up counterpart. This makes sense if one assumes that the magnetic flux sheets have DNA strands or as fractality suggests, their scaled up variants as transversal sections.

This conforms with the general vision that high $T_c$ superconductivity involves two different competing super conductivities at quantum criticality, which presumably corresponds to the temperature interval 36-37 C in the recent case. Quantum criticality is a necessary prerequisite that AND gate gives result 1. The supra currents flowing in the interior of cell or its nucleus correspond to large $\hbar$ variant of BCS superconductivity. Second superconductivity corresponds to surface supra currents flowing along the membrane of cell or nucleus. For the surface super-conductivity the notion of Josephson junction makes sense only in synaptic contacts or gap junctions since the electrons of Cooper pair belong to different lipid layers. Josephson junctions between interior and exterior are a sensible concept if both are in large $\hbar$ phase. For cell nucleus inside cell this holds true. This kind of Josephson junctions could be also between two cells in synaptic contacts or gap junctions. This consideration generalizes straightforwardly to the scaled up version of cell and cell nucleus.

Consider now how the hierarchy of AND gates could be realized.

1. At cell membrane the perturbation $V_1$ affects Josephson junctions. For this effect the value of the frequency is not essential as long as the condition $\omega_J^1 \gg \omega$ is satisfied. $V_1$ affects generalized EEG. This means essentially a representation of $V_1$ in terms of EEG frequency and communication of this information to higher level magnetic body, which then reacts to situation by sending a

control signal. The effects are therefore high level "behavioral" rather than direct "physiological" effects (this is of course relative concept due to the hierarchy). Indeed, in case of $E = 10^{-7}$ V/m perturbations the effects are high level effects affecting prey detection and navigation. Note that the size of the effect do not depend on the amplitude as long as $\omega_J^1 \gg \omega_c$ is satisfied since it is the phase of Josephson current rather than amplitude that is affected by $V_1$. This is absolutely essential for the universality of EEG amplitudes. If EEG wave indeed results it has amplitude in the range 5-10 V/m it it is expected to induce similar effect at $k_d = 2$ level of hierarchy if the proposed interpretation for $E \in [1-10]$ effects is correct. This means that also communication to lower levels occurs automatically. Here the amplitude window condition is guaranteed by the properties of Josephson current.

2. $V_1$ induces also cyclotron transitions in the cell nucleus or its fractally scaled up counterpart and in this manner affects the competing BCS type interior supra currents and BE condensates. Any controlled biological activity must involve the activation of genome inducing the translation of genes to amino-acid sequences needed to realize the needed action. Hence the AND gate could be realized in a simple manner: cyclotron transitions would simply turn the communication line from magnetic body to nucleus on. If the frequency is wrong, the higher level magnetic body receives the message and responds but since the nucleus does not experience the cyclotron transitions it is off-line and nothing happens. If amplitude is not in the window but frequency is correct, the communication lines is on but no signal goes to the magnetic body and no command for action is received.

## 3.8 What is EEG made of?

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

### 3.8.1 The most recent model for the generation of nerve pulse

Quite recently I learned [106, 107, 108, 109, 110] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) [O4] leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of tqc. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of

the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

3. The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that solitonic velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as tqc sine also microtubule-cell membrane systems are good candidates for performers of tqc. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane tqc would represent higher level tqc distinguishing between multi-cellulars and mono-cellulars.

4. New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [F9] predicts that ordinary fermionic ions (such as $K^+$, $Na^+$, $Cl^-$) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic $W$ bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

### 3.8.2 Basic contributions to EEG and ZEG

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

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

2. Cyclotron frequencies generated in cyclotron transitions of ions. An attractive guess is that cyclotron frequencies correspond directly to the control signals from the magnetic body or that they result as a consequence of the generalization actions of the magnetic body so that Josephson junctions and magnetic body would form a closed feedback loop. For instance, ions could drop during generalized motor actions to excited cyclotron states at dark magnetic flux quanta and their decay would produce dark cyclotron photons. Cyclotron frequencies can be classified to those associated with bosonic and fermionic ions respectively. The transitions of Bose-Einstein condensates of bosonic ions are of special interest. The scale of these frequencies could be be subject to homeostatic regulation which is local and can vary even inside genes of a given nucleus.

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

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

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

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

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

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

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

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

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

### 3.8.3 Classification of cyclotron frequencies

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

1. Cyclotron frequencies can be classified those associated with atomic and molecular ions. For biologically important atomic ions most frequencies are above 7.5 Hz. For molecular ions frequencies are lower and for DNA sequences the frequencies are in delta band. Thermal stability condition suggest a lower bound of $\sim 1$ Hz for significant frequencies of this kind. Thus it would seem that delta band dominating during deep sleep corresponds to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions.

2. Atomic ions can be classified into bosonic and fermionic ions. Practically all biologically important bosonic ions have $Z = 2$ and in alpha band: $f(^6Li^+) = 50$ Hz and $f(Mg^{2+}) = 25$ Hz are the

only frequencies above alpha band. Situation is essentially the same for biologically interesting ions too. $^7Li^+$ is exception and corresponds to 42.9 Hz: as a fermionic ion it does not possess satellites and does not contribute to Josephson part of EEG. Thus the frequency range $7.5-15$ Hz is very strongly represented and expected to be fundamental.

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

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

### 3.8.4 Wake-up EEG

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

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

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

3. Beta band is above 12 Hz and associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous. The natural interpretation is as large amplitude satellite of alpha band involving the activation of communications to the magnetic body and large control signals with $f_J^1 \gg f_c$. Hence the spectra would for a considerable part of period $1/f_c$ effectively consist of frequencies $f_\pm = f_J \pm f_J^1$, where $f_J^1$ varies in frequency range characterized by the amplitude of perturbation. There is no definite resonance frequency since $\omega_1^J$ can vary continuously. Globally the situation is different since the spectrum can in principle be decomposed to frequencies $f_J \pm nf_c$. These two descriptions correspond to time domain and genuine frequency domain.

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

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

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

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

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

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

### 3.8.5 Satellites exist as mirror pairs!

The existence of the mirror satellites might be regarded as a killer prediction. Amazingly, narrow EEG bands which are mirror images of each other with respect to alpha band have been reported [47]. 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 [47]. All these frequencies are expressible in the form $f_c \pm f_J$, $f_J = 5$ Hz, which is one half of the frequency 10 Hz of the memetic code and by 14 per cent higher than 3.7 Hz predicted assuming $\lambda = 2^{11}$. The value of $\lambda$ deduced from these frequencies would be $\lambda = 1902$ and about 7 per cent smaller than $\lambda = 2^{11}$. This estimate cannot be taken too seriously since it is quite possible that the thickness of Josephson junction is not scaled up completely exactly.

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

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

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

### 3.8.6 Alpha band dominance during relaxed state

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

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

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

### 3.8.7 EEG during sleep

The EEG during sleep [40] provides a testing ground for the proposed anatomy of EEG. Sleep consists of 90 + 90 minute periods of NREM and REM sleep. This period is also the period of brain hemisphere dominances during wake up and day dreaming occurs with the same period as REM sleep. During REM sleep the EEG is essentially similar to that during wake-up. These observations inspire the hunch that brain hemisphere dominance dictates whether REM or NREM is in question. This turns out to be a correct guess.

### EEG during stage 1

During stage 1 theta of deep sleep [40] waves in frequency range 4-8 Hz dominate and amplitudes increase when frequency is reduced. The control signals from magnetic body are expected to be weak so that $f_J^1 < f_J$ approximation should hold true implying that frequencies $f_J \pm f_c$ should dominate and EEG would look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/\omega_c$ and thus increase with decreasing $\omega_c$. The fact that amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

These facts does not conform with the general picture as such. If theta and beta bands are mere satellites of alpha band, both of them should be present during stage 1 sleep but this is not the case. The idea that cyclotron frequencies of heavier ions in $B_{end} = .2$ Gauss could replace those appearing during wake-up does not work. Theta band simply does not contain the cyclotron frequencies of biologically important ions for $B_{end} = .2$ Gauss. One can imagine two manners to resolve the difficulty.

*1. Two manners to quantize magnetic flux*

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

One can image several manners to resolve the problem but the most natural resolution of the puzzle came with the frustrating realization that $B_{end} = .2$ Gauss explaining the observations of Blackman and others is not equal to the Earth's magnetic field $B_E = .5$ Gauss. Although $B_{end}$ corresponds to $k = 169$, the value of Planck constant is $\hbar = 5\hbar_0$ and flux unit is $h_5 = 5h_0$. For $B_{end}$ $k = 169$ flux tubes carry two units of flux and for $B_{end}/2$ single unit so that the halved value of $B_{end}$ emerges very naturally.

The different values of field intensities might relate to the character of ions at the flux sheets in left and right hemisphere.

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

2. Assume the quantization condition corresponds to $Z = 1$ for the left hemisphere and $Z = 2$ for the right hemisphere. The presence of fermionic ions implies additional cyclotron frequencies on left hemisphere and the presence of fermionic ions conforms with the old proposal that fermionic Fock states provide a realization of quantal version of Boolean algebra. This conforms with the view that left brain is more reductionistic and performs linear logic operations whereas right brain is more holistic.

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

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

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

*2. Exotic ions as a resolution of the problem?*

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

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

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

### EEG during stage 2

Sleep spindles appearing in the state 2 of deep sleep are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [49]. The spindles .5-.1.5 seconds and appear with a period of about minute. In some sources frequency range 7-16 Hz is given as sleeping spindle range. The so called K-complexes are sudden increases in EEG amplitude but no change in frequency.

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

### EEG during stages 3 and 4

Most of EEG power during deep sleep stages 3 and 4 is in the range .75-4.5 Hz [40]. This implies that control signals at cyclotron transition frequencies of ions from the magnetic body cannot be appreciably present and the control signals at cyclotron frequencies of molecular ions, such as DNA with cyclotron frequencies below 1 Hz, should be responsible for the EEG. The small amplitude of control signal implies $1/f_c$ behavior and large amplitude as compared to the corresponding amplitudes at higher bands at weak amplitude limit.

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

### Transcendental states of consciousness and EEG

Transcendental states of consciousness are characterized by the presence of alpha and theta bands [60] (note that theta band is present also during childhood, youth and even early adolescence but usually disappears at older age). It is found that that theta and alpha bands are preserved also during deep sleep [61]. A possible interpretation is that the presence of alpha band signifies that left brain remains awake in a state of relaxed alertness involving weak signals from magnetic body. One could also argue that even deep sleep is a conscious state but that the presence of alpha band activity in left brain is necessary in order to have memories about this state.

### 3.8.8 Scaled up EEG periods at levels $k_d = 5, 6, 7$

It of considerable interest to find the scaled up EEG periods corresponding to frequencies $8, 10, 12$ Hz in alpha band and their satellites for levels $k_d = 5, 6, 7$ levels in order to see whether they might correspond to some important bio-rhytms. For $\lambda = 1902$ Josephson periods are given by $T_J = 7.35$ minutes, 9.02 days, and 43.6 years.

| | | | |
|---|---|---|---|
| $T_c/min$ | 4.59 | 3.66 | 3.06 |
| $T_+(1)/min$ | 12.25 | 7.35 | 5.25 |
| $T_+(3)/min$ | 1.93 | 1.47 | 1.19 |
| $T_+(5)/min$ | 1.05 | 0.82 | 0.67 |
| $T_-(1)/min$ | 2.83 | 2.45 | 2.16 |
| $T_-(2)/min$ | 1.27 | 1.05 | 0.90 |
| $T_-(3)/min$ | 0.82 | 0.67 | 0.57 |

Table 7. Periods $T_c$ and $T_\pm(n)$ corresponding to $f_c$ and $nf_c \pm f_J$, $n = 1, 3, 5$ for scaled up EEG at $k_d = 5$ level corresponding to alpha band frequencies 8, 10, 12 Hz of the ordinary EEG. The unit is one minute and Josephson period is 7.35 minutes.

| | | | |
|---|---|---|---|
| $T_c/day$ | 5.6 | 4.5 | 3.8 |
| $T_+(1)/day$ | 15.03 | 9.01 | 6.44 |
| $T_+(3)/day$ | 2.37 | 1.80 | 1.45 |
| $T_+(5)/day$ | 1.29 | 1.00 | 0.82 |
| $T_-(1)/day$ | 3.47 | 3.01 | 2.65 |
| $T_-(2)/day$ | 1.55 | 1.29 | 1.10 |
| $T_-(3)/day$ | 1.00 | 0.82 | 0.69 |

Table 8. Periods $T_c$ and $T_\pm(n)$ corresponding to $f_c$ and $nf_c \pm f_J$, $n = 1, 3, 5$ for scaled up EEG at $k_D = 6$ level corresponding to alpha band frequencies 8, 10, 12 Hz of the ordinary EEG. The unit is one day and Josephson period is 9.02 days. Note that 1 day (24 hours) appears as period.

| | | | |
|---|---|---|---|
| $T_c/y$ | 27.3 | 21.8 | 18.2 |
| $T_+(1)/y$ | 72.7 | 43.6 | 31.2 |
| $T_+(3)/y$ | 11.5 | 8.7 | 7.0 |
| $T_+(5)/y$ | 6.2 | 4.8 | 4.0 |
| $T_-(1)/y$ | 16.8 | 14.5 | 12.8 |
| $T_-(2)/y$ | 7.5 | 6.2 | 5.3 |
| $T_-(3)/y$ | 4.8 | 4.0 | 3.4 |

Table 9. Periods $T_c$ and $T_\pm(n)$ corresponding to $f_c$ and $nf_c \pm f_J$, $n = 1, 3, 5$ for scaled up EEG at $k_d = 7$ level corresponding to alpha band frequencies 8, 10, 12 Hz of the ordinary EEG. The unit is one year and Josephson period is 43.6 years.

### 3.8.9 Is $k_d = 3$ level responsible for kHz neuronal synchrony?

The time scale of nerve pulse emission is millisecond and synchronous emission of nerve pulses suggests the existence of a clock with frequency 1 kHz. Also memetic codeword for which single bit corresponds to 1027 Hz frequency requires a clock at $\sim 1$ kHz frequency.

The scaled up hierarchy of EEGs indeed predicts 1 kHz frequency band as a scaled up variant of 1 Hz cyclotron frequency associated with DNAs. Suppose that also magnetic flux tubes with area scaling as $S = \hbar^2$ and $B$ scaling as $B \propto 1/\hbar$ are present, at least for sufficiently large values of $k_d$. For this hierarchy cyclotron frequencies would scale as $1/\hbar$ and for $k_d = 3$ 1 Hz DNA frequency in delta band would scale up to 2 kHz for $Z = 1$ magnetic flux quantization. For $Z = 2$ flux quantization scaled up DNA cyclotron band would be around 1 kHz and could serve as a drum beat making possible synchronized neuronal firing. Similar situation would be obtained for the cyclotron frequencies of singly charged exotic ions for which color bond inside nucleus has become color charged so that cyclotron frequency is typically in or below alpha band scaled down to 5 Hz.

### 3.8.10 Generalization of EEG to ZEG

The generalization of the model of EEG to ZEG (E in the middle of EEG could be of course replaced with appropriate letter such as K) is rather straightforward.

Also now there are three contributions: $Z^0$ Schumann frequencies, cyclotron frequencies, and the frequencies associated with Josephson junctions. The most conservative approach assumes that also $Z^0$ flux sheets characterized by $k_d$ traverse DNA (that is genes have wormhole contacts with these flux sheets). If these sheets possess the thickness of DNA double strand, the finite range $L_w(k_d)$ of $k = 113$ $Z^0$ quanta does not pose other restrictions than the requirement that the overall width of flux sheets is below $L_w(k_d)$.

For $k = 113$ weak bosons with $k_d = 2$ one has $L_w \simeq .2$ $\mu$m. For $k_d = 4$ which is thermally stable one would have $L_w \simeq .8$ m corresponding to the size scale of the human body, which is by a factor $2^{-22}$ smaller than the corresponding size in the electromagnetic case. $Z^0$ magnetic fields satisfy flux quantization condition implying that cyclotron frequency and energy are proportional to $Q_Z/Q_{Z,0}$, where a particle with charge $Q_{Z,0}$ defines flux quantization. Cyclotron frequencies would differ from their electromagnetic counterparts for $k_d = 2$ level only by factors $Q_Z/Q_{Z,0}$. The condition that $Z^0$ ions are em neutral would mean that $Z^0$ ions and bosonic ions are in one-one correspondence so that ZEG would be more or less identical with EEG as far as cyclotron frequencies are considered.

The model of Josephson junction hierarchy must be based on guesses. The simplest guess is that the cell membrane involves also a space-time sheet giving rise to $Z^0$ voltage, which is minimal in the sense that the energy of a singly charged $Z^0$ ion is at thermally marginally stable and thus also now $\simeq .08$ eV. The hierarchy of $Z^0$ Josephson junctions would result in an exactly the same manner as in the electromagnetic case and Josephson energies are same for all levels whereas frequencies scale down as $1/\hbar$.

Also the notion of Schumann resonance at same energy range as in em case could make sense. The finite range of weak force implies effectively the presence of conductive spherical surface analogous to ionosphere at radius $L_w$ preventing the penetration of $Z^0$ electric field through. Hence the system would possess effective $Z^0$ Schumann cavity and it could be possible to speak about cavity oscillations. Earth length scale would correspond to $k_d = 6$ level of dark matter hierarchy for $Z^0$ field which would mean that the Schumann energy would be very large in this length scale, about .64 MeV. $k_d = 4$ level ($L_w = .8$ m) would give Schumann energy which is of the same order of magnitude as in electromagnetic case.

With these assumptions the spectrum of ZEG for $k_d = 4$ level would be very much like the spectrum of EEG. An important difference would come from the fact that simplest exotic ions obtained by the generation of charged color bonds inside nuclei would be singly charged bosons and alpha band would be scaled down to 5 Hz for them. The mass number differs by one unit from that of ordinary ion and the resulting change of cyclotron frequency could be used as an experimental signature of exotic ion. Also Josephson energy would be one half from that of $Z = 2$ satellites so that alpha band its satellites would be suffer exact scaling by factor 1/2. For $k_d = 3$ and $Z^0$ magnetic field scaled up by $\lambda$, the 1 Hz lower bound dictated by thermal stability would correspond to kHz frequency for $Z = 2$ flux quantization. Scaled up delta band might be the "drum beat" making possible neuronal synchronization.

## 3.9 How EEG and ZEG relate to conscious experience?

In this section possible interpretation of cyclotron phase transitions and EEG from the point of view of conscious experience are discussed.

### 3.9.1 Sensory canvas hypothesis

Sensory canvas hypothesis assumes that magnetic transition frequencies code for the temporal and possibly also spatial positions of the objects of the 4-D perceptive field at the personal magnetic body characterized by field strength $B_{end}$.2 Gauss at the surface of Earth. Magnetic transition frequencies are associated with MEs serving as sensory projectors to which various sub-selves representing features are entangled.

The view about evolution of consciousness as a gradual emergence of increasingly lower EEG frequency scales suggests a general paradigm concerning the assignment of the frequency bands with various cyclotron frequencies and possibly spin flip frequencies. 40 Hz band could naturally correspond to MEs projecting symbolic representations associated with the sensory input to the magnetic sensory canvas. The range 20-40 Hz could be associated with some simple cognitive features or emotions (say associated with odor discrimination) whereas 13-20 Hz interval could correspond to more refined cognitive features. Alpha and theta bands could relate to the features representing memories. The possibility of communications at theta, delta and alpha frequencies to higher level many-brained magnetic selves representing collective levels of consciousness must be considered seriously in TGD framework.

The processing of the sensory input involves where-what division. The fact that 'where' aspect has developed earlier encourages to think that it is more primitive aspect of perception so that the EEG frequencies associated with the simplest 'where' aspects might be higher. This is supported also by the fact that the EEG rhythms associated with brain stem and cerebellum correspond to 80 Hz and 200 Hz respectively.

The narrow highly coherent frequency bands with width of order 1-2 Hz reported by Nunez at 3, 5 and 7 Hz, the alpha band at 11 Hz, and the narrow bands at 13, 15 and 17 Hz [47] plus the 8 Hz width band around 40 Hz provide empirical support for the basic assumptions and a good starting point for possible more detailed identifications.

### 3.9.2 Magnetic quantum phase transitions, EEG, and ZEG

The original attempt to assign our qualia to magnetic and $Z^0$ magnetic transitions need not be correct. The following scenario looks a more realistic working hypothesis.

1. The negative energy EEG and ZEG MEs associated with magnetic and $Z^0$ magnetic transitions serve as quantum entanglers of the bodily mental images to the personal magnetic body. $Z^0$ magnetic quantum phase transitions for cognitive neutrinos associated with $\nu\overline{\nu}$ wormhole contacts serve as a correlate for conscious hearing: perhaps also magnetic qualia are analogous to hearing. If sensory representations are realized at the personal magnetic body, the magnetic quantum phase transitions at the personal magnetic body contribute to our conscious experience by the fusion of "simple feeling of existence" mental images with much more complex bodily mental images.

2. The field patterns associated with positive energy EEG and ZEG MEs code for declarative long term memories perhaps using the hierarchy of p-adic cognitive codes discussed above. The model of long term declarative memories suggests that bodily magnetic qualia need not be conscious-to-us. The magnetic quantum phase transitions would represent a step in the transformation of the field patterns of EEG MEs representing declarative memories to conscious experiences.

The overall conclusion would be that, as far as primary sensory qualia are considered, magnetic transitions are not very interesting from the view point of our conscious experience. On the other hand, the hypothesis that magnetic fields are such that magnetic transition frequencies tend to coincide with various universal p-adic frequencies, makes them very interesting concerning the practical models for what might be happening at the magnetic flux tubes of body and brain.

#### Sensory maps by magnetic frequency scale coding

There is a large temptation to assume that the great variety magnetic and $Z^0$ magnetic transitions in EEG frequency range make possible hierarchy of living maps. A varying magnetic and $Z^0$ magnetic frequency scale would code for a position of neuron or some larger unit of brain and to which input from a point of perceptive field is mapped by entanglement (sharing of mental images) and/or by classical communications. Personal magnetic body would essentially remember what happens at material body by sending entanglement inducing negative energy ME to brain along magnetic flux tube and receiving positive energy MEs inducing self-organization and generation of mental images.

The classical communication would be like communicating selectively by broadcasting radio waves to receivers each having their own narrow radio wave band.

The working hypothesis is that various mental images in the cortex are projected outside the cortex and CNS at the canvases formed by the magnetic and/or $Z^0$ magnetic flux tubes associated with various body parts. There are good reasons to believe that these maps are realized in the length scales of EEG wavelengths. The resulting 3-dimensionality of the map is a strong argument in favor of these maps as also the complete decoupling between representation and information processing yielding the representation.

Quantum maps could be realized by place coding using magnetic and $Z^0$ magnetic frequencies associated with ELF MEs emerging radially from various parts of CNS, also from sensory organs even. If the time mirror mechanism is the general mechanism of sensory perception, motor action, and memory applied by the magnetic body, the length along the magnetic flux tube codes for the temporal distance to the geometric past. This coding would rely on resonance mechanism involving also resonant interaction of MEs with Alfven waves associated with magnetic flux tubes (much like oscillations of string). The very slow dependence of these frequencies on distance would be determined by the strengths of the classical magnetic fields for which these flux tubes provide a representation as topological field quanta.

Of course, one can imagine several options. One possibility is that magnetic transitions could be used for the temporal coding of the sensory representations whereas $Z^0$ magnetic transition could be used for the temporal coding of generalized motor actions. This would obviously help to avoid overlap between signalling associated with sensory representations and motor actions.

Magnetic and $Z^0$ magnetic quantum phase transitions could give rise to chemical maps of parts of organ. By using appropriate value of frequency, magnetic quantum phase transitions can be induced and the intensities of these transitions would provide conscious measure for the densities of Bose-Einstein condensates of ions (and perhaps even their Cooper pairs if they manage to be thermally stable) whose densities in turn relate to those at atomic space-time sheets by many-sheeted ionic equilibrium conditions. If the thickness of the magnetic flux tube varies different quantum phase transitions occur at different points of the flux tube and kind of conscious spectrogram results. This kind of generalization of NMR spectroscopy need not be conscious to us although chemical senses could relate to it.

#### Place coding for the geometric parameters characterizing simple geometric features

Place coding for various geometric parameters characterizing simple geometric 'features' could be realized using the variation of the cyclotron frequency along a magnetic flux tube of varying thickness. The hierarchy of the sensory canvases allows a modular structure in which a geometric feature such as triangle, line, or ellipse represented at a lower level sensory canvas is projected to a *single* point of 'our' sensory canvas. If one accepts that only negative energy MEs can serve as entanglers, the conclusion would be that place coding must utilize negative energy MEs to entangle brainy mental images with the "simple feelings of existence" at the magnetic body.

Becker tells in his book "Cross Currents" [60] about a technique discovered by Dr. Elizabeth Rauscher, a physicist, and William Van Bise, an engineer. The technique uses magnetic fields generated by two coils of wire, each oscillating at a slightly different frequency and directed so as to intersect at the the head of the subject person. When two energy beams with different frequencies intersect at some point in space, a third frequency, so called beat frequency is formed as the difference of the frequencies. What Bise and Rauscher found that this ELF frequency (unfortunately, I do not know what the precise frequency range was) generates simple visual percepts like circles, ellipses and triangles and that the variation of the second frequency induces the variation of the shape of the percept.

The simplest interpretation is that the beat frequency is extracted by non-linear effects in brain and induces a magnetic quantum phase transition at magnetic tubes whose thickness varies and codes for a parameter (say scaling in some direction) characterizing the geometry of the primitive percept (or 'feature'). The proposed general mechanism for how EEG MEs give rise to declarative memories should apply also now and would mean that EEG MEs induce cyclotron transitions giving in turn rise to neural activity. If primary sensory organs are seats of sensory qualia, back-projection to the eyes is involved with the process as also in the case of electric stimulus of cortex inducing visual sensations. The intersection of ELF waves would wake-up symbolic mental images representing triangle and back-projection would make this concept visual. The geometric parameters characterizing the triangle would be coded to frequency differences. An analogous phenomenon occurs also for auditory inputs with slightly different frequencies feeded into ears and makes it possible to 'hear' sounds below the audible range. The mechanism could be the same.

### Flag-manifold qualia and magnetic fields

Recall that the flag-manifold representing various choices of quantization axes is a coset space associated with the zero modes. The association of the six-dimensional flag-manifold of color group $SU(3)$ to honeybee dance and geometric aspects of honeybee's sensory experience (described in the chapter [K3] inspired the hypothesis that the values of the flag manifold coordinates might be quite generally mapped to magnetic or $Z^0$ magnetic frequencies by mapping these coordinates to the parameters characterizing magnetic flux tubes. Thus there are two frequencies involved and the mappings projects everything to 2-dimensional space.

The flag-manifold defined by the choices of the quantization axes for the super-canonical algebra of the configuration space is infinite-dimensional. One can however consider finite-dimensional flag-manifolds as lowest order approximation. In the case of MEs of type $E^2 \times CP_2$, the minimal flag-manifold would be the one defined by the Cartan group of $SO(2) \times SU(3)$, which is just the flag-manifold $F_3 = SU(3)/U(1) \times U(1)$ of color group introduced by Barbara Shipman. For MEs of type $S^2 \times CP_2$ which correspond to spherical light fronts the flag manifold is $S^2 \times F_3$. A very natural identification of $S^2$ is as labelling orientations of a vector in 3-space. Thus one might consider the possibility that the increments $S^2$ coordinates could represent changes of orientation at the level of conscious experience. On the other hand, linear sequence of sub-selves inside self would represent experienced orientations very concretely.

One could try to generalize, and consider the possibility that the proper flag manifold is defined by $SO(3,1) \times SU(3)$ by the division by Cartan subgroup. Lorentz group would give 4-dimensional flag-manifold $SO(3,1)/R \times SO(2)$. Lorentz rotations can be decomposed to boosts followed by rotations in rest frame of the resulting system. This suggests that $SO(3,1)$ flag-manifold has a bundle structure with the sphere $S^2$ defined by boost directions serving as the base and the sphere $S^2$ defined by the possible directions for the axis of rotation in the rest frame serving as the fiber. Again sub-self moving inside self could represent the direction of boost naturally.

There must be some correlation between the values of zero modes (in particular, flag manifold coordinates) and classical em $Z^0$ magnetic fields. For instance, color rotation affects the em and classical $Z^0$ fields. In this sense flag-manifold coordinates can be coded to em and $Z^0$ magnetic frequencies but the image is 2-dimensional. The work of Barbara Shipman with the dance of honeybee indeed implied that flag-manifold coordinates are mapped to spatial positions in *2-dimensional* plane representing the dance stage. This suggests that $F_3 = SU(3)/U(1) \times U(1)$ coordinates have representational role: they represent concrete geometric information about spatial positions. This representational role could derive from more general assumptions. The positions of plane are represented as frequencies by the place coding by magnetic and $Z^0$ magnetic frequencies and $SU(3)$ rotations affect em and $Z^0$ magnetic frequencies so that plane points can be mapped to equivalence classes of $SU(3)$ rotations so that a 2-dimensional space associated with the flag-manifold $F_3$ emerges naturally.

### Could magnetic and $Z^0$ magnetic phase transitions define sensory qualia?

If universality principle holds true, both magnetic and $Z^0$ magnetic qualia can be divided to universal kinesthetic qualia and to generalized chemical qualia corresponding to the change of a number of particles in a state with given quantum numbers (say the integer $n$ characterizing cyclotron state). The interpretation of these qualia is far from obvious.

1. $Z^0$ magnetic qualia could be "universal feelings of existence" associated with the place coding of the motor actions from the sensory canvas and also inside brain. This would mean a neat separation of sensory and motor representations from each other. Universal feeling of existence might also be the basic aspect of tactile senses and in fact, all sensations.

2. If the harmonic of the cyclotron frequency does not affect the character of the quale, the number of cyclotron qualia of both em and $Z^0$ type is finite. Alpha band is expected to be the most interesting frequency range as far as qualia are considered. The five bosonic ions

$Mn^{2+}, Fe^{2+}, Co^{2+}, Zn^{2+}$, and $Se^{2-}$ have cyclotron frequencies 7.6, 9.4, 10.0, 10.8 and 11.4 Hz. The number of basic tastes is thought to be five, which could mean that magnetic cyclotron phase transitions correspond to the basic tastes. The number of odors is definitely larger than basic tastes as is also the number of exotic $Z^0$ ions, which are almost always bosons. Thus the identification of $Z^0$ magnetic cyclotron transitions as correlates for odors can be considered.

This proposal can be criticized. Any bosonic molecule with $A/Z \leq 223$ (thermal stability of the BE condensate at room temperature) could as such directly define a cyclotron quale so that tastes and odors would correspond to cyclotron transitions of molecules themselves rather than those of bosonic ions in alpha band. One could also argue that the odors and tastes should have a natural ordering according to the value of cyclotron frequency and be continuously transformable to each other by changing the strength of the magnetic field. This doesn't seem to be the case.

**What about Larmor frequencies?**

Larmor frequency characterizes the nuclear contribution of this interaction to energy and is related to the cyclotron frequency of a singly ionized atom by

$$\omega_L = g\frac{S}{2}\omega_c \ , \quad \omega_c = \frac{eB}{m} \ .$$

where $S$ denotes the maximal projection of spin in the direction of the magnetic field and $g$ is Lande factor, which equals to $g = 1$ in the ideal classical case for which spin corresponds to angular momentum whereas $g = 2$ holds true for elementary fermions. Nuclear contribution is the dominant contribution for ions $Na_+, K_+, Cl_-$ since electron shell is full for the ions in question. The magnetic moments of ions $Cl_-, K_+, Na_+$ reduce to their nuclear magnetic moments and are rather large:

$$\mu = x\frac{e}{2m_p}S \ , \quad g \simeq 2xA \ ,$$

where $m_p$ denotes proton mass and $x$ is a parameter of order one so that Lande factor is proportional to the mass number $A$ of nucleus. The reason for large value of $\mu$ is that magnetic interaction energy of the nucleus is essentially the sum over the interaction energies of nucleons.

If anomalous magnetic moment vanishes Larmor frequency differs by a factor 1/2 from cyclotron frequency: $f_L = f_c/2$ so that spin flip frequency is same as cyclotron frequency. For atomic nuclei the Larmor frequency tends to be larger than cyclotron frequency as the table of Appendix demonstrates. The effects of em fields in living matter at Larmor frequencies have not been however reported.

The interaction of the nuclear spin with magnetic field dominates over the cyclotron interaction energy by a factor of order $A$ and that the natural frequency scale for the ionic Larmor frequencies is hundreds of cycles per second. The values of the parameter $x$ are $x(Na) = 2.214$, $x(Cl) = .82181$ and $x(K) = .3915$. For instance, for $Na_+$ spin flip transition frequency with $\Delta S = 1$ is $f \sim 222$ Hz. For $Ca_{++}$ spin and magnetic moment vanishes. Note that for $J = 3/2$ ions there are in principle three kinds of transitions corresponding to $\Delta S = \pm1, \pm2, \pm3$. If transition reduces to single nucleon level, $\Delta S = \pm1$ is the only possibility. The conclusion is that Larmor frequencies probably correspond to different components of sensory modalities than cyclotron frequencies.

The transitions changing the direction of spin of the Cooper pair are induced by the frequencies

$$\omega = (2n+1)\omega_c + 2\Delta m\omega_L = (2n+1+g\frac{\Delta m}{2})\omega_c \ .$$

Odd multiples of the cyclotron frequency are possible in the first order perturbation theory whereas even multiples are possible only in the second order.

The natural question is whether also spin flips to which Larmor frequencies are associated could be also important from the point of view of conscious experience. The natural expectation is that Larmor frequency behaves in the same manner as cyclotron frequency in the scaling of Planck constant and this is indeed the case since spin scales as $\hbar_{eff}$. This allows to consider the possibility that also spin flip transitions are of interest and perhaps define correlates for sensory qualia.

Consider now some examples.

1. For proton and neutron the Lande factors are $g(p) = 3.58$ and $g(n) = -3.82$ so that the spin flip transition frequencies in Earth's magnetic field would be $2\omega_L = 542$ cycles/second for proton and 570 cycles/second for neuron. The frequencies $2f_L$ and $2f_L + f_c = 842$ cycles/second could have

something to do with the time scale of nerve pulse in case of proton. Note that $2f_L - f_c = 242$ cycles/second is of same order as $f_c$ for proton so that corresponding qualia might resemble each other.

2. For electron $g = 2$ in excellent approximation and the Larmor frequency is very nearly identical with one half of cyclotron frequency. The deviation is

$$\frac{\Delta g}{g} = \frac{\alpha}{2\pi}$$

in the lowest order of perturbation theory ($\alpha \simeq 1/137$) and thus the frequency for the transition $(n+1, up) \leftrightarrow (n, down)$ changing the spin direction of the second electron of the Cooper pair is $\omega \simeq 902$ Hz. This time scale corresponds to the duration of memetic codon fixed by the fact that memetic code corresponds to Mersenne prime $M_{127}$, which happens to be the p-adic prime characterizing also electron.

3. Spin flip frequencies for atomic nuclei are in general of order few hundred Hz for $B = .2$ Gauss. For instance, the spin flip frequencies of Mn, Co, Cu, and Na are for $B = .2$ Gauss 228 Hz, 199 Hz, 223 Hz, and 222 Hz. What makes this interesting is that cerebellar resonance frequency is around 200 Hz.

The eight ions listed in the table below have however exceptionally low Larmor frequencies and, very importantly, the singly ionized states have vanishing electronic spin for all ions except Rh and Ir for which electronic configuration corresponds to $J - e = 2/2$ (non-vanishing electronic spin implies that the Larmor frequency of ion is of order $f_L = f_c(e)/2 \simeq 3 \times 10^5$ Hz). This suggests that electromagnetic spin flip transitions for these ions at least could be related to our consciousness. Note that K, Ag and Au have spin flip frequencies near to the harmonics of the fundamental frequencies of exotic super-canonical representations important in EEG frequency range. Note that the spin flip frequency of $K$ is 39.1 Hz which is in 40 Hz thalamocortical resonance band. The spin flip frequency 82.2 Hz for Cl might relate to the resonance frequency 80 Hz associated with retina.

| Ion | (Z,A,S) | $f_1/Hz$ | $f_{flip}/Hz$ | J |
|---|---|---|---|---|
| $Cl$ | (17,35,F) | 8.5 | 82.2 | 3/2 |
| $K$ | (19,39,F) | 7.5 | 39.1 | 3/2 |
| $Rb$ | (37,85,F) | 3.5 | 81.0 | 5/2 |
| $Y$ | (39,89,F) | 3.4 | 41.2 | 1/2 |
| $Rh$ | (45,103,F) | 2.9 | 26.6 | 1/2 |
| $Ag$ | (47,107,F) | 2.8 | 34.2 (39.2) | 1/2 |
| $Ir$ | (77,193,F) | 1.6 | 17.0 | 3/2 |
| $Au$ | (79,197,F) | 1.5 | 14.0 | 3/2 |

Table 10. The ions for which electronic spin vanishes in ground state and minimum spin flip frequency $f_{flip}$ is below 90 Hz. $f_{flip}$ is defined as $f_{min} = 2f_L/J$m, where $J$ is nuclear spin. $Ag$ allows two stable isotopes with almost same abundances and the values of $f_{flip}$ are given for both.

Magnetic states have momentum in the direction of the magnetic field and a priori the transition frequency spectrum is continuous rather than discrete. Energy and momentum conservation however imply that the increment of longitudinal momentum is fixed in transition and in excellent approximation transition energies are equal to those obtained by neglecting longitudinal momenta altogether.

To get an idea about energy and momentum transfers involved with the transitions between magnetic states with longitudinal momenta $k_1$ and $k_2$, one one apply energy and momentum conservation by assuming that the classical field associated with ME, and thus propagating with light velocity, induces the transition. Let $k_1$ and $k_2$ denote the wave vectors of initial and final magnetic states in the direction magnetic field: the corresponding contributions to the energies of the magnetic states are $k_i^2/2m$, $i = 1, 2$. Let $k_{||} = kcos(\theta)$ denote the projection of the wave vector $k$ of the ME em wave to the direction of the magnetic field satisfying $k = E$: momentum conservation gives $k_1 - k_2 = k_{||}$. Energy conservation in turn gives

$$\Delta E = \Delta E_B + (k_1^2 - k_2^2)/2m = E \ ,$$

where

$$\Delta E_B = n\omega_c + \omega_{flip}$$

denotes to the contribution of the cyclotron and spin flip components to the transition frequency. The condition

$$(k_1 + k_2)/m << 1$$

is certainly satisfied and this allows the approximations

$$k = \Delta E \simeq \Delta E_B$$

$$k_1 - k_2 \simeq \Delta E_B cos(\theta)$$

The result means that transition frequencies are not essentially affected by the energy transfer in longitudinal degrees of freedom and it is an excellent approximation to assume that the frequencies inducing magnetic transitions correspond to the transition frequencies associated with the transitions in cyclotron and spin-flip degrees of freedom.

### 3.9.3 Altered states of consciousness and EEG

The magnetic flux tubes in the length scale range determined by theta and delta band could quite well connect magnetic body to several different organisms and make possible sharing of experiences. Also magnetosphere and even larger magnetic structures could give rise to sensory and other representations receiving input from several organisms and sharing of mental images would allow to share these experiences.

If magnetic body is the experiencer applying time mirror mechanism and if positive energy EEG boundary MEs in delta and theta bands correspond to classical communications of declarative memories usually not conscious-to-us, the dominance of theta and delta waves during sleep suggests two alternatives.

1. During the sleep our attention is directed to transpersonal levels of consciousness but that we do not remember anything about this. The reason might be that no declarative memories are generated during this period.

2. We are entangled with transpersonal levels of consciousness and have lost our personal consciousness. A conscious contact with transpersonal levels requires sharing of mental images with these levels and this might occur during meditation. Theta and delta bands are also known to dominate during deep meditation.

One can consider two alternative interpretations corresponding to interior MEs (phase velocity equal to light velocity) and positive energy boundary MEs (phase velocity equal to EEG phase velocity) associated by scaling law with the negative energy MEs.

1. For positive energy interior MEs the frequencies would correspond to magnetic flux tube lengths up to about 10 Earth circumferences and contained within Earth's magnetotail at the night side. Time scale would be $T = 1/f$. These MEs could feed data using appropriate cognitive codes at p-adic resonances frequencies to the magnetospheric multi-brainy collective selves responsible for the transpersonal levels of consciousness.

2. The scaling law, assuming the alpha wave phase velocity to be the effective phase velocity $v$ of boundary ME, would predict that the time $T_1 = \lambda/v$ needed by the boundary MEs to travel the distance $L = c/f$ defining the distance to the point of the magnetic body wherefrom the negative energy EEG ME was sent to the brain, is measured using decade as a natural unit. If magnetic body is the experiencer applying time mirror mechanism this would mean that delta band would correspond to memories with time span of about ten years. One might think that the magnetic body triggers boundary MEs using negative energy MEs in ULF range which automatically give rise to memories experienced after time $T_1$.

#### Transpersonal levels of consciousness

Individual organisms or even larger structures could define the 'pixel size' for higher level multi-brained selves realized as sensory, symbolic and cognitive representations at various magnetic structures like the magnetosphere of Earth. These levels could correspond to any p-adic length scale above brain size. These levels would obviously represent the consciousness of various kinds of groups and collectives.

*1. Sleep and transpersonal states of consciousness*

The simplest assumption is that one loses consciousness during sleep by entanglement with some higher level self, say magnetospheric multi-brained self. This would give rise to a fusion of mental images at this higher level and to a stereo consciousness representing "human condition".

One should not be however too hasty to make this kind of conclusion. If it is indeed biological body which sleeps, our field body could be full awake with attention directed to transpersonal levels of existence. If this is indeed the case, the basic question would be about how to have these experiences and simultaneously form long term declarative memories about them: some part of brain, probably including hippocampus, should be kept awake during these experiences. Perhaps meditative states, often characterized as transpersonal ego-free consciousness, are this kind of states.

*2. Who am I?*

These arguments raise the question 'Who am I really?'. What precise length scale my ME does corresponds size of Earth, of solar system, of galaxy? Or can my self size be literally infinite and correspond to some infinite p-adic prime and is only the localization for the contents of my conscious experience to this particular corner of this particular galaxy which creates the illusion that I am this biological body? During episodal memories and also ordinary memory recall parts of magnetic body and MEs having size $L = cT$, $T$ the time span of the episodal memory are actively involved so that one can say that the size of "me" is measured in light years. But it is difficult to say whether the contents of my consciousness contains only personal memories even in ordinary states of consciousness. For instance, it is difficult to locate mathematical ideas in any particular portion of space-time and p-adic space-time sheets which are infinitesimally small p-adically are infinitely large in real sense.

Whatever the detailed answer to these questions is, this view allows to interpret physical death as a re-directed attention and giving rise to what might be called re-incarnation. What would differentiate between my and my dog's soul that our attentions are differently directed.

*3. Examples of transpersonal experiences*

Near-death experiences and out-of-body experiences could be examples of of almost transpersonal, 'ego-free' consciousness. That these experiences often involve the experience of seeing one's own body from outside, is consistent with the transpersonal nature of the experience. As already noticed, delta band is peak frequency in the EEG of infant, which would suggest that children either direct their attention mostly to the transpersonal levels or that children are strongly entangled and almost unconscious as also we are when theta and delta bands of EEG dominate. That this would be the case would conform with the ideas about bicamerality. Otherwise our personal development would be gradual spiritual degeneration.

The experiences of what I call whole-body consciousness could also be example of consciousness involving transpersonal component. These states appear often at night time as dream like experiences and involve illusion of being in ordinary wake-up consciousness. The usual 'noise' present everywhere in body, possibly due to the averaging over proprioceptive experiences of sub-selves, disappears totally and peculiar silence falls down. Whole-body consciousness starts as a stir in spine (same as generated by good music sometimes) extending gradually to the entire body. Experiences of weightlessness and of 'wavy' nature of physical body, flying into roof and falling down smoothly back into bed are typical aspects of these experiences. During this kind of experience it is sometimes also possible to leave the room. During my 'great experience' I experienced of leaving the hospital and walking along street knowing that I was invisible. This experience ended to experience of being brought back to hospital by hospital personnel.

Short lasting form of whole-body consciousness is also possible after waking-up immediately after falling asleep in daytime: perhaps theta consciousness prevails for a short time after wake-up. My personal 'great experience' involved besides whole body consciousness enhanced cognition: entire flux of ideas many of which have later developed to basic principles of quantum TGD.

### Meditative states of consciousness and EEG

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The proposed general picture allows to build a rough model for the mechanism leading to meditative states. One can also understand how so called ORMUS elements [116] might help to achieve these states.

The harmonics of cyclotron frequencies in delta band should represent even more deeper transpersonal qualia with time scale of about $t_1 = (c/V) \times T$, $T = 1/f$ light years for $f = 1.5$ Hz and $V = 3$ m/s. One could of course argue that the concentrations of heavy ions in brain are so low so that corresponding cyclotron transitions do not give rise to any experiences even if scaling law would not forbid them. This objection is not necessarily very convincing since the needed densities of ions in cellular space-time sheet might be by a fraction of order $[L(137)/L(167)]^3 \sim 10^{-13}$ smaller than density of water and because heavier ions are in gas form and presumably tend to be mostly in non-atomic space-time sheets. TGD predicts also new electro-weak physics would could dramatically change the isotope ratios at cellular space-time sheets.

Delta waves might relate to the interaction of brain with sferics which are atmospheric em perturbations [21]. The spectrum of sferics at delta frequencies resembles EEG spectrum at same frequencies [21]. The electric fields associated with sferics are of same order of magnitude as waves in delta band so that they are not amplified as much as alpha waves. This could explain why delta and theta consciousness is so weak.

One could also consider enhancing delta consciousness artificially: perhaps this could make enlightment experience, if not more probable, at least more intense. This could perhaps be achieved by feeding in brain some heavy singly ionized ions with cyclotron frequencies in delta band and stimulating brain using ELF em field at corresponding cyclotron frequency in $B_{end} = 0.2$ Gauss. Some candidate ions are $Ag^+ : f_c = 2.8$ Hz; $I^+ : f_c = 2.4$ Hz and $Au^+ : f_c = 1.5$ Hz. Also heavy ions like Hg and Pb are in the same frequency range as Gold. For $Z = 1$ flux quantization these frequencies are halved since magnetic field strength is halved.

There are claims for so called ORMUS atoms which somehow differ from ordinary atoms [116]. The persons involved take doses of what they call ORMUS elements, in particular so called White Gold, to induce spiritual experiences. In fact, Barry Carter who wanted to understand what is involved, contacted me about five years ago and told about these effects and I ended up the notion of wormhole Bose-Einstein condensate as a possible explanation of the claimed properties of White Gold. It might be that Gold ions and other heavy element ions enhance transpersonal sensory consciousness in delta band and lead therefore to spiritual experiences.

There is also a patented process developed by Robert Monroe and called Hemi-Synch [47] which might induce delta and theta consciousness. Feeding audible sounds to ears with carrier frequencies below kHz and frequency difference of say 10 Hz, which is as such not audible, generates binaural beat involving appearance of an EEG wave at difference frequency [48]. The difference frequency is not only 'heard' but binaural beats in delta and theta range tend to induce relaxed, meditative and creative states [47]. This method might provide a test for the hypothesis that linear combinations or p-adic frequencies are crucial for consciousness by choosing beat frequencies equal to these frequencies. In a similar manner one could test the alternative hypothesis that cyclotron frequencies are fundamental for consciousness. One should know the precise value of local magnetic field and also take into account the possibility that brain could be able to regulate the value of the local magnetic field to some extend. It could be also possible to apply EEG biofeedback and delta and theta frequencies.

### Empirical evidence for transpersonal levels of consciousness

Recall that hyper-genes would correspond to flux sheets traversing through cell nuclei belonging to several organisms. Obviously this level would correspond to a transpersonal level of consciousness: kind of multi-brained conscious entities receiving sensory input from several organisms and performing intentional control over their behavior would be in question. Strong correlations between EEGs of individuals, in particular those having a close personal relationship, would be the obvious implication.

The experiments of Mark Germine [57] provide evidence for the notion of transpersonal conscious entities and associated collective memory perhaps realized in terms of flux sheets traversing the neuronal nuclei of several persons. What was studied was the evoked EEG response to a series of random quantum stimuli which consisted of series of identical sound stimuli with randomly located deviant stimulus. Two subject persons, A and B, were involved. In the case that A observed the differing stimulus 1 second before B, the evoked EEG response of B became incoherent. Since evoked stimulus was oscillation at EEG frequency of about 11 Hz in the case that A had not observed the stimulus, one could understand the mechanism as a direct evidence for transpersonal conscious entity interacting with brains of both A and B. When transpersonal conscious entity had hear the stimulus once, it did not react to it in similar manner.

### 3.9.4 EEG and Golden Mean

Dan Winter has reported [115] that in certain altered states of consciousness (described as experiences of bliss) the ratio of beta and alpha peaks approaches Golden Mean $\Phi \simeq 1.618...$ It is interesting to look what TGD based model for EEG could say about this finding.

1. For $f_J = 5$ Hz and $f_c = 10$ Hz (the p-adic frequency corresponding to the secondary p-adic time scale $T_2(127)$ associated with Mersenne prime $M_{127}$, and identifiable as a fundamental biorhythm) one has $\beta/\alpha = 3/2$ which is the lowest approximation to Golden Mean in terms of ratios of Fibonacci numbers. The higher approximations approach to $\Phi$. The approximation sequence would be consistent with the 1 Hz width for the narrow beta bands.

2. This would suggest that beta/alpha ratio is maximal in this state and approaches to $\Phi$ in a discrete manner. The question is whether the resting potential is quantized in terms of ratios of Fibonacci numbers $F_{2n}/F_{2n-1} \in \{3/2, 8/5, 21/13, ..\}$. At the limit theta peak would approach to 3.92 Hz: note that shamanic drumming rhythm corresponds to 4 Hz frequency. This hypothesis is testable by comparing possible changes in the measured resting potentials with subjective reports of meditators.

3. The sequence of ratios of $F_{n+1}/F_n$ approaches Golden Mean in an oscillatory manner, which suggests that states of hyperpolarization following generation of nerve pulse correspond to ratios $F_3/F_2 = 5/3$, $F_8/F_5 = 13/8$,... above Golden Mean. In the sate of "full bliss" there would be no hyperpolarization after the generation of nerve pulse. A possible interpretation is that there is no "dead" time after nerve pulse and system is immediately in a state of maximal possible alertness. On the other hand, the state of pure bliss should be ideally a state of pure alertness without mental images. In the state in which cell membrane in resting state is maximally hyperpolarized, nerve pulse generation does not occur too easily and thus sensory or other mental are not easily generated.

4. The sequence of Fibonacci numbers could relate to a hierarchy of finite-dimensional approximations for Jones inclusions for quantum phase $q = exp(i\pi/5)$ represented in terms of braids. $n = 5$ is also the minimal value of $n$ allowing universal topological quantum computation [E9]. The state of full bliss would correspond to the limit at which the number of strands of braid is infinite so that topological quantum computations resources are maximal.

5. Dan Winter has also emphasized the importance of tedrahedral and icosahedral symmetries for DNA. These symmetries correspond to the only genuinely 3-dimension finite subgroups of rotation groups and are symmetries of water molecule clusters. Icosahedral group has $n = 5$ and would allow universal topological quantum computation.

### 3.9.5 Pineal gland, EEG and ZEG

Pineal gland is an unpaired structure and strictly speaking not part of brain being located outside the brain in primitive vertebrates. Pineal gland is known to play a role in the control of both central nervous system, endocrine system and immune system [64]. There is also strong evidence that pineal gland forms part of the magnetic navigation system in birds, and possibly also in humans who also have this system. Pineal gland is biological timekeeper and responsible for 24-hour circadian rhythms via a secretion of hormones, in particular melatonin. What pineal gland does is to inhibit secretion whereas pituitary gland facilitates it. Pineal melatonin level controls the hormone secretion and sleep wave cycle and magnetic exposure changes pineal melotonin secretion [64].

What makes pineal gland interesting is that it is accompanied by 10 Hz rhythms. This rhythm corresponds to the strongest resonance frequency in the alpha band for both EEG and ZEG.

**Pineal gland as timekeeper**

10 Hz corresponds to the p-adic frequency $f(2,127)$ associated with the 126-bit memetic code, which is an especially important code in the hierarchy of the cognitive codes. The fact that tiny electric field at average alpha frequency of 10 Hz restores biorhythms in absence of local magnetic field [77], suggests that pineal gland has a coupling to some cavity resonances or some magnetic transition frequency equal to 10 Hz.

1. The lowest Schumann frequency 7.8 Hz is too low. On the other hand, the resonance frequency associated with effectively two-dimensional excitations of em fields inside Schumann cavity is exactly 10 Hz and could be involved with the realization of the memetic code.

2. $Fe^{++}$ ion appears naturally and has cyclotron frequency of 10.74 Hz and provides a natural candidate for a biological clock, not necessarily associated with the pineal gland. A 3 per cent reduction of the Earth's magnetic field from the nominal value of .5 Gauss would reduce the cyclotron frequency to 10 Hz.

3. $Co^{++}$ cyclotron frequency would be 10 Hz for $B = .5$ Gauss. $Co^{++}$ has very high nuclear spin and is therefore a natural magnet: Yarrow has indeed suggested that vitamin $B_{12}$ containing $Co$ makes pineal gland magnetic hormone and fundamental biological clock at 10 Hz frequency [77]. Thus at least ELF ME with $Co^{++}$ cyclotron frequency should go through pineal gland. In the case that they are singly ionized $n = 2$ multiples of corresponding cyclotron frequencies would be involved with the biological clocks in question: these transitions are possible in the second order of perturbation theory.

In darkness 24-hour circadian rhythm changes to 25-hour rhythm perhaps defined by the rotation of Moon and Earths's own rotation. The ratio of 24-hour period to 25-hour period is .96. The ratio of the average of $Co^{++}$ and $Fe^{++}$ frequencies to $Fe^{++}$ frequency is .964 giving period of 24 hours 53 minutes if the average period is 24 hours. This observation suggests that circadian period is measured during daylight in time unit given by the period of $Fe^{++}$ rhythm possibly associated with some visual pathway, perhaps even with eyes, and in darkness by the slightly slower $Co^{++}$ rhythm associated with the pineal gland. Under this assumption the ordinary circadian rhythm $f$ is weighted average of $Fe^{++}$ and $Co^{++}$ rhythms:

$$f = xf(C0^{++}) + (1-x)f(Fe^{++}) \ ,$$

In ideal circumstances circadian rhythm is 24 hours: this gives $x = .44$ with roughly 13.5 day hours and 10.5 dark hours. In continual darkness the rhythm would transform to the slower $Co^{++}$ rhythm of 25 hours with $f = f(Co^{++})$. These two rhythms would presumably distinguish between sleep and awake since pineal gland closely related to the regulation of sleep-wake cycle.

The deviation of $x$ from ideal value $x = .44$ could be an important factor in some disorders. It is known that human melatonin levels do not depend very strongly on season except in arctic latitudes (seasonal affective disorder) but that melatonin levels affect sleep-wake cycle. Abnormally high activity of pineal gland is associated with the hallucinatory periods of schizophrenia: perhaps visual hallucinations of schizophrenic are partially mediated by pineal gland. The manic (depressive) phase of bipolar disorder correlates also with over- (under-) activity of the pineal gland [64]. Keeping $x$ by artificial lighting near its ideal value could be of help. The artificial modification of the strength of the local magnetic field should modify the unit of biological time: perhaps this could provide a manner to cure not only jet lag but even much more serious mental disorders.

**Pineal gland as "third eye"**

The question is whether the 25-hour rhythm equals to the rhythm defined by moon's rotation or is it a mere coincidence. If not, then the MEs going through through pineal gland might mediate unconscious-to-us information about the rotation of Moon. Could higher level self 'see' moon in its orbit? Perhaps in some sense! The ability to restore circadian rhythms is based on the photosensitivity of the pineal gland. Pineal gland has been indeed regarded as "third eye" by mystics. As a matter fact, in some lower vertebrates pineal gland serves as a genuine eye [65]. For long it has been thought that in mammals pineal gland is not (or perhaps cannot be!) directly photosensitive. Indeed, there is a pathway from the retinas to the hypothalamus called the retinohypothalamic tract [65]. It brings information about light and dark cycles to a region of the hypothalamus called the suprachiasmatic nucleus (SCN). From the SCN, nerve impulses travel via the pineal nerve (sympathetic nervous system) to the pineal gland. These impulses inhibit the production of melatonin. When these impulses stop (at night, when light no longer stimulates the hypothalamus), pineal inhibition ceases and melatonin is released. The pineal gland is therefore a photosensitive organ and an important timekeeper for the human body.

The belief that pineal gland receives information about changes in the lighting from retinas only, has turned to be wrong: mammals lacking ordinary rods and cones genetically, can preserve they circadian rhythms [65]! Thus pineal gland must perceive changes in lighting somehow. TGD based explanation for pineal vision is based on the many-sheeted space-time concept and ELF selves: light reaches pineal gland via MEs associated with EEG frequencies. Why we do not then see with our third eye? Or do do we actually see?: perhaps visual dreaming involves also seeing with the third eye providing 'spiritual input'! This hypothesis can be tested by checking whether the dreams of people with pineal gland injury somehow change. This explanation also suggests that also eyes are foci of converging MEs so that eyes would be rather concretely mirror of the soul!

**Perhaps Descartes was not so wrong after all!**

Descartes has been ridiculed for his belief that pineal gland is the seat of soul. Perhaps this sentence has been precipitate as suggested by a clinical case in which over-activity of 5-year old child had led to premature adolescence. Here is a fragment from Frederic Tilney's book 'The Pineal Gland':

*Until a few decades ago scant attention was paid to the pineal gland. Then came the case, noted by Dr. Berman, in which a child was brought to a German clinic suffering from eye trouble and headaches. He was five years old and very mature, and apparently had reached the age of adolescence. He was abnormally bright mentally, discussing metaphysical and spiritual subjects. He was strongly group-conscious and only happy when sharing what he had with others. After his arrival at the clinic, he rapidly grew worse and died in a month. An autopsy showed a tumor of the pineal gland.*

Pineal gland is one of so called chakras in mystic teachings and it is known that pineal gland is involved with altered states of consciousness [64]. Meditation practices assign to third-eye meditation development of "light in the original cavity or center of spirit" located in the center of the brain and "waking of Kundalini" is associated to pineal gland [64].

The fractal hierarchy of the magnetic flux tubes corresponds to a hierarchy of selves and pineal gland is known to contain magnetic crystals. These crystals create magnetic fields which are much weaker than Earth's magnetic field. Their flux tubes, with thickness measured in centimeters, could thus be carriers of super-conducting BE condensates with cyclotron time scale measured in the range year–thousand years. These higher level magnetic selves together with corresponding MEs could be responsible for the higher levels of the self hierarchy. One could perhaps understand also the various characteristics of near death experiences in terms of higher level magnetic consciousness [I3]. Thus Descartes could have been right after all!

## 3.10 Great vision about biological evolution and evolution of brain

The following great vision about evolution and is not perhaps strictly about hierarchy of EEGs. The hierarchy of dark matter and EEGs however leads to this vision naturally. The first part of vision relates to biological evolution. Second part is about the evolution of brain. Here the key thread is evolution of two kinds of intelligences, the ordinary fast intelligence evolving via the emergence of fast computation type activities and emotional slow intelligence developing via the emergence of higher levels of dark matter hierarchy. The latter intelligence is what distinguishes us from animals.

### 3.10.1 Dark matter hierarchy and big leaps in evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

There are two hierarchies involved with the dark matter hierarchy. The dark levels associated with weak bosons for which $k_W = 1$ corresponds to the p-adic length scale about $L_W(1) \sim 1$ Angstrom with exotic weak bosons corresponding to $k = 113$ (rather than $k = 89$ as for ordinary weak bosons). There is also electromagnetic dark hierarchy and in a given length scale one has $k_W = k_{em} + 2$. In a given scale weak sector would be ahead in evolution by two units so that weak dark bosons can be associated with more abstract functions like cognition and planning whereas em level would be related to simpler functions.

Ordinary matter corresponds to $k_W = k_{em} = 0$ and ordinary value of $\hbar$ and higher levels correspond to scaled up values of $\hbar$ with scalings $\lambda^k$, $\lambda \sim 2^{11}$. This mean scaling up of various quantum length scales and also the sizes of space-time sheets by $\lambda$. It seems that magnetic flux quanta are the primary structures forming hierarchy of this kind and large $\hbar$ means that cyclotron energy scales expressible as $E = \hbar(k)eB/m \propto \lambda$ so that an arbitrarily weak magnetic field strength can in principle correspond to a cyclotron energy above thermal threshold at room temperature.

The appearance of space-time sheets zoomed up in size by a power of $\lambda$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of scaling of $\hbar$ by $\lambda$ and emergence of new large magnetic flux sheets satisfying magnetic flux quantization condition with the unit of flux scaled up by $\lambda$. This leap is quantum leap but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by $\lambda$ as the new level of dark matter hierarchy emerges.

The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a detailed vision about big evolutionary leaps.

*1. Molecular life*

Magnetic body with $(k_W, k_{em}) = (1, 0)$ corresponds to the lowest level of hierarchy with the size of the basic structures corresponding to atomic length scale. The anomalous properties of water would be partly due to the presence of this level. At least the simplest bio-molecules regarded as living organisms would correspond to this level.

*2. The emergence of prokaryotes as simplest membrane bounded structures*

At $(k_W, k_{em}) = (2, 0)$ level high $T_c$ superconductivity predicting the basic length scales characterizing the double layered cell membrane, the size scale of the cell, and the weak length scale $L_w(2) \simeq .3$ $\mu$m. Prokaryotic cells (bacteria, archea) without cell nucleus and other cell organelles would correspond to this level. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes in this framework. Also viruses and nannobacteria could correspond to this level of hierarchy. Cell membrane is responsible for metabolic functions and genome is scattered around the cell at this stage.

*2. The emergence of cells having organelles*

The appearance of magnetic bodies with $(k_W, k_{em}) = (3, 1)$ correlate with the emergence of simple eukaryotic cells, in particular plant cells. Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles plus would form a symbiosis by topologically condensing to $(k_W, k_{em}) = (3, 1)$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. The interpretation would be that they are also life forms and magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Centriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtubuli. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. This means that there is no need for static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on coherent photons and weak bosons of generalized EEG associate with the level of dark matter hierarchy in question. The mysterious bio-photons could be decay products of dark photons resulting via de-coherence meaning that the size of the dark photons is reduced in stepwise manner by factor $1/\lambda$ in single step.

*3. The emergence of organs and animals*

The emergence of magnetic bodies with $(k_W, k_{em}) = (4, 2)$ leads to the formation of multicellular animals. Magnetic body at this level gives rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures formed from centrosomes and corresponding microtubuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

*4. The emergence of nervous system*

$(k_W, k_{em}) = (5, 3)$ magnetic body makes possible nervous system. The period of Josephson oscillations associated with the scaled up variant of cell membrane is about 10 kHz and is consistent with the characteristic millisecond time scale of nerve pulse activity. Nerve pulse reception involves communication to the magnetic body via receptors of the neuronal membrane and the reaction of the magnetic body possibly generating a nerve pulse sequence. Charge entanglement made possible by $W$ MEs makes possible nerve pulse generation as a quantum coherent process.

The emergence of the new level means also the integration of axonal microtobuli to text lines at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

*5. The emergence of vertebrates and EEG*

$(k_W, k_{em}) = (6, 4)$ magnetic body would bring in EEG possessed by vertebrates and also ZEG and WEG. Magnetic body is now of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and basic building blocks of our sensory experience correspond to a fundamental period of .1 seconds.

*6. Cultural evolution*

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the genes involved. The development of speech faculty is certainly a necessary prerequisite for this breakthrough.

### 3.10.2 Could insect colonies have "EEG"?

The hypothesis that only vertebrates (having EEG) corresponds to $k_{em} = 4$ whereas insects would have $k_{em} = 3$ is only a hypothesis consistent with the empirical findings about the effects of ELF em fields on vertebrate brain. These findings do *not imply* the hypothesis. Indeed, the situation need not be so simple as the hypothesis suggests in the case of social insects forming colonies. Indeed, ELF magnetic field and magnetic fields affect the behavior of honeybees just as ELF em fields affect the behavior of vertebrates [100]: the model for this findings led to a model for the fractal hierarchy of EEGs.

It seems safe to assume that insect brain is so simple (in the case of honeybee the number of neurons 1/1000 of number of neurons in human retina) that it is not possible to assign $k_{em} = 4$ to it: this would also mean "personal" EEG not possessed by honeybees. The fact that a honeybee isolated from colony dies just as does the cell separated from organism, suggests that the relationship of insect to colony is like that of a cell to organism. Hence one could test whether colonies of social insects or their sub-colonies might possess an analog of ordinary EEG. What this would mean that ant colonies have sufficiently complex hyper-genome making possible collective variants of memory, sensory input, and intelligence, as well as the ability to realize collective motor actions. Even bacterium colonies have intricate social structures [105] so that one must remain open minded.

#### Do honeybees have long term memory?

The realization that insect colonies rather than insects might correspond to higher $k_{em} > 3$ levels of the dark matter hierarchy came via an indirect route. The article "Why honeybees never forget a face?" of New Scientist [98] described evidence supporting the view that that honeybees might possess long term memory in the time scale of days.

Adrian Dyer of the University of Cambridge and colleagues trained honeybees to associate a sucrose drink with a photograph of a particular face. The insects were then tested on their memory and recognition skills by being presented with the picture of this face and the pictures of three other faces not associated with any reward. Of the seven bees tested, two lost interest in the trial and flew away. But the five remaining bees correctly identified the target face in more than 80 per cent of trials, even though the reward had been removed. Moreover, some bees remembered the face two days later, indicating that they had formed a long-term memory of it.

The conservative explanation is that the achievement is due to keeping the face-honey association intact in the absence of the stimulus which created it in a time scale of days. For this option the ability of honeybee to express the distance and orientation to the food source could be hardwired involving no conscious memory about the flight. Also the interpretation of the honeybee dance telling the distance and orientation of food source to advices where to fly would be completely "instinctive".

A more radical option is that honeybee hive rather than honeybee has long term memories in the sense as long term memories are interpreted in TGD framework: that is as communications with the geometric past. In this case the span of long term memories is determined by the level of dark matter hierarchy as time $T(k_{em})$ and few days span for long term memories forces the conclusion $k_{em} \geq 6$. For $k_{em} = 6$ level of the dark matter hierarchy the basic "drum beat" defined by the corresponding Josephson frequency (counterpart of 5 Hz frequency in EEG) corresponds to 9 days.

One can ask whether the ability of honey bee queen to found a new honeybee colony could involve long term memory in an even longer time scale $T(k_{em} = 7)$. If this were the case, the queen would not face her formidable challenge alone: the former colony in the geometric past still exists as a conscious entity and could communicate advices to the queen. $k_{em} = 7$ is perhaps an un-necessarily strong an assumption since the magnetic body of the former colony presumably exists also in the geometric now, being physically associated with the queen. This magnetic body could serve as the conscious entity communicating to the queen the advices and commands making possible to construct the beehive. A more conservative explanation is that these activities are genetically hardwired and instinctive (leaving open what this statement really means).

The distinguished social position and anatomy of queen are consistent with the hypothesis that queen has more massive connections than other bees with the magnetic body of beehive. For instance, it is known that the new hive is oriented in exactly the similar manner as the old. Either long term memory or passive magnetic coding of the orientation of the hive with respect to Earth's magnetic field made possible by the magnetite in the abdomen of queen could explain this.

$k_{em} = 6$ implies that also the levels $k_{em} = 4$ corresponding to ordinary EEG and $k_{em} = 5$ corresponding to short term memory are present. The colony would have sensory resolution in a time scale of a fraction of second and short term memory in minute time scale. The counterpart of EEG at the level of hive is highly suggestive and conforms with the finding that ELF magnetic fields with strengths in the range .1-1 mT ($2B_E - 20B_E$ affect honeybee dance [100] as does also the absence of Earth's magnetic field. Interestingly, 1-2 mT DC field causes epileptiform activity in the case of humans [101] (the change of the DC field used seems to be more important that the period it is applied). Could the beehive suffer a kind of epileptic seizure!

The intentional actions of the honeybee colony would be realized via magnetic flux sheets traversing the super-genes of the insects participating to the action in question. Workers, soldiers, etc.. would act to some extent as organs of the colony being connected by hyper-genes of hyper-genome to larger units. Queen could act as the analog of a complex Grand Mother neuron in brain or a leader in human society.

This view can be criticized. Honeybee dance [102] is performed by forager bees and the dance represents among other things the angle between the lines connecting hive to the food source and sun as the angle between movement of bee and vertical direction (also other options are possible). The intricate pattern of the dance in turn codes for the distance to the food source. If beehive is a conscious entity using bees as its cells, why is honeybee dance needed at all? TGD based vision about the evolution of modern human society from a bicameral society in which individuals received advice and commands from "God" [N6, N5], suggests an answer to this criticism. The society able to survive must be maximally flexible and allow maximal individual intelligence and maximal freedom of individual actions consistent with the overall goals. This requires delegation of simple tasks to lower levels meaning also that communications between individuals become necessary (the development of language and other communications parallels the transition from bicamerality to modern society in the case of humans). The communication itself might however involve also the beehive. Foreagers could be like the prophets of the bicameral society communicating in semitrance the advices of God to the colony.

It should be noticed in passing that honeybees have already earlier made a visit to TGD inspired theory of consciousness [K3]. As discovered by topologist Barbara Shipman [18], honeybee dance has a mathematical description in terms of a construct assignable to color group SU(3) of gauge interactions between quarks and gluons. This led her to propose that color interactions might have some deep role in living matter. This is in a sharp contrast to the fact that color interactions as establishment knows them are completely invisible above the length scale of $10^{-15}$ meters. The TGD based prediction that there exists an entire hierarchy of scaled up copies of QCD, in particular QCDs with confinement length scale of order cell size, changes completely the situation.

#### Honeybees as magneto-receptors of the beehive or magnetic cells as magneto-receptors of bee?

Earth's magnetic field has a crucial status in the model of living systems even at the lowest levels of dark matter hierarchy so that Earth's magnetic field is expected to play a role in the functioning of all cells, also bees and ants. This is indeed the case.

It is known that that bees have two navigation systems. The first system is based on the direction of sun and polarization of solar light but does not work on cloudy days. The second navigation system uses Earth's magnetic field and is used in cloudy days. Bees have in their abdomen magnetite ($Fe_3O_4$) particles of size about 30 nm and iron storage protein ferritin which correspond 10 to nm sized super-paramagnetic particles [103]. Magnetite particles and ferritin in principle make possible magneto-reception instead of a mere passive compass behavior.

The minimum option is that honeybee itself does not receive any neural information about the magnetic field but acts as a passive magneto-receptor of the bee colony or sub-colony (such as workers flying to the food source) and that the information contained by the receptor grid allows the sub-colony to deduce its position in the varying magnetic field. "BEEG" would mediate this information to the magnetic body of the (sub-)colony and the general mechanism based on Josephson currents does not require nerve pulse patterns to achieve this.

Since foreagers seem to act as individuals able to navigate in the magnetic field of Earth, it would seem that some cells of the honeybee could act as magneto-receptors so that the reaction of the magnetic particles would be coded to a neural signal. It has been proposed that the changes in the shape of the configurations formed by magnetite particles in a varying magnetic field induce changes in the shape of neuron and in this manner can induce neural signal. This mechanism could also induce the voltage perturbations coding the information to the Josephson current giving rise to the sensory part of EEG as a state of coherent ELF photons. Perhaps the genes expressing these neurons are activated only in foragers and ferritin makes possible the magneto-reception in this sense.

#### Social bacteria and magneto-tactic bacteria

Magneto-tactic behavior of bacteria [104] was discovered for 30 years ago by microbiologist Richard P. Blakemore and means that certain motile, aquatic bacteria orient and migrate along magnetic field lines. This ability could be purely passive compass mechanism made possible by the magnetite detected in the bacteria.

During last years we have learned that bacteria are not simple creatures having only single goal: to multiply and fill the Earth. Bacteria are able to communicate and act co-operatively [105]. This raises the question whether hyper-genes could appear already at this level and whether bacteria acting as a colony they individual bacteria could act as magneto-receptors of colony allowing it to detect even variations of the magnetic field much like individual cells in the brain of vertebrates or perhaps even in the abdomen of honeybee are believed to serve as magneto-receptors.

#### Great leaps in evolution as emergence of higher levels of dark matter hierarchy at level of individuals

The vision about large leaps in evolution led to the view that the emergence of EEG corresponds to the emergence of $k_{em} = 4$ level of dark matter hierarchy. On the other hand, the time scale of gene translation corresponds to that associated with the ordinary EEG, which would suggest that $k_{em} = 4$ level is present already at the lowest life forms. The findings about honeybees support the view that levels up to $k_{em} = 6$ at least are present but are associated with the honeybee colony rather than individuals.

Therefore a more precise formulation of the hypothesis about great leaps in evolution would be that great leaps in evolution correspond to the emergence of a new dark matter level at the level of individual organism. If this view is correct then $k_{em} = 4$ level would correspond to a collective level of consciousness in the case of invertebrates down to bacteria, which are indeed found to form societies [105]. This conforms also with the fact that the genome of invertebrates is too small to allow realization of $k_{em} = 4$ flux sheets as genes or even super-genes. The somewhat unexpected conclusion would be that all activities of invertebrates involving gene expression would be controlled by collective levels of consciousness: invertebrates would not be individuals in this sense. Viruses do not possess DNA translation machinery which is consistent with the absence of also collective $k_{em} = 4$ level. One can of course ask whether the queen of honeybee could be an exception to this rule.

This picture provides also an explanation for the universality of the genetic code would be that $k_{em} = 4$ level controls gene expression: $k_{em} = 4$ indeed corresponds to the length scale assignable to the magnetosphere of Earth.

### 3.10.3 Dark matter hierarchy, hierarchical structure of nervous system, and hierarchy of emotions

One can ask how the structural and functional hierarchy of CNS and the hierarchy of emotions relates to the dark matter hierarchy. The basic picture wherefrom one can start is following.

1. The emergence of nervous system corresponds to the emergence of $k_{em} = 3$ level of dark matter hierarchy. For instance, worms and insects would correspond to this level.

2. Vertebrates have EEG and thus the most primitive vertebrates (reptiles) should correspond to $k_{em} = 4$. $k_{em} = 7$ is the highest level for which the natural time scale is below the duration of the human life cycle but need not be the highest level present in CNS of the highest mammals.

3. The emergence of new structures need not mean the emergence of new levels of dark matter hierarchy. Rather, the most reasonable criterion for the presence of these levels is the emergence of behaviors involving long term goals and the magnetic bodies of the parts of brain assignable to the control of this kind of behaviors would correspond to higher values of $k_{em}$. Also the maximum span of memories at given level should be characterized by the value of $k_{em}$ associated with the brain structures involved (hippocampus, mammillary bodies). This picture conforms with the fact that already insects possess neurons, ganglia, and head containing the predecessor of cerebrum but correspond to $k_{em} = 3$ most naturally.

It is useful to list some basic time scales. 5 Hz frequency in EEG defines the characteristic "drum beat" associated with $k_{em} = 4$ level. The counterpart of .2 second time scale would be 6.7 minutes for $k_{em} = 5$, 9.3 days (day=24 hours) $k_{em} = 6$, and 50.7 years for $k_{em} = 7$ for $\lambda \simeq 2^{11}$.

For goal related emotions the maximal time scale assignable to the achievement of the goal might allow to identify the time scale characterizing corresponding level of dark matter hierarchy. The lowest level emotions would be "primitive" emotions not related to any goal and would be assignable to organs consisting of ordinary cells and correspond to $k_{em} \leq 2$ levels of dark matter hierarchy. Also the typical span of memories should correspond to the time scale $T(k_{em})$.

Brain has anatomic division into midbrain, hindbrain, and forebrain [66]. Midbrain and hindbrain (sometimes both are included in brain stem) is possessed by even the most primitive vertebrates and its emergence could hence correspond to the emergence of $k_{em} = 4$ level and EEG. The emergence of $k_{em} > 4$ levels relates naturally to the emergence of long term planning of motor actions in motor areas. The emergence of limbic brain, which defines the most primitive forebrain, could mean the emergence of $k_{em} = 5$ level and goal related emotions. This conforms with the fact that for mammals forebrain and cerebral hemispheres dominate whereas for other vertebrates hindbrain and cerebellum are in the dominant role.

### Reptilian brain as $k_{em} = 4$ system

Reptilian brain contains only the structures corresponding to brain stem (midbrain and hind brain, in particular cerebellum) and would thus correspond to $k_{em} = 4$ level of the hierarchy. Cerebellum is not believed to contribute directly to our consciousness and this might be true quite generally for $k_{em} = 4$ level of dark matter hierarchy (visual awareness might be an exception as will be found).

Simplest emotions correspond to emotions involving no goal. Moods like excitement, feeling good/bad/tired/strong, etc.. could represent examples of such emotions and could be experienced already by reptilians. Of course, the scaled up variants of these emotions could appear at higher levels of hierarchy and would relate to the states of magnetic bodies (degree of the quantum coherence of Bose-Einstein condensates!).

### Limbic system

Limbic system is not possessed by reptiles [68]. It is responsible for emotions, control of emotions, and also emotional intelligence. Limbic system corresponds to the brain of the most mammals. The limbic brain includes the amygdala, anterior thalamic nucleus, cingulate gyrus, fornix, hippocampus, hypothalamus, mammillary bodies, medial forebrain bundle, prefrontal lobes, septal nuclei, and other areas and pathways of the brain.

1. The sub-cortical part of the limbic system involves amygdalar and septal divisions. According to [68] amygdalar division promotes feeding, food-search, angry, and defensive behaviors related to obtaining food. Septal division promotes sexual pleasure, genital swelling, grooming, courtship, and maternal behavior. These divisions are emotional mirror images of each other hand could correspond to $k_{em} = 5$ with 6.7 minute "drum beat".

2. The cortical part of the limbic system contains cingulate gyrus which is the newest part of the limbic system and belongs to thalamo-cingulate division which promotes play, vocalization (e.g.,

the separation cry), and maternal behavior. $k_{em} = 6$ level would correspond to a "drum beat" of 9.3 days.

3. Frontal lobes [69] are often regarded as the organ of volition. The frontal lobes are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgement, impulse control, and social and sexual behavior. Prefrontal lobes representing the extreme front part of frontal lobes belong also to the limbic system and are responsible for motivation and ability to pose long term goals. This ability distinguishes humans from other primates. For these reasons frontal lobes, in particular prefrontal lobes, could involve the highest levels of dark matter hierarchy in the case of humans. $k_{em} = 7$ with a characteristic time scale of 50 years could be assigned naturally to this level.

Cortico-striatal emotions like sadness, hate, fear anger, surprise, embarrassment, happiness, contentment, and joy involve goal structures and failure or success to achieve the goal in essential manner and would involve prefrontal lobes.

$k_{em} = 7$ and even lower levels can also relate to collective levels of consciousness coded by hyper genes. Hence these emotions could also relate to goals not directly related to the fate of biological body. Mirror neurons are crucial prerequisite of social behavior (autistic children seem to lack them), which suggests that hyper genes are involved at least with them.

Social emotions (feeling embarrassed, ashamed, guilty, loved, accepted, ...) could be induced by the collective levels of dark matter hierarchy as punishments or rewards for social behavior very much like neurotransmitters are believed to provide rewards and punishments at neuronal level.

### Neocortex and two kinds of intelligences

Neocortex is often assumed to be superior ("neomammalian") part of the brain and makes the majority of brain hemispheres. The species which are considered to be highly intelligent, such as humans and dolphins, tend to have large amounts of neocortex. The amount of neocortex is roughly proportional to the brain size for primates.

Neocortex cannot correspond to $k_{em} = 7$ as a whole. The decomposition of sensory areas to layers is consistent with $k_{em} = 4$ since it is time resolution which matters in the case of sensory representations. Same conclusion applies to sensory association areas. The fine tuning of the motor control performed by cerebellum is of course consistent with $k_{em} = 4$. Intelligence understood in the conventional sense of the word is accurate, works fast, and is computer like. The part of neocortex responsible for ordinary intelligence would be a rapid and accurate processor of sensory and cognitive representations. Hence $k_{em} = 4$ would be naturally characterize sensory areas, secondary and primary motor areas, to hippocampal representation of declarative memories, and all association areas except dorsolateral prefrontal sensory-motor association cortex where short term memories are represented.

Emotional intelligence works slowly and is responsible for visions and holistic views and would thus correspond to higher levels of dark matter hierarchy. Limbic system is involved with emotions, motivation and long term planning and would thus be responsible for emotional intelligence. Indeed, the damage to frontal lobes [69] need not affect ordinary intelligence but affects emotional intelligence.

### The levels of dark matter hierarchy associated with short and long term memory

The time spans of memories should correspond to the time scales assignable to the dark matter hierarchy. According to [72], the span of other than visual short term memories is 30-45 seconds. Visual short term memories [73] representing selected features of visual field are reported to have time span of few seconds whereas so called iconic memories representing entire visual field have much shorter time span.

Visual short term memories are marginally consistent with $k_{em} = 4$ level of hierarchy since for the right brain hemisphere $T = 2$ seconds is predicted to correspond to the lowest EEG frequency. Iconic memories could also correspond to $k_{em} = 4$ level and to higher EEG frequencies.

$k_{em} = 5$ level of dark matter hierarchy corresponds to 400 second "drum beat": hence 40 seconds would correspond to 50 Hz EEG frequency by scaling so that the time span of other than visual short term memories is consistent with $k_{em} = 5$ identification. The short term memories representing stimuli to which motor system is going to respond are located in dorsolateral prefrontal sensory-motor association cortex which could thus correspond to $k_{em} = 5$.

$k_{em} = 6$ would correspond to memories whose span would have upper limit of 9 days. Scaling up of short term memory span would give span of about 1 day and this might relate to the sleep-wake-up cycle. Perhaps it is good to remember what I did during the day and that I existed yesterday! This could also relate to the fact that dreams use the memories of previous day as a material. Usually long term memories are defined as memories with a span longer than year so that few days time scale is a hopefully testable prediction. Frontal lobes are central for personality, which must based on some kind of a self narrative. Hence at least $k_{em} = 6$ should be assignable with some regions of frontal lobes.

$k_{em} = 7$ would correspond to the time scale of 50 years assignable to prefrontal cortex [70] forming part of the limbic system. Scaling from the span of short term memories would give 10 year scale. The stimulation of some regions of temporal lobes induces vivid sensory memories. Hence also temporal lobes should contain $k_{em} = 7$ regions crucial for the long term memory recall. The instantaneous communications with geometric past as a mechanism of long term memory recall involve naturally higher levels of dark matter hierarchy.

Hippocampus and mammillary bodies involved with long term memory recall are part of the limbic system. That hippocampal theta rhythm is in the range 4-12 Hz suggests $k_{em} = 4$ for hippocampus itself and that hippocampus just builds kind of bit sequence which during memory recall is communicated from the geometric past to some part of the future brain or magnetic body.

Anterograde amnesia means an inability to restore long term memories. The damage of hippocampus or of mammillary bodies can induce anterograde amnesia. In the usual conceptual framework the explanation would be the inability to store new long memories. In TGD framework this would be inability to construct those cognitive representations which are communicated to the geometric future in long term memory recall. Retrograde amnesia seems to involve almost always anterograde amnesia and means loss of memories for some time span before the injury. A possible explanation is that injury can propagate also to the geometric past of the brain quantum jump by quantum jump.

During ageing memories tend to be lost but the memories of childhood are the most stable ones. A possible interpretation is that at $k_{em} = 7$ level faster rhythms of generalized EEG tend to disappear: kind of scaled up variant for the process of falling into sleep accompanied by silencing of higher EEG bands could be in question.

**What about transpersonal levels of consciousness?**

$k_{em} > 7$ levels of dark matter hierarchy cannot relate to the biological body. They could relate to higher collective levels of dark matter hierarchy and evolution of social structures. For instance, the "god module" located to temporal lobes could correspond to $k_{em} > 7$ level of dark matter hierarchy. The memories extending over personal life span claimed by meditators could have interpretation in terms of $k_{em} > 7$ transpersonal levels of consciousness.

## 3.11 Appendix

In this appendix the generalization of the notion of imbedding space realizing mathematically the hierarchy of Planck constants is discussed and tables for cyclotron frequencies are given.

### 3.11.1 Generalization of the notion of imbedding space

Quite generally, the hierarchy of Planck constant is realized by generalizing the notion of imbedding space such that one has a book like structure with various almost-copies of imbedding space glued together like pages of book. Each page of book correspond to a particular level of dark matter hierarchy and darkness means that there are no Feynman diagrams in which particles with different value of Planck constant would appear. The interactions between different levels of hierarchy involve transfer of the particles mediating the interaction between different pages of the book. Physically this means a phase transition changing the value of Planck constant. At classical level the interactions correspond to the leakage of magnetic and electric fluxes and radiation fields between different pages of the book.

The original generalization of imbedding space was too restricted and the belief that the proposed generalization of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge turned out to be wrong. The idea was that a given page of the book like structure would correspond to an orbifold obtained from $H$ by identifying the points of $H$ obtained from each other by the action of group $G_a \times G_b$, where the factors act in $M^4$ and $CP_2$ degrees of freedom. As a matter fact, this identification implies just the opposite of fractionization if these quantum numbers are assigned with the symmetries of the imbedding space. For instance, quantization unit for orbital angular momentum becomes $n_a$ where $Z_{n_a}$ is the maximal cyclic subgroup of $G_a$.

One can however imagine of obtaining fractionization at the level of imbedding space for space-time sheets, which are analogous to multi-sheeted Riemann surfaces (say Riemann surfaces associated with $z^{1/n}$ since the rotation by $2\pi$ understood as a homotopy of $M^4$ lifted to the space-time sheet is a non-closed curve. Continuity requirement indeed allows fractionization of the orbital quantum numbers and color in this kind of situation.

### Both covering spaces and factor spaces are possible

The observation above stimulates the question whether it might be possible in some sense to replace $H$ or its factors by their multiple coverings.

1. This is certainly not possible for $M^4$, $CP_2$, or $H$ since their fundamental groups are trivial. On the other hand, the fixing of quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where $S^2$ is a geodesic sphere of $CP_2$. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ have fundamental group $Z$ since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. $H_4$ represents a straight cosmic string. Quantum field theory phase corresponds to Jones inclusions with Jones index $\mathcal{M} : \mathcal{N} < 4$. Stringy phase would by previous arguments correspond to $\mathcal{M} : \mathcal{N} = 4$. Also these Jones inclusions are labelled by finite subgroups of $SO(3)$ and thus by $Z_n$ identified as a maximal Abelian subgroup.

   One can argue that cosmic strings are not allowed in QFT phase. This would encourage the replacement $\hat{M}^4 \times \hat{CP}_2$ implying that surfaces in $M^4 \times S^2$ and $M^2 \times CP_2$ are not allowed. In particular, cosmic strings and $CP_2$ type extremals with $M^4$ projection in $M^2$ and thus light-like geodesic without zitterwebegung essential for massivation are forbidden. This brings in mind instability of Higgs=0 phase.

3. The covering spaces in question would correspond to the Cartesian products $\hat{M}^4{}_{n_a} \times \hat{CP}_{2n_b}$ of the covering spaces of $\hat{M}^4$ and $\hat{CP}_2$ by $Z_{n_a}$ and $Z_{n_b}$ with fundamental group is $Z_{n_a} \times Z_{n_b}$. One can also consider extension by replacing $M^2$ and $S^2$ with its orbit under $G_a$ (say tedrahedral, octahedral, or icosahedral group). The resulting space will be denoted by $\hat{M}^4 \hat{\times} G_a$ *resp.* $\hat{CP}_2 \hat{\times} G_b$.

4. One expects the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds $M^2$ or $S^2$. This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of $M^2$ the quantization axes for angular momentum would be replaced by the set of quantization axes going through the vertices of tedrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

5. Also the orbifolds $\hat{M}^4/G_a \times \hat{CP}_2/G_b$ can be allowed as also the spaces $\hat{M}^4/G_a \times (\hat{CP}_2 \hat{\times} G_b)$ and $(\hat{M}^4 \hat{\times} G_a) \times \hat{CP}_2/G_b$. Hence the previous framework would generalize considerably by the allowance of both coset spaces and covering spaces.

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the imbedding space to another one.

1. How the gluing of copies of imbedding space at $M^2 \times CP_2$ takes place? It would seem that the covariant metric of $M^4$ factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of $M^4$ metric can make sense. This is consistent with the identical vanishing of Chern-Simons action in $M^2 \times S^2$.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in $M^4$ degrees of freedom. This is not the case. Light-likeness in $M^2 \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset M^2 \times S^2$, where $X^1$ is light-like geodesic. The requirement that the partonic 2-surface $X^2$ moving from one sector of $H$ to another one is light-like at $M^2 \times S^2$ irrespective of the value of Planck constant requires that $X^2$ has single point of $M^2$ as $M^2$ projection. Hence no sudden change of the size $X^2$ occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunnelling. Classical non-vacuum extremals of Chern-Simons action have two-dimensional $CP_2$ projection to homologically non-trivial geodesic sphere $S^2_I$. The deformation of the entire $S^2_I$ to homologically trivial geodesic sphere $S^2_{II}$ is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that $CP_2$ projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere $S^2_I$ of $CP_2$ can be deformed to that of $S^2_{II}$ using 2-dimensional homotopy flattening the piece of $S^2$ to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) and classical light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

**Do factor spaces and coverings correspond to the two kinds of Jones inclusions?**

What could be the interpretation of these two kinds of spaces?

1. Jones inclusions appear in two varieties corresponding to $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$ and one can assign a hierarchy of subgroups of $SU(2)$ with both of them. In particular, their maximal Abelian subgroups $Z_n$ label these inclusions. The interpretation of $Z_n$ as invariance group is natural for $\mathcal{M} : \mathcal{N} < 4$ and it naturally corresponds to the coset spaces. For $\mathcal{M} : \mathcal{N} = 4$ the interpretation of $Z_n$ has remained open. Obviously the interpretation of $Z_n$ as the homology group defining covering would be natural.

2. $\mathcal{M} : \mathcal{N} = 4$ should correspond to the allowance of cosmic strings and other analogous objects. Does the introduction of the covering spaces bring in cosmic strings in some controlled manner? Formally the subgroup of $SU(2)$ defining the inclusion is $SU(2)$ would mean that states are $SU(2)$ singlets which is something non-physical. For covering spaces one would however obtain the degrees of freedom associated with the discrete fiber and the degrees of freedom in question would not disappear completely and would be characterized by the discrete subgroup of $SU(2)$.

   For anyons the non-trivial homotopy of plane brings in non-trivial connection with a flat curvature and the non-trivial dynamics of topological QFTs. Also now one might expect similar non-trivial contribution to appear in the spinor connection of $\hat{M}^2\hat{\times}G_a$ and $\hat{CP}_2\hat{\times}G_b$. In conformal field theory models non-trivial monodromy would correspond to the presence of punctures in plane.

3. For factor spaces the unit for quantum numbers like orbital angular momentum is multiplied by $n_a$ *resp.* $n_b$ and for coverings it is divided by this number. These two kind of spaces are in a well defined sense obtained by multiplying and dividing the factors of $\hat{H}$ by $G_a$ *resp.* $G_b$ and multiplication and division are expected to relate to Jones inclusions with $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$, which both are labelled by a subset of discrete subgroups of SU(2).

4. The discrete subgroups of $SU(2)$ with fixed quantization axes possess a well defined multiplication with product defined as the group generated by forming all possible products of group elements as elements of $SU(2)$. This product is commutative and all elements are idempotent and thus analogous to projectors. Trivial group $G_1$, two-element group $G_2$ consisting of reflection and identity, the cyclic groups $Z_p$, $p$ prime, and tedrahedral, octahedral, and icosahedral groups are the generators of this algebra.

   By commutativity one can regard this algebra as an 11-dimensional module having natural numbers as coefficients ("rig"). The trivial group $G_1$, two-element group $G_2$¡ generated by reflection, and tedrahedral, octahedral, and icosahedral groups define 5 generating elements for this algebra. The products of groups other than trivial group define 10 units for this algebra so that there are 11 units altogether. The groups $Z_p$ generate a structure analogous to natural numbers acting as analog of coefficients of this structure. Clearly, one has effectively 11-dimensional commutative algebra in 1-1 correspondence with the 11-dimensional "half-lattice" $N^{11}$ ($N$ denotes natural numbers). Leaving away reflections, one obtains $N^7$. The projector representation suggests a connection with Jones inclusions. An interesting question concerns the possible Jones inclusions assignable to the subgroups containing infinitely manner elements. Reader has of course already asked whether dimensions 11, 7 and their difference 4 might relate somehow to the mathematical structures of M-theory with 7 compactified dimensions. One could introduce generalized configuration space spinor fields in the configuration space labelled by sectors of $H$ with given quantization axes. By introducing Fourier transform in $N^{11}$ one would formally obtain an infinite-component field in 11-D space.

5. How do the Planck constants associated with factors and coverings relate? One might argue that Planck constant defines a homomorphism respecting the multiplication and division (when possible) by $G_i$. If so, then Planck constant in units of $\hbar_0$ would be equal to $n_a/n_b$ for $\hat{H}/G_a \times G_b$ option and $n_b/n_a$ for $\hat{H}\hat{\times}(G_a \times G_b)$ with obvious formulas for hybrid cases. This option would put $M^4$ and $CP_2$ in a very symmetric role and allow much more flexibility in the identification of symmetries associated with large Planck constant phases.

### Phase transitions changing the value of Planck constant

There are two basic kinds of phase transitions changing the value of Planck constant inducing a leakage between sectors of imbedding space. There are three cases to consider corresponding to

1. leakage in $M^4$ degrees of freedom changing $G_a$: the critical manifold is $R_+ \times CP_2$;
2. leakage in $CP_2$ degrees of freedom changing $G_b$: the critical manifold is $\delta M^4_+ \times S^2_{II}$;
3. leakage in both degrees of freedom changing both $G_a$ and $G_b$: the critical manifold is $R_+ \times S^2_{II}$. This is the non-generic case.

For transitions of type 2) and 3) $X^2$ must go through vacuum extremal in the classical picture about transition.

Covering space can also change to a factor space in both degrees of freedom or vice versa and in this case $G$ can remain unchanged as a group although its interpretation changes.

The phase transitions satisfy also strong group theoretical constraints. For the transition $G_1 \rightarrow G_2$ either $G_1 \subset G_2$ or $G_2 \subset G_1$ must hold true. For maximal cyclic subgroups $Z_n$ associated with quantization axes this means that $n_1$ must divide $n_2$ or vice versa. Hence a nice number theoretic view about transitions emerges.

One can classify the points of critical manifold according to the degree of criticality. Obviously the maximally critical points corresponds to fixed points of $G_i$ that its points $z = 0, \infty$ of the spheres $S^2_r$ and $S^2_{II}$. In the case of $\delta M^4_+$ the points $z = 0$ and $\infty$ correspond to the light-like rays $R_+$ in opposite directions. This ray would define the quantization direction of angular momentum. Quantum phase transitions changing the value of $M^4$ Planck constant could occur anywhere along this ray (partonic 2-surface would have 1-D projection along this ray). At the level of cosmology this would bring in a preferred direction. Light-cone dip, the counterpart of big bang, is the maximally quantum critical point since it remains invariant under entire group $SO(3,1)$.

Interesting questions relate to the groups generated by finite discrete subgroups of $SO(3)$. As noticed the groups generated as products of groups leaving $R_+$ invariant and three genuinely 3-D groups are infinite discrete subgroups of SO(3) and could also define Jones inclusions. In this case orbifold is replaced with orbifold containing infinite number of rotated versions of $R_+$. These phases could be important in elementary particle length scales or in early cosmology.

As already explained, the original too restricted view about generalization of imbedding space led to the idea about p-adic fractal hierarchy of Josephson junctions. Although this vision can criticized as unrealistic I decided to keep the original section discussing this idea in detail.

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

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

### 3.11.2 Em cyclotron frequencies of biologically important ions

A detailed study of the cyclotron frequencies demonstrates that they indeed seem to correspond to important EEG frequencies. The cyclotron frequencies associated with other singly ionized atoms can be obtained by the formula

$$f = \frac{A}{20} \times f(Ca^{2+}) \qquad f(Ca^{2+}) \simeq 15\ Hz\ . \tag{3.11.1}$$

Here the strength of the magnetic field is assumed to be $B_{end} = .2$ Gauss $= 2 \times 10^{-5}$ Tesla. Note that published material there was an erratic identification $B = B_E = .5$ Gauss due to the calculational error.

The following table lists cyclotron frequencies and their lowest multiples for some of the most important ions.

| Elementary particle | $f_1/Hz$ | J | $f_L/Hz$ |
|---|---|---|---|
| $e$ | $5.6 \times 10^5$ | 1/2 | $2.8 \times 10^5$ |
| $p$ | 300 | 1/2 | 419 |
| Bosonic ions | | | |
| $^6Li$ | 50.1 | 1 | 88.3 |
| $O^{2-}$ | 37.4 | 0 | 0 |
| $Mg^{++}$ | 25.0 | 0 | 0 |
| $Ca^{++}$ | 15.0 | 0 | 0 |
| $Mn^{2+}$ | 11.4 | 5/2 | 520 |
| $Fe^{2+}$ | 10.8 | 0 | 0 |
| $Co^{2+}$ | 10.0 | 7/2 | 695 |
| $Zn^{2+}$ | 9.4 | 0 | 0 |
| $Se^{2-}$ | 7.6 | 0 | 0 |
| Fermionic ions | | | |
| $^7Li^+$ | 42.9 | 3/2 | 489 |
| $N^+$ | 21.4 | 1 | 60.6 |
| $F^-$ | 15.8 | 1/2 | 395 |
| $Na^+$ | 13.0 | 3/2 | 333 |
| $Al^+$ | 11.1 | 5/2 | 546 |
| $Si^+$ | 10.7 | 0 | 0 |
| $P^+$ | 9.7 | 1/2 | 170 |
| $S^-$ | 9.4 | 0 | 0 |
| $Cl^-$ | 8.5 | 3/2 | 130 |
| $K^+$ | 7.5 | 3/2 | 58.5 |
| $Cr^-$ | 5.7 | 3/2 | 71.1 |
| $Cu^+$ | 4.8 | 3/2 | 333.9 |
| $Ag^+$ | 2.8 | 1/2 | 17 |
| $I^+$ | 2.4 | 5/2 | 420 |
| $Au^+$ | 1.5 | 3/2 | 21 |

Table 11. The first column gives cyclotron frequency in cycles per second for some ions in Earth's magnetic field assumed to have strength $B_{end} = .2 \times 10^{-4}$ Tesla. The remaining columns give spin or

nuclear spin and Larmor frequency $f_L$.

### 3.11.3 Cyclotron frequencies of exotic ions and periodic table

Exotic em and $Z^0$ ions result when some color bonds in atomic nucleus become charged and are simultaneously ordinary ions. By magnetic flux quantization $Z^0$ magnetic cyclotron frequencies differ from their electromagnetic counterparts for singly charged ions only by charge ratio factors $Q_Z/Q_{Z,0}$. Hence it is convenient to represent electromagnetic cyclotron frequencies instead. The ions in various periods correspond to bands of EEG: it seems however that satellites of the harmonics of cyclotron frequencies beta and theta bands and that harmonics of frequencies in alpha band provides a more natural explanation for gamma and higher bands. For completeness cyclotron frequencies for all periods are given although the biologically important heavy ions are rather scarce.

#### Ions in Helium period correspond to beta and gamma bands

The table below lists the relevant data about ions in He period. Cyclotron frequencies are in the range $(15.8 - 75)$ Hz for nuclear exotic ionization which respects statistics. Note that $Be$ and $N$ atoms are exceptional being fermions in ground state. $Li$ ion has rather high cyclotron frequency 42.9 Hz.

| Ion | (Z,A,S) | $f_1/Hz$ | Ion | (Z,A,S) | $f_1/Hz$ |
|---|---|---|---|---|---|
| $He$ | (2,4, F) | 75 | $C$ | (6,12,F) | 25.0 |
| $Li$ | (3,7, F) | 42.9 | $N$ | (7,14,B) | 21.4 |
| $Be$ | (4,9,B) | 33.3 | $O$ | (8,16,F) | 18.8 |
| $B$ | (5,11,F) | 27.3 | $F$ | (9,19,F) | 15.8 |

Table 12. Basic data for the ions in Helium period. Cyclotron frequency and nuclear spin for exotic ion with unit electric charge due to the charged color bond in nucleus. $F$ or $B$ tells the statistics of the electronically ionized atom (most atoms are bosons in ground state).

#### Ions in Neon period correspond to alpha band

For Neon period nuclear exotic ionization the frequencies span the range $8.5 - 15.0$ Hz: only 15 Hz cyclotron frequency of Ne belongs to beta band.

| Ion | (Z,A,S) | $f_1/Hz$ | Ion | (Z,A,S) | $f_1/Hz$ |
|---|---|---|---|---|---|
| $Ne$ | (10,20,F) | 15.0 | $Si$ | (14,28,F) | 10.7 |
| $Na$ | (11,23,F) | 13.0 | $P$ | (15,31,F) | 9.7 |
| $Mg$ | (12,24,F) | 12.5 | $S$ | (16,32,F) | 9.4 |
| $Al$ | (13,27,F) | 11.1 | $Cl$ | (17,35,F) | 8.5 |

Table 13. One can arrange the exotic ions in Neon period to one triplet of exotic ions allowing also spin flip qualia and to a quintet assigned with cyclotron qualia. For the meanings of various notations see previous table.

#### Ions in Argon period correspond to theta band

Singly ionized exotic ions in Argon period have cyclotron frequencies in the range ($3.6\ Hz < f \leq 7.5\ Hz$).

| Ion | (Z,A,S) | $f_1/Hz$ | Ion | (Z,A,S) | $f_1/Hz$ |
|---|---|---|---|---|---|
| $Ar$ | (18,40,F) | 7.5 | $Co$ | (27,59,F) | 5.0 |
| $K$ | (19,39,F) | 7.5 | $Ni$ | (28,58,F) | 5.2 |
| $Ca$ | (20,40,F) | 7.5 | $Cu$ | (29,63,F) | 4.8 |
| $Sc$ | (21,45,F) | 6.7 | $Zn$ | (30,64,F) | 4.7 |
| $Ti$ | (22,48,F) | 6.3 | $Ga$ | (31,69,F) | 4.3 |
| $V$ | (23,51,F) | 5.9 | $Ge$ | (32,74,F) | 4.1 |
| $Cr$ | (24,52,F) | 5.7 | $As$ | (33,75,F) | 4.0 |
| $Mn$ | (25,55,F) | 5.5 | $Se$ | (34,80,F) | 3.8 |
| $Fe$ | (26,56,F) | 5.4 | $Br$ | (35,79,F) | 3.8 |

Table 14. Basic data for singly charged exotic ions with frequencies in Argon period and having cyclotron frequencies in theta band.

**Ions in Krypton period correspond to delta band**

Krypton period provides an almost identical copy of Argon period. The cyclotron frequencies of Krypton band are in the range $2.3 - 3.5$ Hz.

| Ion | (Z,A,S) | $f_1/Hz$ | Ion | (Z,A,S) | $f_1/Hz$ |
|---|---|---|---|---|---|
| $Kr$ | (36,84,F) | 3.6 | $Rh$ | (45,103,F) | 2.9 |
| $Rb$ | (37,85,F) | 3.5 | $Pd$ | (46,108,F) | 2.8 |
| $Sr$ | (38,86,F) | 3.5 | $Cd$ | (48,114,F) | 2.6 |
| $Y$ | (39,89,F) | 3.4 | $Ag$ | (47,107,F) | 2.8 |
| $Zr$ | (40,90,F) | 3.3 | $In$ | (49,115,F) | 2.6 |
| $Nb$ | (41,93,F) | 3.2 | $Sn$ | (50,120,F) | 2.5 |
| $Mo$ | (42,98,F) | 3.0 | $Sb$ | (51,121,F) | 2.5 |
| $Tc$ | (43,99,F) | 3.0 | $Te$ | (52,130,F) | 2.3 |
| $Ru$ | (44,102,F) | 2.9 | $I$ | (53,127,F) | 2.4 |

Table 15. Basic data for singly charged exotic ions having [Kr] as ground state configuration. $Tc$ does not allow stable isotopes but the lifetimes of two long-lived Tc isotopes are $1.5 \times 10^6$ years and $2.1 \times 10^5$ years.

**Basic data for Xenon period**

The table below lists ions with [Xe] ground state. Note that all ions in Xe band do not have stable isotopes and it is questionable whether any biologically interesting ions are in this period. Cyclotron frequencies of singly charged exotic ions in Xenon period vary in the range $1.5 - 2.2$ Hz.

| Ion | (Z,A,S) | $f_1/Hz$ | Ion | (Z,A,S) | $f_1/Hz$ |
|---|---|---|---|---|---|
| $Xe$ | (54,132,F) | 2.3 | $Yb$ | (70,174,F) | 1.7 |
| $Cs$ | (55,133,F) | 2.3 | $Lu$ | (71,176,B) | 1.7 |
| $Ba$ | (56,138,F) | 2.2 | $Hf$ | (72,178,F) | 1.7 |
| $La$ | (57,139,F) | 2.2 | $Ta$ | (73,181,F) | 1.7 |
| $Ce$ | (58,140,F) | 2.1 | $W$ | (74,184,F) | 1.6 |
| $Pr$ | (59,141,F) | 2.1 | $Re$ | (75,187,F) | 1.6 |
| $Nd$ | (60,142,F) | 2.1 | $Os$ | (76,192,F) | 1.6 |
| $Pm$ | (61,147,F) | 2.0 | $Ir$ | (77,193,F) | 1.6 |
| $Sm$ | (62,152,F) | 2.3 | $Pt$ | (78,195,B) | 1.5 |
| $Eu$ | (63,154,B) | 1.9 | $Au$ | (79,197,F) | 1.5 |
| $Gd$ | (64,158,F) | 2.0 | $Hg$ | (80,202,F) | 1.5 |
| $Tb$ | (65,160,F) | 1.9 | $Ti$ | (81,205,F) | 1.5 |
| $Dy$ | (66,164,F) | 1.8 | $Pb$ | (82,206,F) | 1.5 |
| $Ho$ | (67,165,F) | 1.8 | $Bi$ | (83,209,F) | 1.4 |
| $Er$ | (68,166,F) | 1.8 | $Po$ | (84,209,F) | 1.4 |
| $Tm$ | (69,?,?) | ? | $At$ | (85,211,F) | 1.4 |

Table 16. Basic data for ions with having [Xe] as ground state configuration.

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# Chapter 4

# Quantum Model for EEG: Part I

## 4.1 Introduction

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

### 4.1.1 Magnetic canvas hypothesis

Very general objections against the idea that sensory, symbolic and cognitive representations are realized completely inside brain lead to the view that the magnetic flux tube structures associated with the primary and secondary sensory organs define a hierarchy of sensory representations outside brain with magnetic flux tubes serving as the canvas to which place coding by magnetic frequency generates sub-selves and associates with them various sensory, symbolic and cognitive representations by quantum entanglement.

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

MEs define the sensory projection and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size. One can say that entire magnetic body is the experiencing entity and also the ultimate motor actor. Actually the personal magnetic body decomposes to a fractal hierarchy of magnetic bodies associated with body parts and even cell nucleus has magnetic body responsible for sensory experiencing and motor control at this level. Clearly, the TGD based view about sensory representations and motor actions is a diametrical opposite of the standard view.

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

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

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

### 4.1.2 Dark matter hierarchy, sensory representations, and motor action

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

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

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

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

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

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

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

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

### Fractal hierarchy of magnetic flux sheets

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

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

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

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

### Charge entanglement as a tool of generalized motor action

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

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

### Overview about quantum control and coordination

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

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

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs

parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere.

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

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

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

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

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

### 4.1.3 General vision about EEG and ZEG

There is a wide variety of EEG and ZEG MEs involved, and one can make guesses about the functions of various MEs only if some general vision about sensory perception, motor action, and memory is available. The following assumptions summarize the most general vision achieved hitherto and consistent with the findings of Libet about strange time delays of consciousness [38, 27] discussed in [17] and [K1].

#### Overall view

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

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

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

**Basic contributions to EEG and ZEG**

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

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

2. Cyclotron frequencies generated in cyclotron transitions of dark ions.
   Dark cyclotron photons result naturally in the dropping of dark ions to excited cyclotron states at dark magnetic flux sheets. This assumption explains the findings of the pioneers of bio-electromagnetism [58]. A similar mechanism is suggested to work at the gene level and perhaps also in the intermediate length scales and the experimental findings of Gariaev [64] support this picture, in particular scaled up version of the band structure seems to be present at radio frequencies.

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

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

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

bond inside nucleus becomes charged are present. This reduces the scale of cyclotron frequencies by a factor 1/2 and leaves only theta and delta bands.

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

### 4.1.4 Emotions and cognition as sensory qualia of magnetic body

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

#### Right brain sings and left brain talks

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

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

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

#### p-Adic cognitive codes

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

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

### 4.1.5 Scaling law

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

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

## 4.2 EEG, MEG, nerve pulse and mini-potentials

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

### 4.2.1 EEG

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

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

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

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

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

### 4.2.2 MEG

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

#### SQUIDs

SQUIDs [41, 42, 35] are instruments used to measure extremely weak magnetic field in the case that the resolution needed is below the magnetic flux quantum $h/2e$ ($\hbar = c = 1$) for magnetic flux in super conductor. An important application of SQUIDs is to the measurement of the weak magnetic fields generated by brain and having strengths as weak as fT. SQUID technology has been used to detect the weak magnetic fields created by brain ($10^{-13}$ Tesla region) and quite an impressive knowledge exists about the magnetic correlates of the brain activity in ELF region [35].

A rough description of SQUIDs goes as follows.

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

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

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

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

$$\begin{aligned} LC\frac{d^2\Phi}{dt^2} &= -\tau\frac{d\Phi}{dt} - \Phi - \beta sin(\Phi) - \xi \ , \\ \beta = \frac{Li_c}{\Phi_0} \ \ , \ \ \tau &= \frac{L}{R} \ \ , \ \ \Phi_0 = \frac{\hbar}{2e} \ . \end{aligned} \tag{4.2.1}$$

Here $\xi$ denotes the white noise contribution to the Josephson current. $\Phi$ is measured in units of $\Phi_0$ and in the equation above $\Phi$ denotes the deviation of $\Phi$ from an integer multiple of $\Phi_0$. The equation is obviously invariant under the symmetry $\Phi \rightarrow \Phi + n2\pi$. $i_c$ denotes the critical current for which the super current in the circuit becomes dissipative. Usually also an additional external current guaranteing a slight over-criticality is added. If the inertial term proportional to $LC$ can be made small, the system rapidly dissipates to equilibrium configuration. For small deviations of $\Phi$ from a valued corresponding to a quantized magnetic flux system indeed exhibits stochastic resonance [36].

### Magnetic fields associated with brain activity

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

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

The simplest hypothesis is that far-away radiation fields decompose into MEs propagating in the radial direction. In TGD based model of EEG, brain is in electromagnetic bath provided by 'free' ELF MEs moving along the surface of cortex with the velocity of nerve pulse, and generating electromagnetic responses which decompose in far-away region into MEs propagating into the radial directions. In the induction region more complex flux quanta are possible. The criterion for the radiation region reads as $r \geq \sqrt{\lambda L}$ and relates the distance $r$ between observation point and source, the size $L$ of the source region, and the wavelength. For a point like source this criterion holds everywhere.

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

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

### 4.2.3 Nerve pulse

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

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

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

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

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

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

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

### 4.2.4 Miniature postsynaptic potentials

Miniature postsynaptic potentials have quantized amplitude of order .5 mV to be compared with the value of the rest potential, which is roughly 100 times larger [38]. Miniature potentials are generated in the postsynaptic neuron, when it has received nerve pulse. The quantized packets of neurotransmitters such as ACh give rise to the emission of miniature potentials. According to [38] miniature potentials might consist of superpositions of much smaller micro-potentials of amplitude of order .3 $\mu V$ generated by single neurotransmitter molecule. One could however consider also the possibility that the minimum size for the quantized packet of neurotransmitter is dictated by the requirement that the packet is able to generate the mini-potential.

## 4.3 Summary about TGD based view about qualia

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

### 4.3.1 Non-geometric qualia and thermodynamics

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

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

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

in the direction of the subjective time. Super-canonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

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

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

#### What kind of qualia could emotions correspond?

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

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

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

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

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

   The objection is that the entropy of sub-self is expected to increase as sub-self ages so that this kind of emotions would be always negatively colored. The notion of number theoretic negentropy based on p-adic variants of Shannon entropy is however non-negative in general and could increase of decrease as the size of the ensemble determined by quantum jumps increases. It is however not obvious whether it is sensible to assign this kind of entropy to ordinary statistical ensemble.

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

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

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

### Kinesthetic qualia defined by generalized forces

p-V pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. The increments of maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define this kind of qualia. The increments of four-momentum code for the sensation of force whereas the increments of orbital angular momentum code for the sensation of torque. Spin flip could code for something else. Tactile senses such as pressure sense and their generalizations involve kinesthetic qualia. The increment of energy or equivalently, increment of frequency, can be identified as correlate for hearing in generalized sense responsible for the dynamical nature of auditory experience (hearing is time-like version of force sense). In TGD based model of auditory experience hearing relates to $Z^0$ magnetic spin flip phase transitions for cognitive neutrino pairs.

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

### Generalized chemical qualia

$\mu - N$ pair corresponds to 'objective existence' defined by quantum histories and $N$ is generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. Quite generally, super-canonical and quaternion conformal super algebras should define these qualia and the number of these qualia is very large.

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

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

iii) For super canonical qualia the number of Bose-Einstein condensed 'configuration space photons' having nontrivial dependence on configuration space degrees of freedom replaces number of molecules. The condensation rates for the numbers of the configuration space photons with non-vanishing color quantum numbers could be interpreted as correlates of color qualia whereas the condensation rates for color singlet configuration space photons could relate to the intensity of color sensation. The capacitor model of sensory receptors however allows any colored particles as realizers of color vision.

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

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

#### Boolean qualia

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

A general model for abstraction process, not only explains the basic numbers of the genetic code, but also suggests an entire hierarchy of codes [L1] in accordance with fractality of TGD Universe. The next code in the hierarchy is very attractive candidate for 'memetic code'. The hypothesis predicts correctly the .1 second time scale for the duration of 'our' self (immediate short term memory, duration of psychological moment). Memetic codewords corresponds to sequences of 126 bits with duration of one millisecond: this time scale is somewhat shorter than the time scale of nerve pulse and it is quite possible that membrane oscillations induced by $Z^0$ MES are responsible for the representation of the memetic codewords. Sounds are indeed transformed to membrane oscillations in the auditory receptors. Real and p-adic variants of anti-neutrinos might realize symbolic and cognitive representations [M2].

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

### 4.3.2 Geometric qualia and zero modes

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

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

### 4.3.3 Place coding by cyclotron frequency scale

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

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

### 4.3.4 Capacitor model for sensory qualia of biological body

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

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

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

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

1. During nerve pulse various ions flow between cell interior and exterior, which suggests that sub-neuronal sensory qualia are generated in a time scale of a millisecond. Also membrane oscillations might give rise to some kind of sensory qualia. In particular, super-conducting Cooper pairs and bosonic ions enter or leave the Bose-Einstein condensates at the magnetic flux tubes and

this should give rise to a chemical experience defined by the quantum numbers of the carrier particle. Not only the increment of electric charge but increments of magnetic quantum numbers characterize the qualia in question. Various information molecules transferred through the cell membrane could also give rise to sensory qualia.

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

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

## 4.4 EEG and sensory canvas hypothesis

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

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

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

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

Dark matter hierarchy correspond to a hierarchy of values of Planck constant coming as $\hbar = \lambda^k \hbar_0$, $k = 0, 1, 2, ...$ $\lambda \simeq 2^{11}$ is integer and and its harmonics and sub-harmonics cannot be excluded. In fact, the model for the quantization of Planck constant allows all integer scalings of $\hbar$ but number theoretical arguments favor products of arbitrary power of two multiplying product of different Fermat primes characterizing polygons constructible only ruler and compass [A9]. Hence only $\lambda = 2^k$ can define fractal hierarchies for the preferred values of Planck constant. Furthermore, $\lambda = 2^{11}$ corresponds to a fundamental constant in TGD Universe.

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

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

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

*1. Cerebellar, retinal, and cortical rhythms*

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

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

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

2. The micro-tremor of retina corresponds to 80 Hz frequency and would relate naturally to 40 Hz thalamocortical resonance frequency if the magnetic field in question corresponds to transversally scaled down magnetic flux sheets having $k = 167$ instead of $k = 169$. Note that $k = 167$ corresponds to the Gaussian Mersenne $(1+i)^{167} - 1$.

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

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

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

The spin flip frequencies in EEG range (see the table 4) are $f_s(Cl) = 82$ Hz and $f_s(Rb) = 81$ Hz (80 Hz micro-tremor in retina); $f_s(K) = 39$ Hz and $f_s(Y) = 41$ Hz (both very near to 40 Hz thalamocortical resonance frequency); $f_s(Ag) = 34.2$ Hz, $f_s(Rh) = 26.6$ Hz (27 Hz resonance frequency in dog's cortex); $f_s(Ir) = 17$ Hz (narrow band in EEG [47]), $f_s(Au) = 14$ Hz (the sleeping spindle frequency).

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

*3. p-Adic length scale hierarchy as abstraction hierarchy*

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

*4. Objection against p-adic evolutionary hierarchy*

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

1. According to [40], the wake-up EEG of infants before 3 months age consists of 'fast' background activity. At three months posterior delta rhythm appears at 3-4 Hz and gradually shifts to 6-7 Hz during the first life year. According to [41], binding related 40 Hz oscillations are evident at the age of 8 months. Also the contrast sensitivity of vision improves rapidly to adult level at this age: this conforms with the hypothesis that EEG is essential for the construction of the sensory representations.

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

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

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

The work of Jaynes inspires the idea about child as a small bicameral nursed by the higher collective levels of consciousness. The location of the sensory motor and alpha rhythms in theta band could indeed be seen as an indication for a kind of magnetic nursery provided higher level magnetic selves and their presence would not corresponds to the infant's consciousness but to the consciousness of the "magnetic nurse". Rather interestingly, according to Jaynes [35] sitting in mother's lap can induce EEG in infants not possessing stable EEG yet. An interesting question is whether mother's EEG shows a correlation with that of infant and whether it deviates from ordinary EEG in theta band.

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

### 4.4.3 EEG rhythms in contrast to evoked and event related potentials

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

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

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

### 4.4.4 Coherence of EEG and sensory canvas hypothesis

If the EEG measured at skull relates closely to the sensory representations, it must inherit high coherence from the high coherence of the sensory landscape. Also fractal like hierarchy is predicted. At higher frequencies associated with sensory representations in shorter length scales, coherence should be restricted in shorter range. Indeed, according to [47], 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 [47], very complex structures of coherence in bands around 3, 5 and 7 Hz and 13, 15 and 17 Hz are definitely inconsistent with simple dipole models for the generation of EEG patterns. The findings are however consistent with the view that several distant regions of cortex can project features to the same point of a sensory map and that the coherence reflects the coherence of the sensory map. Coherence regions could naturally correspond to the objects of the perceptive field. The high coherence in the band $4-5$ Hz during mental calculations [47], 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 [47], also increase of coherence between prefrontal and posterior cortical association areas have been reported during working memory retention in the range $4-7$ Hz.

The coherence lengths for EEG inside cortex are generally much shorter and complex patterns are encountered. Coherence length of order 2 cm is associated with cortical EEG structures which Freeman introduces as basic units of EEG activity [36] and calls mesoscopic level of sensory processing. Note that also retina has same size as the mesoscopic structures. Perhaps it is not accident that this length scale corresponds to the highest ionic cyclotron frequencies in Helium period.

### 4.4.5 EEG synchrony

The place-coding hypothesis differs from binding by EEG synchrony hypothesis. The experiment carried out by Revonsuo originally deviced to test the binding hypothesis in fact supports the place-coding hypothesis. The interpretation for 40 Hz EEG frequency inspired by the binding hypothesis is as a synchronizing frequency necessary for the generation of unified percepts. This hypothesis has been studied using auto-stereograms [39]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when auto-stereogram was experienced as a set of random dots as compared to the situation when it was perceived as a coherent, symmetrical gestalt. The situation was same also in 8-13 Hz and 13-20 Hz beta bands. The finding is consistent with the place coding hypothesis.

On the other hand, when the conscious percept was transformed from a random set of points to a coherent gestalt, there was a detectable increase in 40 Hz power in the occipital and right posterior sites for EEG electrodes in a time window 500-300 ms before the unified percept was reported. No increase of power in beta bands was detected: this might be due to the fact that the widths of the measured bands are much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [47]. Note that in the model for a hierarchy of EEGs based on dark matter hierarchy beta band correspond to data communicated to the magnetic body [M3].

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

If the response is realized as a negative energy signal from the magnetic body to the geometric past, the time lapse due to the propagation of the sensory signal to the magnetic body is compensated since the negative energy signal travels to the geometric past. In this case the time lapse of 300-500 ms would correspond to the time it takes for the cyclotron phase transition at the magnetic body to occur so that the time lapse would not provide estimate for the distance to the magnetic body. The frequency scale of 40 Hz would suggest that the length scale involved is about $.75 \times 10^7$ m whereas 3 ms lapse would imply a length scale of $.5 \times 10^8$ meters if only positive energy signals are involved.

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

### 4.4.6 Narrow EEG bands and sensory canvas hypothesis

Sensory canvas hypothesis predicts the existence of narrow EEG bands corresponding to the magnetic transition frequencies varying in the range determined by the thickness range for the magnetic flux tubes involved with the sensory representation. The most natural candidates for the magnetic transition frequencies are cyclotron frequencies and their harmonics. There is indeed evidence for this kind of bands [47].

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

2. Besides alpha band Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as sub-bands at 13, 15 and 17 Hz in beta band [47]. That beta disappears when eyes are closed conforms with the interpretation of these bands as being associated with sensory communications to the magnetic body. Hence these bands might be associated with the assignment of cognitive features to the points of the sensory canvas. Indeed, the evolutionary hierarchy sensory representations→ cognitive representations→ long term memories involving time like entanglement and making possible historical self, suggests this.

3. 40 Hz band has a width of about 8 Hz, contains several cyclotron frequencies, is associated with the primary sensory areas and disappears during sleep. This suggests that also this band is involved with the projection of the sensory qualia to the sensory canvas. The information about narrow sub-bands of EEG during hypnagogic states (the state between wake-up and sleep involving sensory hallucinations), during the schizophrenic hallucinations and hallucinations generated by sensory deprivation, and during lucid dreaming could provide interesting constraints on the possible sensory quale-EEG frequency correlations.

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

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

### 4.4.7 Propagating and standing EEG waves

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

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

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

1. It is very natural to assume EEG MEs connecting brain to the magnetic body are transversal to the cortex. If this is the case the effective propagation of EEG wave could be a purely kinematical effect due to the transverse propagation of constant phase surfaces along cortex. The mechanism would be same as in the case of transversal $W$ MEs inducing propagating physiological waves. For instance, $Ca^{+2}$ have extremely wide velocity spectrum and they play a key role in the bio-control. They could also have a key role in the realization of non-episodal long term memories as classical communications from the geometric past. This mechanism is the my recent favorite.

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

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

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

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

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

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

### 4.5.1 Fractal hierarchy of Josephson junctions

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

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

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

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

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

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

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

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

3. $k_{em} = 2$ would correspond to layers of thickness 2+2 cm and structures with size smaller than 80 m. Obviously genuinely dark level is in question now. The layers of this Josephson junction could be assignable to left and right halves of central nervous system. The interpretation in terms of dark matter around the magnetic body of organs suggests also itself. $k_{em} = 3$ corresponds to the emergence of double layered dark matter structures of thickness 40+40 m and size scale below 160 km. Now dark matter condensed around magnetic bodies of magnetic bodies of organs could be in question.

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

#### Fractal hierarchy of Josephson junctions and EEGs

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

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

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

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

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

The frequency of $V_1$ is represented as a period of periodic multiplicative modulation of the $V_0$. $J$ itself is not periodic. There is however a periodicity with a period $T = n/f$, where $f$ is frequency of $V_1$ for $f_J = mf/n$. There are two interesting limits. For $f_J^1 = 2eV_1/2\pi\hbar \gg f_J$ amplitude $V_1$

is represented as frequency since in reasonable approximation frequencies $f_{\pm} = f_J \pm f_J^1$ dominate. Second limit corresponds to $f_J^1 \ll f_J$. In this case the dominating frequencies are $f_{\pm} = f_J \pm f$

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

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

The reactions of the Josephson junctions corresponding to different p-adic length scales $k = 151, ..., 169$ (if really present!) to external electric field are different due to $V_1 \propto L(k) \propto 2^{(k-151)/2}$ proportionality and independence of $V$ on $k$.

*2. Thermodynamical considerations*

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

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

*3. Josephson frequencies*

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

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

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

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

The magnetic bodies involved include the magnetic body associated with biological body, presumably that associated with $k_{em} = 2$, magnetic body of Earth for $k_{em} = 4$, magnetic body associated with plasma sheet at night side of Earth's magnetosphere, the magnetic body of Sun for $k_{em} = 6$ and that of solar system for $k_{em} = 7$. Note however that the endogenous magnetic field is $B_{end} = .2$ Gauss and relates to $B_E = .5$ Gauss by a scaling factor. This suggests that personal magnetic bodies in the hierarchy interact with the astrophysical magnetic bodies but are not identical with them.

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

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

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

### What is the precise value of $\lambda$?

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

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

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

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

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

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

### Josephson frequencies for various levels of dark matter hierarchy

The following tables list the Josephson frequencies for doubly charged current carriers for the levels of dark matter hierarchy corresponding to $k_d = 0, ..., 7$ using the value .08 V/m for the resting potential for $\lambda = 2^{11}$.

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

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

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

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

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

### 4.5.2 What is EEG made of?

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

**Basic contributions to EEG and ZEG**

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

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

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

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

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

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

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

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

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

changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control.

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

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

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

#### Classification of cyclotron frequencies

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

1. Cyclotron frequencies can be classified those associated with atomic and molecular ions. For biologically important atomic ions most frequencies are above 7.5 Hz. For molecular ions frequencies are lower and for DNA sequences the frequencies are in delta band. Thermal stability condition suggest a lower bound of $\sim 1$ Hz for significant frequencies of this kind. Thus it would seem that delta band dominating during deep sleep corresponds to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions.

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

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

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

#### Wake-up EEG

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

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

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

3. Beta band is above 12 Hz and associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous. The natural interpretation is as large amplitude satellite of alpha band involving the activation of communications to the magnetic body and large control signals with $f_J^1 \gg f_c$. Hence the spectra would for a considerable part of period $1/f_c$ effectively consist of frequencies $f_\pm = f_J \pm f_J^1$, where $f_J^1$ varies in frequency range characterized by the amplitude of perturbation. There is no definite resonance frequency since $\omega_1^J$ can vary continuously. Globally the situation is different since the spectrum can in principle be decomposed to frequencies $f_J \pm nf_c$. These two descriptions correspond to time domain and genuine frequency domain.

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

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

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

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

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

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

### Satellites exist as mirror pairs

The existence of the mirror satellites might be regarded as a killer prediction. Amazingly, narrow EEG bands which are mirror images of each other with respect to alpha band have been reported [47]. 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 [47]. All these frequencies are expressible in the form $f_c \pm f_J$, $f_J = 5$ Hz, which is one half of the frequency 10 Hz of the memetic code and by 14 per cent higher than 3.7 Hz predicted assuming $\lambda = 2^{11}$. The value of $\lambda$ deduced from these frequencies would be $\lambda = 1902$ and about 7 per cent smaller than $\lambda = 2^{11}$. This discrepancy cannot be taken too seriously since it is quite possible that the thickness of Josephson junction is not scaled up completely exactly.

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

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

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

### Alpha band dominance during relaxed state

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

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

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

### EEG during sleep

The EEG during sleep [40] provides a testing ground for the proposed anatomy of EEG. Sleep consists of 90 + 90 minute periods of NREM and REM sleep. This period is also the period of brain hemisphere dominances during wake up and day dreaming occurs with the same period as REM sleep. During REM sleep the EEG is essentially similar to that during wake-up. These observations inspire the hunch that brain hemisphere dominance dictates whether REM or NREM is in question. This turns out to be a correct guess.

*1. EEG during stage 1*

During stage 1 theta of deep sleep [40] waves in frequency range 4-8 Hz dominate and amplitudes increase when frequency is reduced. The control signals from magnetic body are expected to be weak so that $f_J^1 < f_J$ approximation should hold true implying that frequencies $f_J \pm f_c$ should dominate and EEG would look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/\omega_c$ and thus increase with decreasing $\omega_c$. The fact that amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

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

*a) Two manners to quantize magnetic flux*

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

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

1. The quantization of magnetic flux reads as $Ze \int BdS = n\hbar$ and for Cooper pairs and bosonic ions with $Z = 2$ ($Z$ refers to the absolute value of charge) it gives magnetic field strength which

is one half from that for fermionic singly charged ions. Both fermionic ions with $Z = 1$ and bosonic ions and Cooper pairs with $Z = 2$ are allowed in this case by the single valuedness of wave functions. For $Z = 2$ the quantization condition allows single valued wave functions for $Z = 2$ ions or Cooper pairs only.

2. Assume the quantization condition corresponds to $Z = 1$ for the right hemisphere and $Z = 1$ for the right hemisphere. The presence of fermionic ions implies additional cyclotron frequencies on left hemisphere and the presence of fermionic ions conforms with the old proposal that fermionic Fock states provide a realization of quantal version of Boolean algebra. This conforms with the view that left brain is more reductionistic and performs linear logic operations whereas right brain is more holistic.

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

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

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

*b) Exotic ions as a resolution of the problem?*

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

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

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

*2. EEG during stage 2*

Sleep spindles appearing in the state 2 of deep sleep are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [49]. The spindles .5-.1.5 seconds and appear with a period of about minute. In some sources frequency range 7-16 Hz is given as sleeping spindle range. The so called K-complexes are sudden increases in EEG amplitude but no change in frequency.

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

*3. EEG during stages 3 and 4*

Most of EEG power during deep sleep stages 3 and 4 is in the range .75-4.5 Hz [40]. This implies that control signals at cyclotron transition frequencies of ions from the magnetic body cannot be appreciably present and the control signals at cyclotron frequencies of molecular ions, such as DNA with cyclotron frequencies below 1 Hz, should be responsible for the EEG. The small amplitude of control signal implies $1/f_c$ behavior and large amplitude as compared to the corresponding amplitudes at higher bands at weak amplitude limit.

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

*5. EEG during sleep and sensory canvas hypothesis?*

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

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

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

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

## 4.6 Emotions, cognition, and EEG

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

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

### 4.6.1 Some aspects of emotions

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

#### Emotions and information

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

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

#### Emotions as higher level qualia?

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

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

#### Emotions are whole body feelings

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

#### Could Josephson radiation to the magnetic body generate emotions?

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

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

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

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

There is quite recent finding that the sensation of movement is generated by the intention to move rather than by the real motion of body part itself [25]. The explanation would be that the sensation of movement is a somatosensory of magnetic body about its own motion (the interference patterns for Josephson radiation from the body are changed and therefore also cyclotron transition patterns). The communication-control loop between magnetic body and biological body would guarantee that the two movements correspond to each other. This interpretation would provide also a new view about dreams and hallucinations.

### 4.6.2 The coding of pulse patterns to Josephson current

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

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

#### Right brain sings, left brain talks

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

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

1. *Right brain sings*

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

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

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

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

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

The basic prediction is that the analysis of rhythm and pitch are not separate brain functions and assignable to left *resp.* right hemisphere as one might think first. There is indeed evidence that the patterns of pitch and duration are analyzed by same brain regions and that right hemisphere is more involved [24].

*2. Left brain talks*

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

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

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

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

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

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

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

The two representations would not correspond to the auditory experience as such but to the emotional and cognitive responses to it. Critical reader can of course wonder why left and right magnetic bodies could experiences also the sounds directly.

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

### Realization in terms of postsynaptic potentials

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

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

Music metaphor encourages however to think that it is $\Delta f_J$ which is experienced as a tone rather than $f_J$. If this is the case, then the fundamental frequency would correspond to some minimum deviation $\Delta f_0$ and the notes in the octave to rational multiples of $\Delta f_0$. During music experience the tonic of the scale is remembered all the time even in the case that the scale is modulated temporarily. This suggests that fundamental is represented all the time in some sense. This situation is achieved if the reference value $f_{J,0}$ of $f_J$ corresponding to $\Delta f = 0$ is also communicated to the magnetic body. Music metaphor encourages to think that $f_{J,0}$ is not experienced consciously since it corresponds to infinitely low pitch.

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

### Concrete models for the place coding

Consider now a concrete models for the place coding. Let $x$ define a longitudinal coordinate of the magnetic flux sheet. Suppose that $f_J$ is mapped to a point $x = x_0$ with magnetic field $B_0$. The simplest assumption is that the magnetic field depends on $\Delta x$ via a power law: $\Delta B = -B_1 y$, $y = \Delta x/\Delta x_0$. This implies that $\Delta f_J$ and $y$ relate as $\Delta f_J \propto y$. This implies that scaling of $\Delta f_J$ by a factor 2 implies corresponding scaling of $y$. The scaling by $2^{-n}$, $n \to \infty$ corresponds to $y = 0, \Delta f_J = 0$.

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

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

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

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

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

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

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

### 4.6.3 Music as a language of emotions

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

#### Music metaphor

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

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

#### Rhythm and pitch

Both rhythm and harmony are important in music. Rhythm corresponds to the time domain and pitch to frequency domain and these aspects relate to each other like signal and its Fourier transform. Hence one might think that right brain analyzes the pitch and left brain the rhythmic aspects. TGD based model predicts that this is not the case and there is experimental evidence supporting this conclusion [24]. Left brain would use instead of piecewise constant frequencies modulated frequencies with standard modulation patterns to produce sequences of generalized phonemes instead of singing.

#### Harmonic equivalence of octaves and 2-adic fractality

The scaling of the fundamental frequency by a factor 2 does not change its harmonic character. This encourages to think that p-adic length scale hypothesis ($p \simeq 2^k$, $k$ integer) is involved at a level of dark matter hierarchy corresponding to the typical time scale of music. Multi-p-fractality involving $p = 2$ and some other primes would be thus involved. 2-adic fractality means approximate 2-adic continuity and smoothness and implies that space-time surface at points $x$ and $x + 2^n$ is very similar. If also the local geometry of the magnetic body besides the cyclotron frequency is relevant for the musical experience besides the frequency alone harmonic equivalence of octaves could be understood. In the model for representations of duration and pitch patterns to be discussed below parallel magnetic flux sheets would correspond to different octaves by 2-adic fractality.

### Rational music scales and 2-adic fractality

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

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

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

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

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

$$\begin{array}{lllllllll} \textit{major} & 1/1 & 9/8 & 5/4 & 4/3 & 3/2 & 27/16 & 15/8 & 2/1 \ , \\ \textit{upwards minor} & 1/1 & 9/8 & 6/5 & 4/3 & 3/2 & 27/16 & 15/8 & 2/1 \ , \\ \textit{downwards minor} & 1/1 & 9/8 & 6/5 & 4/3 & 3/2 & 8/5 & 9/5 & 2/1 \ . \end{array}$$

The interpretation in times of multi-p-adicity involving primes 2, 3, and 5 could be considered. The difference between major scale and minor scale is that major scale involves only 2 and 3 in denominators and is in this sense simpler. This and the somewhat naive character of the major scale suggest that minor scale is in some sense more information rich and expressive. This view is supported by the following information theoretic argument.

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

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

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

### Harmony and dissonance

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

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

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

#### Absolute ear

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

Musicians with absolute ear can even decompose sounds that are usually regarded as a noise to a collection of notes with well-defined pitches. Obviously absolute ear means a well-developed ability of some part of brain to perform a Fourier analysis for the incoming sounds. It is known that the temporal planum part of the cortex is much more developed on the left side than on the right side for people with absolute ear [26]. The larger size of left temporal planum correlates also with right-handedness so that "absolutists" might be more strongly righthanded than usual. The increased size of the left temporal planum is also involved with reading: people with dyslexia tend to lack temporal planum asymmetry [27].

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

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

### 4.6.4 p-Adic cognitive representations at EEG frequencies

The upper levels of dark matter hierarchy could control lower levels by inducing modulations of Josephson frequency slow in the time scale characterizing the Josephson frequency of the level in question and scaling as $1/\lambda^k$. For a given magnetic fields cyclotron time scale does not depend on the level. Depending on modulations speech or music like Josephson radiation would result.

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

### p-Adic cognitive codes

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

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

### p-Adic time scales

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

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

p-Adic time scales are in principle quite independent of cyclotron frequencies and EEG frequencies are in principle quite independent. It is possible to imagine a resonant coupling with cognitive code with characteristic duration with Josephson radiation at corresponding frequency but in the case of the cognitive representations this would spoil the representation and one must assume that the duration of bit is longer than the cyclotron time scale involved.

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

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

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

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

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

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

**Table of p-adic time scales in EEG range**

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

| $k_{eff}$ | $k$ | $\tau/ms$ | $f/Hz$ | $\tau_b/ms$ | $f_b/Hz$ |
|---|---|---|---|---|---|
| 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 $\tau$ of the codon and corresponding frequency $f$, as well as the duration $\tau_b$ 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.

**Are phonemes represented by a code?**

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

*1. Memetic code?*

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

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

2. The duration of bit should be longer than the time scale of cyclotron frequency. This excludes EEG frequencies from consideration unless one is satisfied with only few signifying bits. At $k_{em} = 3$ level of hierarchy the situation changes. The Josephson frequency would be $f_J(3) = \lambda f_J(4)$ and from $f_J(4) = 5$ Hz equal to $\simeq 10^4$ Hz. This would allow to regard memetic code as a slow modulation of the scaled up EEG frequencies. Alpha band is scaled up to $2 \times 10^4$ Hz if the magnetic field strength on flux sheets in question is $B = \lambda B_E \simeq .1$ Tesla. Note that the upper limit for audible frequencies is $2 \times 10^4$ Hz.

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

*2. Genetic code?*

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

**2-adic psychophysics?**

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

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

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

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

### 4.6.5 Biological body as an instrument of cognitive and emotional expression

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

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

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

2. Could peptides be involved with the modification of the membrane voltage inducing the modification of Josephson frequencies and modifying thus sensory representations at the magnetic body? Peptides act also as neurotransmitters. Neurotransmitters quite generally lead to a local modification of the postsynaptic membrane resting potential by inducing discrete micro- and miniature potentials having interpretation in terms of a discrete scale analogous to music scale. This modification of Josephson frequency would in turn be coded to the change of the position

at which Josephson radiation generates cyclotron transition at the magnetic body. The modification of the membrane potential is rather small and could relate to the so called miniature and micro-potentials involved with the nerve pulse generation.

All biological information molecules could induce similar modifications of the membrane potential affecting the sensitivity of nerve pulse generation and assigning to the neuron a position at the magnetic flux sheet so that magnetic bodies would carry somatosensory maps about the state of the multi-neuron system. For instance, alert-rest dichotomy would directly correspond to the reduction-increase of the membrane voltage from the resting value (depolarization-hyper-polarization).

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

## 4.7 Scaling law

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

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

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

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

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

The classical fields associated with MEs are expected to code information about the contents of conscious experience at various levels of self hierarchy. EEG represents one level in this hierarchy. This coding is crucial for the realization of declarative memory as classical communications from the geometric past. p-Adic length scale hypothesis to estimate how wide the range of frequencies responsible for coding information about conscious experience at given level of self hierarchy is. The model makes a prediction for the number of EEG harmonics representing information about conscious experience at a given level of self hierarchy, and suggests a general law telling what transition frequencies correlate with experiences conscious-to-us.

#### Relationship between self size and EEG frequency

Scaling law in its basic form reads as

$$
\begin{aligned}
v &= \lambda f \ , \\
L &= \lambda \ . \qquad (4.7.1)
\end{aligned}
$$

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

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

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

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

*1. Ordinary states of consciousness and scaling law*

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

A stronger hypothesis making sense for ordinary states of consciousness encouraged by the empirical data [47] is that apparent phase velocity is actually equal to the conduction propagation velocity of the nerve pulses in the neural pathway involved:

$$v = v_{cond} \ . \tag{4.7.2}$$

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

*2. Transpersonal states of consciousness and scaling law*

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

1. The first guess was that transpersonal states of consciousness correspond by $L = v/f$ law super-luminal effective phase velocities $v = c^2/V > c$ associated with the Lorentz boosts of

time-like soliton sequences. The soliton sequences can be assigned with the possible existing Josephson junction structures connecting parallel super-conducting magnetic flux tubes. The potential differences associated with the junctions are extremely weak and correspond to the EEG frequencies via the formula $\omega = eV$.

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

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

Memory circuits could be also indirectly responsible for the generation of long term episodal memories. It is indeed known that removal of these structures leads to a loss of, say, hallucinations induced by say LSD [33]. In [H4] the mechanism of synesthesia is discussed with the cautious conclusion that the activity in the hippocampal region indirectly induces the generation of long term episodal memories. The over-activity in the memory circuits would induce a "starvation" in certain cortical regions. In order to get metabolic energy these starving regions would apply buy now-let others pay mechanism and generate negative energy MEs inducing a time-like entanglement with the geometric past and a sharing of mental images resulting in episodal memories.

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

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

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

1. For a given p-adic length scale $L(k)$ the self sizes between $L(k)$ and $L(k_{next})$ contribute to the experiences about that level. $v = Lf$ law in turn allows to estimate for a given fundamental transition frequency $f$ how many harmonics contribute to the classical field of ME in question at level $k$. The number of harmonics determines the maximum information content of the experience generated by the classical signal carried by ME at that level.

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

$$L(k_{min}) \leq \frac{v_{cond}}{f} \quad . \tag{4.7.3}$$

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

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

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

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

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

Communication between different levels of p-adic hierarchy means mapping of various functions representing sensory information from a given level $p$ to another level $p_1$. The obvious manner to realize this mapping is simply to scale by the ratio $p_1/p = 2^{(k_1-k)/2}$. Music piece is transposed to $(k_1 - k)/2$ octaves higher. For instance, actual EEG pattern corresponding to virtual motor activity would be simply its fractally scaled version containing virtual nerve pulse pattern as a repeated command ( *'Do this- do this-...'*). It is known that motor neurons indeed serve as low pass filters [34] noticing only low frequencies and this might correspond to this kind of fractality. Unconscious fine structure of motion could result from unconscious-to-us processing by this kind of fractal scaling. This kind of temporal scaling fits nicely with the paradigm of 4-dimensional brain.

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

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

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

$$\frac{v}{f} \in [L(k), L(k_{next})] \ . \tag{4.7.4}$$

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

$$\frac{v_1}{v_2} = \frac{L(k_1)}{L(k_2)} \ , \tag{4.7.5}$$

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

It is possible to make definite estimates about conscious qualia for given species using information about nerve pulse velocities involved and about brain size. There is indeed some evidence for the correlation between brain size and inverse of the peak frequency of EEG [47]. For instance, it is known that in the case of dog intracranial phase velocities of alpha waves are in the range $.3-1.2$ m/s [47]. These data suggests that the sizes of alpha wave selves for dog are in the range $3-12$ cm so that dog's alpha consciousness would correspond to $L(197)=8$ cm, which is the length scale associated with single brain hemisphere for humans. The result supports the view that the sizes of self correlate with brain size. Large animals like whales could have in ordinary wake-up state sensory input from p-adic length scales above $L(199)$ [$L_3(67)=32$ cm, $L_2(101)=45$ cm, $L_2(103)=180$ cm].

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

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

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

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

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

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

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

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

The range for nerve pulse conduction velocities associated with EEG waves does not correspond to the entire range of nerve pulse velocities in somatosensory system ranging from .5 m/s to 120 m/s [34]. Thus our brain anatomy could allow much wider spectrum of sizes for mental images than allowed by the rather narrow range $3-14$ m/s of propagation velocities for alpha waves.

Nerve pulse conduction velocity as a function of the axon thickness obeys the approximate law [34]

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

The value of $k$ is about 6 for thickly myelinated axons and between 1.5 and 5 for thinly myelinated axons. The variation ranges of conduction velocities in somatosensory (!) system are in ranges $80-120$

m/s, 35 − 75 m/s, 5 − 30 m/s and .5 − 2 m/s for unmyelinated axons. Conduction velocity varies in rather wide range (.5 − 120) $m/s$: 'quale key' can vary in a range of almost 8 octaves. The lowering the conduction velocity of nerve pulses by reducing myelinization or thickness could make it possible for us to have qualia about length scales of brain nuclei.

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

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

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

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

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

### 4.7.2 Scaling law and evolution

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

#### Scaling law contra biological, cultural, and spiritual evolution

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

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

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

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

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

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

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

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

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

### Evolution at the level central nervous system

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

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

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

### Scaling law and ontogeny

During the early development neural pathways myelinize gradually [47] and this means gradual increase of the conduction velocities $v = Lf$. This suggest that various versions of quale about given p-adic length scale $L(k)$ labelled by the harmonics of the fundamental frequency emerge gradually one by one as nerve pulse propagation velocities in neural pathway increase. First pops up $n = 1$ version of quale, then $n = 3$ version, etc.. One could visualize this as drift of various versions of quale from shorter to longer p-adic length scales.

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

$$v(n) \quad = \quad nf \times L(k) \ . \qquad (4.7.6)$$

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

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

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

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

### Transition from bicamerality to modern consciousness

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

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

1. *Semitrance mechanism*

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

2. *Development of speech*

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

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

*3. Emergence of long term memory*

What Jaynes believes could be translated to the statement that the transition from bicamerality to modernity involved the emergence of the long term memory and its evolution from a direct sensory memory to declarative memory [35]. Sensory memory means direct re-experiencing by the sharing of mental images made possible by time-like entanglement. Declarative memory would be based on a symbolic representation of the data, and would be communicated classically (communication would be ultra-slow!) from the geometric past as a response to the shared mental image representing the desire to remember.

A possible model for long term declarative memories is based on the generalization of the frequency representation of the memetic code. What is presumably coded, are perhaps not details of particular experience but sequence for names of 'program modules' realizing particular kind of experience. Thus very high level coding would be in question. In this model long term memories could perhaps be represented as a modulation of the carrier frequency of 'hippocampal theta frequency' varying in the range $4-12$ Hz [43] by multiples of some lower ELF frequency representing higher level of self hierarchy.

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

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

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

*4. Schizophrenic as a modern bicameral?*

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

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

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

*5. Child as a small bicameral?*

Scaling law suggests that child is during the first years of her life more or less the modern counterpart of the bicameral man of Jaynes [35] receiving commands and advices of the higher level selves as sensory, in particular auditory hallucinations which should seen preferably in ZEG ($Z^0$ magnetic transitions are responsible for hearing) as suggested in the chapters [N5] and [N6]. Semitrance hypothesis is consistent with the fact that REM occur during wakefulness and sleep. REM is also found to occur few moments after an infant begins to engage in nutritional sucking. Even modern man has day dreams with the same 90-120 minute period as he has REM period during sleep. That small children comment their activities from third person view (*'Now John is going to do this'*) is consistent with semitrance hypothesis.

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

It is known delta band dominates during childhood and that the EEG intensity in delta band is reduced during ageing. A possible interpretation is that the attention is during childhood more directed to transpersonal levels and gradually shifts to more bodily level (perhaps for the simple reason that the unpleasant side effects of ageing require more and more attention to the state of body!). This would suggest that ageing could but need not mean spiritual degeneration. The shift to higher frequencies could mean that higher harmonics of the cyclotron frequency in delta band begin to dominate. On the other hand, sensory acuity gets poorer when individual gets older. This could have purely anatomical reasons but could also involve gradual increase of the average cyclotron frequency associated with the quale so that also harmonics of low cyclotron frequencies responsible for high sensory acuity tend to disappear from EEG. Also the timing accuracy of the temporal patterns of nerve pulses could become worse during ageing. As a consequence, the frequencies of EEG waves would not be sufficiently near to the harmonics of low cyclotron frequencies anymore.

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

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

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

### 4.7.3 Scaling law and sensory maps

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

By scaling law the sizes $L(EEG)$ of ELF selves relate to the sizes $L$ of brain structures: $L(EEG) = (c/v)L$. Here $v$ is the velocity of motion of EEG ME along axon, or equivalently nerve pulse conduction velocity, and $f$ is the EEG frequency. The consistency with the scaling law is achieved if secondary sensory organs, which could be approximately spherical structures analogous to eyeball, have radii $L \sim v/f$ approximately given by various p-adic length scales $L = L_p$. As will be found later, the resulting sensory hierarchy correlates nicely with the brain anatomy, with the band structure of EEG and with the structure of the periodic table.

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

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

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

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

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

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

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

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

By $L = v/f$ correspondence the structures of neocortex correspond to definite ELF selves containing at least the p-adic length scales $L_2(2^5)$, $L(251)$, $L_2(127)$, $L(2^8)$, $L(257)$, $L_2(131)$, ... with fundamental Super Virasoro frequencies $f(k,n)$ equal to 40 Hz, 28.2 Hz, 10 Hz, 5.0 Hz, 3.5 Hz, .63 Hz,... Note that the fundamental frequencies correspond to gamma, beta, alpha, theta and delta bands. The table below provides a concise summary of the proposed correspondences. The length scale $L_3(83)$ corresponds to $f(1,0) = 56$ Hz contained also in the EEG range and is not given in the table.

| | | | | | | |
|---|---|---|---|---|---|---|
| k(bio) | 191 | 193 | $97_2$ | 197 | 199 | $101_2$ ($67_3$) |
| L(k(bio))/cm | 1 | 2 | 2.8 | 8 | 16 | 45 (32) |
| k(ELF) | $2^5_2$ | 251 | $127_2$ | $2^8 = 256$ | 257 | $131_2$ |
| f(k,n)/Hz | 40.0 | 28.2 | 10.0 | 5.0 | 3.5 | .63 |
| sensory area | I | I | II | III | IV | V |
| EEG band | gamma | beta | alpha | theta | delta | delta |
| period | He | He | Ne | Ar | Kr | Xe |

Table 4. The table gives the correspondence between biological and ELF length scales suggested by $v = L(k)f$ relationship assigning to the 'biological' length scale $L(k(bio))$ (not larger than body size) ELF frequency $f(k,n)$ and corresponding 'cultural' p-adic length scale, which is of order of Earth circumference for 8 Hz EEG frequency. Also the proposed assignments of the sensory areas of neocortex to these length scales are given. The lower index associated with the exponent $k$ tells whether the scale is secondary or tertiary in the case that it is not primary (one has $p \simeq 2^k$ by p-adic length scale hypothesis).

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# Chapter 5

# Quantum Model for EEG: Part II

## 5.1 Introduction

In previous chapter the overall TGD based view about EEG was discussed. According to this view, the basic function of EEG is to induce cyclotron phase transitions at the magnetic body and thus producing what might be called higher level sensory qualia identified as emotions and cognitions. In this chapter the relationship between EEG and nerve pulse patterns is discussed in TGD framework.

### 5.1.1 Generalization of the model for sensory receptor and new view about hearing

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. In TGD framework one can consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits and dark matter hierarchy challenges the earlier speculative TGD inspired models for sensory qualia and sensory organ. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be considered. The question arises whether sensory organs define not only sensory, but also corresponding cognitive and emotional representations. The fact that nerve pulses tend to destroy the temporal coherence of cognitive and emotional representations encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further ideas. For instance, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in the case of vision and hearing.

### 5.1.2 Features

Walter Freeman has identified spatially amplitude modulated synchronous but non-periodic EEG patterns serving as correlates for conscious percepts. The identification as MEs is possible and the spectrum of durations for the synchronous time patterns encourages the interpretation of these patterns as an electromagnetic realization of genetic code words. A compression of memetic code words defined by the nerve pulse patterns giving rise to abstraction and classification would be in question. The representation would be achieved by the amplitude modulation of the alpha waves by higher harmonics of alpha frequencies. In case of hearing the contraction seems to be un-necessary and memetic code could perhaps be realized also at the level of features. This would explain the completely exceptional role of the language in cognition.

### 5.1.3 Synchronization

Synchronization in and between various cortical areas is known to occur with millisecond precision. Also disjoint brain regions can be in synchrony. This is difficult to understand without synchronizing agent oscillating at kHz frequency. In TGD framework magnetic body is the natural agent inducing the synchrony and MEs could induce the synchronization. Synchronization would naturally occur at the frequency corresponding to a duration of the bit of the memetic code.

### 5.1.4 Stochastic resonance

Concerning the mapping of EEG frequencies to nerve pulse patterns, stochastic resonance promotes itself as a basic mechanism. In bistable systems stochastic resonance allows to amplify very weak periodic signals by utilizing white noise. Stochastic resonance is known to be relevant also at the neuronal level as demonstrated by the autocorrelation functions for spike sequences exhibiting peaks at the harmonics of the signal frequency. Neuron is however far from being bistable system, and this raises the question whether bi-stability might be present at some deeper quantal level.

Nerve pulses generate 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. Pendulum metaphor suggests how spike patterns amplify EEG waves at frequencies, which appear as resonances in the autocorrelation function of the spike sequence: when the pendulum is kicked at correct half of its period its oscillation frequency remains unchanged but amplitude and phase suffer discontinuous changes. The EEG waves generated by subsequent nerve pulses tend to interfere constructively resulting in amplification if the EEG frequency corresponds to a resonance frequency of the spike autocorrelation function.

### 5.1.5 Temporal codings

The conventional view that the information content of conscious experience is determined completely by rate coding from nerve pulse patterns does not seem plausible in TGD framework. Indeed, p-adic cognitive codes define an entire hierarchy of binary codes associated with the p-adic frequencies and frequency coding would apply only to the average intensity of the sensory input. For high stimulus intensities the duration of the bit of the p-adic cognitive codeword tends to become shorter. This is comparable to the increase of the speech rate during a high state of arousal, and conforms with the observed shift of EEG towards higher frequencies in this kind of situation. There is a lot of experimental evidence supporting the existence of various kinds of temporal codings, and these codings are discussed in TGD framework.

Before continuing some words about terminology are in order. Earlier I have used to talk about em and $Z^0$ MEs and em MEs. This terminology would make sense in standard gauge theory framework but is misleading in TGD context where classical fields are extremely tightly correlated so that it is not possible to have a situation in which only em or $Z^0$ field is present as a classical field. Same neutral ME carries both em, $Z^0$, and color fields and whether it looks like em, $Z^0$ ME, or color ME or some combination of them depends solely on the gauge charges of the particles interacting with it. One implication is that the earlier assignment of em MEs with sensory perception and $Z^0$ MEs with motor actions must be given up. Note however that in TGD framework p-adic and dark matter hierarchy predict hierarchy of copies of standard model physics so that also $Z^0$ and color interactions are predicted to be important in living matter.

## 5.2 Generalization of the model for sensory receptor and new view about hearing

Dark matter hierarchy defines a well-come challenge for earlier speculative models of sensory qualia and sensory organ, and leads to a considerably more detailed view about how sensory qualia, emotion, and cognition are related. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be seriously considered. The question arises whether sensory organs define not only sensory, but also corresponding cognitive and emotional representations. Nerve pulses tend to destroy the temporal coherence of cognitive and emotional representations, and this encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further concrete ideas: in particular, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in case of vision and hearing.

### 5.2.1 General ideas

Consider first general ideas about sensory qualia and capacitor model of the sensory receptor stimulated by the application of dark matter hierarchy.

#### Modification of the capacitor model of sensory qualia

From the time scale of sensory experience it seems obvious that all qualia are realized at the level of dark matter. .1 seconds defines a unit of time for sensory experience which suggests that EEG relates closely to sensory qualia.

A modification of the original capacitor model of sensory receptor must be considered. In the original model the capacitor discharge was associated with the sensory receptor. The time scale .1 seconds characterizing sensory mental images would support the view that the capacitor discharge producing the sensory qualia should be assigned to the Josephson junctions at $k_{em} = 3$ level of dark matter hierarchy rather then cell membrane which corresponds to $k_{em} = 0$ level in the hierarchy of selves.

Charge entanglement by $W$ ME would induce non-local capacitor discharges which can be regarded also as exchanges of virtual $W$ bosons inducing exotic ionization leading to dark plasma oscillation patterns inducing various kinds of physiological activity such as $Ca^{2+}$ waves. .1 seconds could be seen as a period of recurring plasma oscillations. Sharing of mental images by entanglement would result as a by product.

#### Selection of percepts in state function reduction

State function reduction reducing charge entanglement could give rise to the selection of percepts involved for instance with binocular rivalry involving of magnetic body in the scale of brain. This selection means that only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism would guarantee reliable perception.

#### Also the magnetic bodies of sensory organs carry cognitive and emotional representations

Fractality forces the conclusion that also the magnetic bodies associated with the sensory organs carry cognitive and emotional representations. The level of cognition and emotion would be only lower than the cortical level and correspond to $k_{em} = 3$ most naturally. For instance, physical pain and psychological pain would correspond to emotions at different levels of the dark matter hierarchy.

An interesting possibility is that emotions and cognitions correspond to neutral gauge fields (em and $Z^0$ gauge fields and neutral color gauge fields) whereas sensory qualia or at least part of them would correspond $W$ gauge fields and color charged gluon fields. Quite generally, cognition and emotions would have neutral Lie-algebra (or Kac-Moody algebra) generators as correlates whereas charged generators would correspond to sensory qualia.

#### The new view about the role of sensory receptors and glial cells

The starting point is the 4-dimensional view about gradual build-up of 4-dimensional percept as an evoked potential representing genetic, memetic or more general codon or single "note" depending on whether one considers cognitive or emotional representation.

Quite generally, sensory receptor neurons do not fire and the primary sensory input is represented as an evoked potential. That this must be the case is easy to understand if sensory receptor neurons generate cognitive and emotional representations at their magnetic bodies based on modulations of $k_{em} = 3$ frequencies by EEG frequencies. The reason is that nerve pulse would spoil the temporal coherence of the cognitive and emotional representations by cyclotron transition patterns by taking Josephson frequency through zero to a large negative value and back to the original value. This would be like playing entire piano scale from right to left and back inducing cyclotron phase transition sweeping through a large portion of the magnetic body.

This applies also in the case of higher level emotional and cognitive representations and the only reasonable conclusion seems to be that glial cells which do not fire correspond to these representations. I have already earlier suggests this but on different grounds. Glial cells would not be mere metabolic storages but receive the metabolic energy directly because they are primary users of it utilizing it to build generalized EEG and ordinary EEG. T

he leakage of $Ca^{2+}$ ions through sensory receptor cell membrane induced by a plasma oscillation pattern gives rise to temporal patterns of evoked membrane potential. Plasma frequency would correspond to the frequency of recurrence for these patterns. The temporal characteristics of plasma wave patterns should correlate with various codes, in particular memetic code. The same picture would apply at the level of glial cells. Neurons would us much less metabolic energy since supra currents through the cell membrane would not use much of the metabolic energy, and ionic channels and pumps would actually play the role of sensory receptors at neuronal level [J3].

#### Hearing *resp.* vision ↔ electro-weak *resp.* color interactions

Hearing-vision dichotomy and weak interaction-color interaction dichotomy could correspond to each other. The sensation of hearing could correspond to the change of weak isospin resulting in $W$ exchange. Sound-silence dichotomy ($\Delta I_3^w = \pm 1$) would be completely analogous to white-black dichotomy assignable to color isospin ($\Delta I_3^w = \pm 1$). Similar pairing should occur at the level of cognitions and emotions accompanying auditory and visual percepts and correspond to neutral weak gauge bosons and neutral color bosons.

#### The assignment of scaled up EEG with sensory organs

The assignment of $k_{em} = 3$ variant of EEG to sensory organs suggests itself. In the case of ordinary sensory qualia the scaled up 5 Hz Josephson frequency of ordinary EEG would be $10^4$ Hz. If magnetic field strength associated with DNA is scaled up to .1 Tesla for these representations, alpha band is mapped to $2 \times 10^4$ Hz. Delta band for right/left brain DNA cyclotron transitions at .5 Hz/1 Hz is mapped to 1 kHz/2 kHz. Hence the identification of the 1 kHz synchronization frequency of neural firing as the scaled up cyclotron frequency of DNA must be considered.

The frequency range $20-2\times10^4$ Hz of frequencies audible by humans overlaps with the spectrum $0-10^4$ Hz of sferics known to correlate with consciousness. This coincidence has a natural interpretation in this picture since the $k_{em} = 3$ Josephson junctions (scaled up cell membrane thickness) would correspond to size scale of 80 m and scaled up cell size to the scale 160 km assignable to lito-ionosphere complex in the general model of EEG [M3]. Therefore hearing and also other sensory qualia cold be accompanied by low level cognitive and emotional representations resulting as EEG modulations of the frequencies above kHz: sensory organs would feel and cognize to some extent.

### 5.2.2 TGD based model for hearing

It is very difficult to understand how neural processing could cope with the fast temporal gradients of the auditory input. The basic difficulty is that the time scale of nerve pulses is below millisecond whereas the highest audible sounds correspond to frequencies of about 200 kHz for some sea mammals [22]. Also bats hear very high frequencies. The frequencies below kHz are known to be coded to spike interval distributions [28] but for higher frequencies this is not possible. The mystery is how brain receives the information about higher frequencies.

If sensory representations are realized at the level of sensory organs the problem becomes much easier. Without feedback from cortex one would however end up with difficulties: for instance, the phenomenon of missing fundamental could not be understood. Microtubular communications of sound to and from brain would allow to transform sound waves to signals propagating along axonal microtubuli. Feedback along microtubuli makes possible an active construction of percept so that phenomena like missing fundamental can be explained as being caused by spike interval distribution of nerve pulse patterns associated with feedback. The outcome is a more concrete view about hearing at the level of ear. This aspect have not been discussed in the earlier model which has concentrated on an attempt to understand the cognitive aspects of hearing [M6].

### The anatomy of cochlea

The ear of mammals involves outer and inner hair cells [22, 23]. Outer hair cells have no axons to brain but there are efferents from cortex to them. The usual interpretation is that outer hair cells act as pre-amplifiers. They make possible feedback from cortex allowing to build sensory percepts already at the level of ear. This makes reasonable the idea that acoustic representations are indeed constructed at the level of sensory organs.

The cochlea for which piano keyboard is a good but not complete metaphor represents the phoneme as a spatio-temporal pattern. The input at a given frequency presses various keys with maximum activation at a key characterized by this frequency. The magnetic body of the entire cochlea experiences the sounds as spatial patterns of cyclotron transitions. Lower level emotional and cognitive components could emerge already here and correspond to rhythm and pitch. Meaning emerges at higher level as phonemes integrate to words and speech and associations are formed.

### The coupling of hair cells with neurons

The coupling of hair cells with neurons mediating neuronal signals to brain is poorly understood [22, 23].

1. The transmission of neurotransmitters to postsynaptic neuron from the hair cell should be uncannily fast. The existence of unidentified very fast neurotransmitter is postulated.

2. Hair cell contains near presynaptic cleft mysterious structure with ring like shape known as presynaptic dense body. The function of this structure is not known but is believed to be crucial for the transmission of the neural transmitter.

3. There is chronical $Ca^{2+}$ leakage to hair cell. This is also believed to be crucial for the transmission of mystery transmitter.

### TGD based model for hearing

TGD based model hearing is inspired by the attempt to understand the meaning of the strange findings just listed.

1. It is known whether and it is difficult to understand how the audible frequencies above kHz can be coded by nerve pulse patterns. The representations based on $k_{em} = 3$ scaled up EEG suggests a solution to the problem. The fundamental sensory representations and also low level emotional and cognitive representations are realized at the level of cochlea so that there would be no absolute need to code for high frequencies by nerve pulse patterns. The representation at the level of sensory organs means that the loss of accuracy of representation due to communications with brain can be avoided. The speech and song type representations based on phonemes and sequences of notes with pitch would be realized at the level of cochlea. The feedback from cortex to the outer hair cells is essential and explains phenomena like hearing the missing fundamental.

2. The extreme rapidity of the transfer of the postulated unidentified nerve transmitter from the hair cells to the nerve axons is a mystery. The transmitter is not needed at all if microtubuli mediate the information about evoked potentials at hair cell membrane to brain as microtubular conformal patterns and/or acoustic/electric waves. Acoustic and electric waves would be both present since microtubuli are electrets.

   The transfer of auditory information from hair cells to postsynaptic neuron could occur via acoustic transmission meaning that the time lag spent in this step would be of order $\sim .1$ ns only. The reported extreme sensitivity of of the axonal signal to the evoked potential (the resolution is about $\Delta V \sim .1$ mV) [22] conforms with the view that evoked potential provides a representation of the sensory input.

   The representation and communication of acoustic signals at microtubular level could induce the coding of frequencies sufficiently below 1 kHz to spike interval distributions [28]. The obvious critical question is how badly nerve pulse disturbs microtubular communications. One might argue that these perturbations do not affect conformational waves. As proposed earlier, the microtubular conformational wave patterns could be responsible for long term memories for instance. Acoustic waves could fulfill the same function.

3. The chronic leakage of $Ca^{++}$ believed to relate to the transfer of the postulated fast transmitter. The TGD inspired interpretation would be that $Ca^{++}$ wave is induced by the temporal plasma wave pattern and represents auditory percept cognitively/emotionally. The presynaptic dense body would be involved with the transformation of the temporal pattern represented by the time pattern of $Ca^{2+}$ leakage to a signal propagating along the microtubule. Coupling to the microtubular conformational waves/acoustic signals could be also mechanical and the dense body could generate acoustic oscillations representing the temporal pattern of $Ca^{2+}$ waves.

4. Mammals have two kinds of hair cells [23, 22]: inner hair cells are possessed also by lower life forms and outer hair cells only by mammals. Outer hair cells are thought to act as pre-amplifiers but TGD suggests that the deeper function of outer hair cells is to mediate auditory feedback from cortex. There are indeed efferents from cortex to outer hair cells making possible cortical feedback which sometime can create sounds audible even from outside (otoacoustic sounds).

   The feedback makes possible the realization of the experienced auditory percepts at the level of cochlea. This would explain various phenomena interpreted usually as a support for the hypothesis that sensory qualia are produced by neuronal activity. Consider only the emergence of pitch not present in the primary sensory input such as the missing fundamental when only its harmonics appear in the auditory input [28]. This feedback would of course occur also at the level of other sensory organs and rapid eye movements during REM sleep could be interpreted as being induced by the feedback from visual cortex.

The emergence of the outer hair cells increases the span of audible frequencies. For sea mammals 200 kHz which corresponds to 100 Hz for ordinary EEG. This would be just what would be needed for the representation of memetic codons or EEG patterns as amplitude modulations. This would mean emergence of a new symbolic level distinguishing mammals from lower levels in the evolutionary hierarchy. For frequencies below few kHz, say 3 kHz only pitch representation makes sense. Single formant vowels for which formant frequency is sufficiently below 1 kHz would have representation also as nerve pulse patterns.

Hair cells communicate with cortex using sequences of "phonemes" or "notes" defining amplitude modulations of frequencies above few kHz. At this limit modulation preserves the pitch so that durational and pitch representations are mutually consistent. This explains the unexpected finding that same brain regions, prevalently in right hemisphere, are responsible for the analysis of pitch and durational patterns [24]. Only frequency representation would be realized at the lower frequencies so that the presence of cognitive and emotional amplitude modulations at the level of cochlear would distinguish mammals from lower life forms.

**Why microtubuli are needed?**

The time pattern represented by $Ca^{2+}$ leakage to the inner hair cell could be transferred to the post-synaptic axon and transformed to a signal propagating along the axonal microtubuli. An interesting hypothesis is that left brain utilizes phoneme sequences and right brain note sequences. Also the signals from auditory cortex to the outer hair cells would propagate along axonal microtubuli.

The signals would propagate with a velocity which could be faster than the conduction velocity of nerve pulse and constant to a very high degree unlike the conduction velocity of nerve pulse. The measurement of a time lag of order millisecond for signals arriving to the right and left ear using co-incidence detectors in the brain stem (medulla oblongata) allows to determine the direction of the sound source. The typical time interval between nerve pulses varies and is somewhat more than millisecond, and is not at all clear whether nerve pulse conduction can preserve the time differences accurately enough to allow their meaningful comparison. If the signals from cochlea to brain stem propagate along microtubuli the situation could improve.

**Memetic code, and genetic code as a representation of phonemes?**

The average duration of phonemes is about 140 ms, which is by a factor $\sqrt{2}$ longer than the duration .1 seconds of the memetic codon. Durations vary in the range 60-300 ms. Note that the 250-300 Hz rhythm associated with speech organs defines the pitch of speech but phonemes can be recognized even in the absence of the fundamental. The basic pitch of about 250 Hz implies that the number of memetic codons associated single single period is at most 2.

Phonemes can be classified by the vocal tract mechanism generating them and phonemes can be also recognized by their spectral decomposition.

1. Formants [20, 21] correspond to vowels, approximants (say (r,l) and (j,w)) , and nasals (m and n). Only few resonant frequencies are needed to characterize the formant. Lowest formant is below 1 kHz but higher formants above kHz and frequencies up to 3 kHz are possible. It is easy to understsand that for vowels the frequency distribution does not depend on time for approximants and nasals it does.

2. Fricatives (hiss, buzz). Fricatives lack the formant structure. Both correspond to a repeated time amplitude peak and frequency distribution involves wide range of frequencies with same intensity.

3. Plosives (such as p,b and t,d) correspond to a single peak in the time domain and constant frequency distribution.

All sensory input might be transformed by a feedback circuit to sequences or notes/memetic codons represented as a modulation of the membrane voltage providing a universal cognitive/emotional representations. Also ordinary phonemes and notes would be represented in this manner. Sensory organs correspond naturally to $k_{em} = 3$ level of dark matter hierarchy since .1 seconds represents the basic unit of sensory time. Therefore memetic codons modulating scaled up EEG at $k_{em} = 3$ level would be a good guess for how the sensory input is represented cognitively.

Also other p-adic codes are possible. Phonemes, the number of which is 41 in American english, could correspond to a sub-code reducing to a genetic code with 64 codons. It is important to notice that the temporal distance between memetic codons does not matter. Other memetic codons could code for recognizable sound patterns not representing phonemes and could have meaning at some other levels of self hierarchy.

One can argue that the representations as "notes" and "phonemes" should carry roughly the same amount of information. For frequency representation as sequence of "notes" 10 octaves represents upper limit for the modulation frequencies. For high modulating frequencies the representation tends however to fail since slow modulation is not anymore in question. This would mean that the number of distinguishable "notes" is below $10 \times N$, where $N$ is the maximum number of distinguishable frequencies inside octave. $N = 12$, the number of half notes in octave, would give 120 different "notes", which is not far from 127 and corresponds to $M_7$ allowing $2^7 - 1$ different codons making almost 7 bits with bit duration of 67 ms. Since the first codon in pulse-no pulse representation must be always pulse to tell that the codeword starts, this leaves 6 bits and genetic code. Codons can have varying but long enough pauses between them and the average duration .14 s of phonemes allows this. The association of genetic or memetic codons to characteristic spectrograms of phonemes as a function of time and frequency would result by cortical feedback.

p-Adic cognitive codons could be also 2-adic fractals in the sense that the octaves of the fundamental p-adic frequency $f(n, k)$ would correspond to the frequencies coding for bits. This would give rise to a very robust representation. In the case of memetic code this would mean that the frequency range $10 - 10^3$ Hz dictated by the time scale 1 ms of nerve pulse activity would contain 6 octaves meaning an effective reduction of the memetic code to 6-bit genetic code. The prediction would be that the frequencies 10,20,40,80,160,320,640 Hz are in a special role in neural dynamics.

### 5.2.3 Some examples about deficits of color vision as a test of the model for cognitive representations

The article "Quining the Qualia" by Daniel Dennett gives [31] a good view about the difficulties encountered as one tries to understand qualia as a philosopher. Dennett's reaction to the problems is to give up the notion of qualia altogether. To me this is like denying the causal role of consciousness just because we do not have mathematical and conceptual tools to describe it. This is however not the main point now. Dennett lists some fascinating empirical findings related to deficits in color vision, which serve as excellent tests for any theory of qualia.

It is instructive to consider these examples in the framework provided by the model of cognitive representations just discussed. For this purposes let us list the basic general assumptions of the model in the case of color vision.

1. Assume that color capacitor discharges occur between cones/rods and the corresponding magnetic body. The paradoxical fact that receptor cells hyper-polarize rather than depolarize as they receive light is consistent with the requirement that incoming light must increase the color voltages between cone system and its magnetic body in order to generate color discharge. Rods would differ from cones in that the full color algebra SU(3) to its sub-algebra SU(2) so that only the increments of color isospin $I_3$ would be perceived and would give rise to black and white as primary qualia. Thus only charged SU(2) gluons are exchanged between the magnetic body associated with the rod system.

   In the case of cones the most natural assumption is that all 3+3 colors (black and white are counted as colors) are perceived and correspond to increments of color isospin and two generators carrying hyper charge. Single cone could be specialized to produce up the increment of color quantum numbers corresponding to a particular primary color. The increment of color quantum numbers should always have the same sign in the ideal situation (only quale which is red or green, blue or yellow, black or white is produced if the highest weight or lowest weight states of the representation of color algebra (or color Kac-Moody algebra) define the ground state of the system.

2. Cortex is assumed to participate actively to the coloring of the sensory map by using back projections to retina and the experienced color map is an outcome of a complex information processing.

3. The magnetic bodies of retina would contain regions where colors are cognitively represented as an analog of color circle so that the over all color sensation generates cognitive and emotional representations as a "somatosensory" experience at the magnetic body realized as cyclotron phase transition patterns. Pure colors would correspond to patterns localized at single point of the magnetic body whereas mixed colors would correspond to delocalized patterns.

### First example

*Objects to the right of the vertical meridian appeared to be of normal hue, while to the left they were perceived only in shades of gray, though without distortions of form... He was unable to recognize or name any color in any portion of the left field of either eye, including bright reds, blues, greens and yellows. As soon as any portion of the colored object crossed the vertical meridian, he was able to instantly recognize and accurately name its color.*

This finding could reduce the plausibility of the hypothesis that sensory organs are seats of sensory qualia and of primary cognitive and emotional representations. The hypothesis passes the test. Retina decomposes to nasal and temporal retina. This corresponds to the decomposition of the visual field of retina to right and left hemifields [32]. The inability to recognize and name colors in the left visual could be simply due to the fact that cones sensitive to color are not functioning properly or at all in the left temporal and right nasal retina. A more complex situation would results if parts of cortex responsible for the back projections to the left visual field want to "see the world as grey" and actively reduce the color map to the shades of grey.

### Second example

*The patient failed in all tasks in which he was required to match the seen color with its spoken name. Thus, the patient failed to give the names of colors and failed to choose a color in response to its name. By contrast, he succeeded on all tasks where the matching was either purely verbal or purely nonverbal. Thus, he could give verbally the names of colors corresponding to named objects and vice versa. He could match seen colors to each other and to pictures of objects and could sort colors without error.*

What was remarkable that the patient was not aware of any deficit.

There is an obvious analogy with the phenomenon of absolute ear. Almost anyone can tell whether two notes have the same pitch but only people with absolute ear learn to name the heard note. In the case of color vision almost all of us have "absolute eye" in the sense that we can recognize the perceived color and name it but in the above described case this ability would be lost. The analogy is weakened by the fact that musicians not possessing absolute ear are quite well aware of their "deficit".

Accepting the analogy, the TGD based model for absolute ear generalizes as such to the recent situation. The model of absolute ear is based on a comparison in which reference dark photon signal is sent from the temporal planum [26] to the magnetic body assignable to the cochlea. Recognition relies on the constructive interference of the dark photon signals from cochlea and temporal planum enhancing the rate for the cyclotron phase transition. This model generalizes to a general model for how conscious pattern recognition occurs at the level of the magnetic body and applies in the case of vision too.

1. There should exists a region of visual or associative cortex analogous to the temporal planum sending a dark photon signal to the magnetic body of retina ($k_{em} = 3$ corresponds to the level of dark matter hierarchy also now).

2. That the patient is not aware of the syndrome suggests that the reference signal representing given name of color as actual color is sent but goes to a "wrong address" at the magnetic body and is not compared with the real signal. If the cognitive "color circle" correspond to a small portion of the magnetic body as the general model for cognitive representations suggests, the resonance could indeed occur at wrong position of the magnetic body receiving different kind of cognitive input.

**Third example**

*One morning in November 1977, upon awakening, she noted that although she was able to see details of objects and people, colors appeared "drained out" and "not true." She had no other complaint... her vision was good, 20/20 in each eye... The difficulty in color perception persisted, and she had to seek the advice of her husband to choose what to wear. Eight weeks later she noted that she could no longer recognize the faces of her husband and daughter... [So in] addition to achromatopsia, the patient had prosopagnosia, but her linguistic and cognitive performances were otherwise unaffected. The patient was able to tell her story cogently and to have remarkable insight about her defects.*

This case could be understood as the failure of the back projection mechanisms making possible coloring of the percept and the generation of the caricature like percept allowing recognition of faces. Also the recognition of faces could rely on the resonance mechanism in which signal is sent from cortex to an appropriate magnetic body.

These examples should demonstrate that the TGD based notion of qualia combined with the general model for cognitive and emotional representations can easily explain the findings discussed in [31].

## 5.3 Features and synchronization

The model for sensory receptor discussed in the previous section is inspired by the general vision for how magnetic body controls biological body and receives information from it. The model generalizes straightforwardly to a model of features. What is new that features would most naturally be induced by $W$ MEs affecting glial cell groups which in turn would induce the synchoronous neuronal firing.

Cyclotron phase transition at appropriate magnetic body induced by cyclotron and Josephson radiation generated by the corresponding biological body defines the feature. The cyclotron frequency in associated with scaled up EEG at $k_{em} = 3$ level of hierarchy for which alpha band is mapped to $2 \times 10^4$ Hz. The modulated cyclotron frequency could place code a position of the representation at magnetic body representing some geometric quantity, say the distance of the object of perceptive field. The temporal modulation pattern of the amplitude of cyclotron radiation by some EEG frequency in turn would define the feature assigned at this position. One can distinguish between speech and song like features responsible for cognitive and emotional aspects of perception. Also spatial modulation is present but temporal pattern is same at all points of feature.

Genetic and and perhaps even memetic codons with duration of .1 seconds are good candidates for the "phonemes" of speech like features. Recurring feature corresponds to a plasma oscillation with frequency below 10 Hz generated by the charge entanglement by $W$ ME inducing exotic ionization. $Ca^{2+}$, $Mg^{2+}$ and possibly also other bosonic ion waves are physiological correlates of the features.

1 kHz synchronization frequency reduces in this picture to DNA cyclotron frequency associated with the scaled up variant $\lambda B \simeq .02$ Tesla of the magnetic field $B = B_{end}/2 = .1$ Gauss assignable to the right brain hemisphere and having cyclotron frequency .5 Hz and carrying single flux quantum $h_5 = 5h_0$. Also 2 kHz synchronization frequency is highly suggestive. The dark photons of this

radiation could result as DNAs drop to excited cyclotron states at the magnetic flux sheets traversing through the sequences of DNA double strands defining lines of a page of a book represented by the flux sheet. The text line has an interpretation as a supergene expressed collectively during synchronous firing.

Also fractally scaled up variants of features with duration of short term memory and realized as modulations of EEG frequencies are predicted with alpha band taking the role of 1 kHz synchronization. Scaled up variants of memetic/genetic codons would code for information now. In this case the size scale of the features would be $\lambda \times .02 = 40$ m suggesting that collective mental images involving several brains are in question.

### 5.3.1 Features

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 odor perception gives valuable guidelines in this respect [36]. 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 behavior 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.

#### Features as AM modulated EEG patterns

The coherence lengths for EEG inside cortex are in general much shorter than on the surface of the skull and complex patterns are encountered. In particular, synchronous 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) [36], 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.

#### MEs as AM patterns representing features

$W$ MEs as realizers of the generalized motor actions of the magnetic body inducing plasma oscillations and ionic waves are excellent candidates for inducers of AM patterns. They would have transverse cross section of about 1-2 cm. Note that 2 cm corresponds to the scaled up thickness of the lipid layer of cell membrane at $k_{em} = 2$ level of dark matter hierarchy. On the other hand, the thickness for the magnetic flux sheet with field strength of .05 Tesla implied by the identification of 1 kHz frequency as cyclotron frequency of DNA is $L(149) = 5$ nm and corresponds the thickness of the lipid layer.

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 light fronts 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 sufficiently 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 [J4]. In geometric optics picture this means that paths of light rays inside MEs can be also curvilinear light like curves expressible as gradient lines for a Hamilton Jacobi functional $S$ whereas the transverse polarization is defined by a gradient of a polarization function $E$.

### Genetic code and odors

The interpretation of AM patterns as sub-selves representing standardized mental images is natural. The average duration of these sub-selves is of 100 ms which is the duration of the memetic codeword [L1]. 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 odors [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) with bits represented by a pulse or absence of it. The presence of pulse would correspond to some minimum intensity of field. The first bit would be always 1 to signify the beginning of the codon which would give 126 bits. Also a formal representation as superpositions of Fourier components with frequencies $f_n = n/T$, $n = 1, ..., 127$ with coefficients can be considered but would not be so natural than pulse representation.

There are however some objections against this identification.

1. 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 [N5, N6].

2. 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 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.

Genetic code could be also realized as nerve pulse patterns. 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. Also the discrete values of the pulse rate varying from 0 to 64 pulses per .1 seconds could define genetic codons.

### Magnetic representation of the genetic codewords

Genetic code for odors is consistent with the assumption that the modulation frequencies are in the range $20-80$ Hz. The cyclotron frequencies of all biologically important ions including DNA are above 1 kHz so that amplitude modulations at EEG frequencies are slow.

The modulated cyclotron frequencies would naturally represent carrier waves coding for some geometric data, for instance the distance of the object of perceptive field on the sensory magnetic canvas. This prediction could be tested by looking whether the attention directed to a moving object is accompanied by a shift of some cyclotron frequencies.

EEG waves with well defined frequencies would have interpretation in terms of frequency coding by sequences of "notes" whereas chaotic EEG waves such as beta waves might be assignable to the speech like representation. For "note" representation trivial code word would correspond to a mere alpha wave modulation. Alpha wave begins to dominate when eyes are closed which suggests alpha wave modulation represents "no sensory input". In the case of vision alpha wave would assign the color quale black and the mental image "darkness" to the region of the perceptive field. In the case of hearing the trivial codeword would represent the experience of silence, something different from the absence of auditory experience.

#### Data compression as frequency cutoff and threshold coding

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

1. 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.

2. 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.

### 5.3.2 Synchronization

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 behaviorally 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.

#### Temporal binding by synchronization

The article of Engel *et al* [37] 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.

1. 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.

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

3. 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.

4. 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.

5. 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.

#### Empirical evidence for synchronization

Neuronal synchronization is by now a well established phenomenon (see [37] and references therein).

1. 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 [37]. Synchronization has also found even between areas belonging to different hemispheres.

2. Synchronization in visual system predicts synchronization inside visual areas and between areas icro-ss 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.

3. 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.

4. Synchronization seems to serve as a neural correlate for conscious percepts [37]. 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. The interpretation would be that without synchronization no coherent cognitive or emotional mental image is formed at the magnetic body.

Charge entanglement involving $W$ MEs makes possible superpositions of several sensory percepts and state function reduction would select one of them. The possibility to build quantum superpositions of alternative percepts means metabolic economy since only single percept need to be realized in a given quantum parallel universe. The selection of percepts in binocular rivalry might be a basic example about state function reductions at the level of perception. Information processing resembling quantum computing could be realized using quantum superpositions of nerve pulse patterns. Same picture applies also to motor action. When a large number of similar systems (say sensory receptors) is involved, quantum statistical determinism guarantees reliable perception.

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 [37]. The interpretation would be that 1 kHz frequency results as generalized motor actions absent during anesthesia induce the dropping of ions to magnetic flux sheets carrying .05 Tesla magnetic field.

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. The interpretation would be that this synchronization is related to the next level of the dark matter hierarchy, that is to the modulations of ordinary EEG amplitudes by $k_{em} = 5$ level EEG representing short term memories. In particular, the synchronous firing at 40 Hz frequency would correspond to this level and a hopefully testable prediction is that the modulations of 40 Hz frequency code for cognitive and emotional content.

### 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 intentional action identified as p-adic–real transformations for space-time regions takes place at brain level. There 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 if the latter indeed involves the 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 proposed to represent memetic codewords in this process [M6] but not discussed in this chapter at all? Are also cognitive neutrino pairs needed? Recall that cognitive neutrino-antineutrino pair is identified as neutrino and antineutrino located at the opposite throats of a wormhole contact. The throats are quite generally identified as light-like 3-surfaces carrying parton quantum numbers. The question is basically about whether this kind of nearly zero energy particles existing simultaneously at two space-time sheets are important for the understanding consciousness and living matter.

*2) How the dynamics of volition is realized?*
Typically, the transformation of p-adic $W$ MEs representing intentions to real ones connecting magnetic body to some part of the cortex, presumably glial cell group, induces synchronous neural firing exciting or inhibiting some other regions. In excitatory case this should somehow lead to a cascade in which lower level p-adic MEs of excited regions are transformed to real ones. The basic question is what mechanism induces the transformation of the p-adic 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.

1. Volition would be volition of the personal magnetic body and induce a cascade of volitional acts transforming p-adic MEs to negative energy real MEs in shorter length and time scales. p-Adic-to-real transformation of negative energy $W$ ME could occur with a high probability when p-adic $W$ ME oscillates with a frequency which corresponds to the duration of the bit of the p-adic code word which is related to an appropriate dark matter level and p-adic length scale in a simple manner. When out of tune, p-adic 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.

2. One can wonder whether also real-to-padic phase transitions could occur and whether the dynamics of thought could the reversal for the dynamics of volition. Again synchronization and resonance condition would be important. p-Adic length scale hypothesis favors 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.

3. 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 paradoxical 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.

#### A general view about the role of synchrony

The hypothesis that synchronization is due to the presence of MEs suggests the following general view about how conscious brain functions.

1. 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.

2. p-Adic $W$ MEs representing intentions and these would transform to real negative energy $W$ MEs and represent desires inducing generalized motor actions. Negative energy $W$ MEs would select from the sea of cortical chaos islands of order and generate objects of perceptive field or behavior (by sensory-motor analogy one might perhaps speak of "behavioral field") realized as sub-selves. $W$ MEs would obviously feed negentropy to the neuronal primordial chaos and generate macro-temporal quantum coherence and thus sharp sub-selves lasting for a sufficiently long time to contribute significantly to the contents of consciousness and behavior (note the analogy with a social group: very short-lived member does not contribute significantly to the development of the social group).

3. The question whether there exist non-neuronal correlates for consciousness is definitely settled in this framework: they do exist and correspond to both p-adic and real charged and neutral MEs both in the sense of electro-weak and color interactions and the synchronous firing of neurons provides a direct experimental evidence for these correlates visible already at the primary sensory areas.

4. The mesoscopic feature level visible in EEG and reflecting the synchrony MEs could represent a higher abstraction level in which memetic code words are compressed to the genetic code.

Summarizing, this view combined with the general vision about the realization of the various representations represents a reasonably coherent vision about how magnetic body controls brain. There remains of course challenges even at the level of principle. The question whether p-adic-to-real transitions and their reversals really make sense and occur is one of them. The fact that inertial energy is not positive definite in TGD Universe makes in principle possible this kind of transitions.

## 5.4 Stochastic resonance and brain

This section begins with the review of the notion of the stochastic resonance. Also its applications to neuronal systems are reviewed. With motivations coming from conceptual difficulties of the proposed neuronal models, a reduction of the stochastic resonance to the quantum level, which is assumed to control the functioning of bio-systems, is developed by refining the quantum model for nerve pulse generation by specifying the interaction with MEs. Another key idea described in detail in [J2] is that bio-systems correspond to flow equilibria for ions in the many-sheeted space-time with atomic space-time sheets having the role of a controlled system and super-conducting space-time sheets taking the role of the controlling system. The possibility that MEs generate by stochastic resonance soliton sequences associated with Josephson currents, is discussed.

### 5.4.1 Stochastic resonance

Background noise is usually seen as a mere nuisance in communications but under certain circumstances it can in fact improve, rather than hinder the performance. The notion of stochastic resonance [18] was originally put forward by Benzi and collaborators [19] in seminal papers where they study the problem of the periodically recurrent ice ages. The same suggestion was raised independently by C. Nicolis and G. Nicolis [20]. The planetary glaciation sequence has a period of about $10^5$ years which happens to be same as the period of the planetary gravitational perturbations with a typical time scale of $10^5$ years inducing an extremely small (of about .1 per cent) periodic variation of the solar constant which as such cannot explain ice ages. The system is modelled by a bistable potential in which the two potential wells represent the ice-covered Earth and the normal climate. Short term climate fluctuations are modelled by white noise and if the intensity of the white noise is correct, the weak periodic variation of Earth's temperature is amplified to a synchronized hopping between cold and warm climates.

The notion of stochastic resonance has been considerably generalized to include a number of different mechanisms. The unifying features are the increased sensitivity to small perturbations and phase locking for an optimal noise level. Stochastic resonance like features have been reported also for autonomous systems. Also the quantum version of the stochastic resonance taking into account quantum tunnelling has been studied. Stochastic resonance has been also generalized to coupled (that is higher-dimensional) systems and to excitable systems allowing only single stable state and meta-stable states. The interested reader can find references to the rich literature about stochastic resonance in [18].

Stochastic resonance has been verified for a wide variety of system such as Schmitt trigger, bistable ring laser, electron paramagnetic resonance, and super-conducting quantum interference devices (SQUIDs) [18]. An especially important application is to neuronal systems [21].

### 5.4.2 Basic model for stochastic resonance

The archetypal model of stochastic resonance involves a one-dimensional system equivalent with a particle with mass $m$ moving in a double potential well

$$V(x) = -ax^2/2 + bx^4/2$$

under a friction force $\gamma dx/dt$ proportional to velocity, a weak periodic external driving force $A(t) = A_0 sin(\Omega t)$, and a random force which can be modelled as a white noise $\xi(t)$ with vanishing mean and correlation function

$$\langle \xi(t_1)\xi(t_2) = 2D\delta(t_1 - t_2) \ .$$

Here the parameter $D$ characterizes the noise level.

The noise could be also a more general colored Gaussian noise with ultraviolet frequency cutoff. The fluctuational forces cause transitions between the potential wells with a rate given by the Kramers rate [22]:

$$r_K = \frac{\omega_0 \omega_b}{2\pi\gamma} exp\left[-\frac{\Delta V}{D}\right] \ . \tag{5.4.1}$$

Here $\omega_0^2 = V''(\pm x_m)/m$ is square of the frequency of small oscillations at the bottom of well and $\omega_b^2 = -V''(x_b)/m$ is an analogous quantity estimated at origin which correspond to the maximum of the potential. $\Delta V$ denotes the height of the potential barrier separating the two minima.

If a periodic spatially constant force is applied to the particle, it induces a periodic variation in the shape of potential. At a given well the minimum of the potential barrier occurs periodically with frequency $\Omega$ and if the particle hops to second well when barrier height is minimum it experiences minimum height barrier in the second well after a half period. If the white noise is such that the rate $r_K$ is twice the frequency $\Omega$:

$$r_K = 2\Omega \ , \tag{5.4.2}$$

the rate for the jumps between potential wells is synchronized with the periodic variation of the external force. One can understand this relationship intuitively on basis of the previous simple observations.

Stochastic resonance is manifested as a phase locking of $x(t)$ to the external force and as maximum of the average amplitude as function of the parameter $D$ characterizing the noise level when the resonance condition is satisfied. In linear response theory, which is appropriate when the condition $A_0x_m << D$ is satisfied, the approximate expressions for the average amplitude and phase shift read as

$$
\begin{aligned}
\overline{x} &= \frac{1}{m\gamma\omega\omega_b}\frac{A_0\langle x^2\rangle_0}{D}\frac{2r_K}{\sqrt{4r_K^2+\Omega^2}} \ , \\
\overline{\Phi}(D) &= arctan(\frac{\Omega}{2r_K}) \ .
\end{aligned}
\tag{5.4.3}
$$

$\langle x^2\rangle_0$ denotes the variance for the unperturbed noisy system. The distribution of time intervals between hoppings has characteristic peaks at $T = 2\pi/\Omega$ and its integer multiples.

The phase averaged power spectral density $S(\omega)$ defined as the Fourier transform of the correlation function $\langle x(t+\tau)x(t)\rangle$

$$
S(\omega) = \int_{-\infty}^{\infty} exp(-i\omega\tau)\langle x(t+\tau)x(t)\rangle d\tau \ , \tag{5.4.4}
$$

exhibits delta peaks at frequencies $(2n+1)\Omega$ superposed to a noise background $S_N(\omega)$ whereas even multiples of $\Omega$ correspond to dips. This reflects the reflection symmetry of the double potential well. The heights of the spectral spikes behave as $A_0^{2n}$ and since the periodic perturbation is assumed to be weak, it is possible to restrict the consideration to the first spike ($n = 1$). In the linear response theory one obtains following expressions for the noise density $S_N^0(\omega)$, total spectral density $S(\omega)$, and signal-to-noise ratio:

$$
\begin{aligned}
S_N^0(\omega) &= 4r_K\frac{\langle x^2\rangle_0}{\sqrt{4r_K^2+\Omega^2}} \ , \\
S(\omega) &= \frac{\pi}{2}\overline{x}(D)^2\left[\delta(\omega-\Omega)+\delta(\omega+\Omega)\right] + S_N(\omega) \ , \\
SMR &\equiv 2\left[lim_{\Delta\omega\rightarrow 0}\int_{\Omega-\Delta\omega}^{\Omega+\Delta\omega} d\omega\right]/S_N(\Omega) = \pi(\frac{A_0x_m}{D})^2 r_K \ .
\end{aligned}
\tag{5.4.5}
$$

## 5.4.3 Stochastic resonance and neuronal systems

During the last decade stochastic resonance has become a well accepted paradigm in the biological and neurophysiological sciences [21]. This despite the fact that neuronal systems are excitable systems with only single stable ground state and a short-lived excited state with lifetime of order millisecond which can be short as compared to the typical driving frequency. The simplest models effectively assume that neuron is a bistable system. The most obvious functions of the stochastic resonance in neuronal systems are the amplification of weak periodic signals (such as the noise produced by a predator) and temporal coding (say in auditory nerve).

In TGD framework the natural question is whether the stochastic resonance really occurs at the neuronal level or at a deeper control level. If the latter option is correct, the simplest paradigm of bistable system might be enough to model the system.

### Empirical evidence for stochastic resonance in neuronal systems

The encoding of acoustic information on the primary auditory nerve of mammals has been studied for a half century. It has been known that, in contrast to the conventional theory, the information about the frequency of the stimulus is coded also to the inter-spike distribution of the spike sequence. This correlation between neuronal input and output is known as phase locking in neurophysiology and presents one particular form of temporal coding [28]. It is needless to emphasize that various forms of temporal coding and its reverse process are absolutely crucial in TGD based model of qualia.

Longtin, Bulsa and Moss [54] observed that inter-spike interval histograms of periodically stimulated neurons of a cat exhibit a remarkable resemblance to the return time distributions of a periodically driven noisy bistable system with Gaussian noise for which correlation function decays exponentially:

$$\langle \xi(t)\xi(t')\rangle = \frac{D}{\tau_c} exp\left(-\frac{|t-t'|}{\tau_c}\right) \quad . \tag{5.4.6}$$

Return time is defined as the time for the system to be kicked from one well to another and back again. With only one fitting parameter it was possible to achieve an excellent agreement. Neuron is definitely not a bistable system and this forces to ask whether the assumption about the underlying bistable system might make sense at some deeper, controlling level.

Moss and collaborators studied also the behavior of the mechanoreceptor cell of a crayfish [55] by stimulating it with an input consisting of a sum of single tone and noise. The spectral properties of the action potentials were analyzed, yielding a power spectrum typified by a background noise plus sharp peaks at multiples of the frequency of the stimulus. Also signal-to-noise ratio was studied and was found to resemble the shape of the corresponding curve for a bistable system although the resonance peak as function of the noise intensity does not decrease so fast as for stochastic resonance in a bistable system.

Stochastic resonance has been demonstrated to occur also in the hair cell of cricket [50]. In this case the function of the stochastic resonance is to help the detection of a weak periodic signal (a coherent motion of air created by say predator) from a huge noisy background.

### Models of stochastic resonance based on standard neuroscience

Several phenomenological models reproducing the stochastic resonance for inter-spike interval distributions have been proposed.

*1. Neuron firing and Poissonian spike trains*

The simplest model is based on the idea that neuron emits uncorrelated sharp spikes at random times [51] The spiking rate $r(t)$ is however sinusoidally modulated and the specification of $r(t)$ defines the model. One can express the phase averaged spectral density $S(\omega)$ for the spike train as a sum of frequency independent white noise term $\overline{r}$ and sum of delta peaks at frequencies $\omega = n\Omega$:

$$\begin{aligned} S(\omega) &= \overline{r} + 2\pi \textstyle\sum_{n=1}^{\infty} |r_n|^2 \delta(\omega - n\Omega) \quad , \\ r_n &= \textstyle\frac{1}{T}\int_0^T r(t) exp(-in\Omega t) dt \quad . \end{aligned} \tag{5.4.7}$$

The rate theory for noise-induced barrier crossing in the presence of a periodic external force suggest the generalization of the Kramers rate formula for the hopping rate $r_D$ between potential wells to

$$r(t) = \nu \times exp\left[-\tfrac{\Delta V}{D} - \tfrac{A_0 x_m}{D} cos(\Omega t)\right] \quad . \tag{5.4.8}$$

Here $\Delta V$ is the barrier height in absence of forcing, $D$ is noise strength, $A_0$ is the amplitude of the periodic driving force, and the scale factor $x_m$ characterizes the position of the potential well. The pre-factor $\nu$ depends on the details of the process. This formula should make sense for sufficiently low frequencies $\Omega$ (adiabatic approximation).

By calculating the Fourier transform of $r(t)$ one obtains for the signal to noise ratio defined as the ratio

$$SNR = \tfrac{2\pi r_1^2}{\overline{r}} \simeq \tfrac{\pi x_m^2 A_0^2}{D^2} exp\left(-\tfrac{\Delta V}{D}\right) \quad . \tag{5.4.9}$$

Signal-to-noise ratio shows a behavior characteristic for stochastic resonance. The comparison with the data from the mechanically modulated mechanoreceptors of a crayfish shows qualitative agreement with this prediction although the decrease of SNR for large noise levels is overestimated by this model. The parametrization of $r(t)$ is based on the assumption that system is effectively bistable: this is of course not true at the neuronal level.

*3. Integrate and fire model*

Integrate and fire model assumes that the input of the neuron consists of a spike train $i(t)$ (cortical neurons) or a continuous signal (sensory neurons) [52, 18]. The membrane voltage $u(t)$ is obtained by integrating the input $i(t)$ represented as a current through the membrane. By representing cell membrane as a capacitance $C$ and resistance $R$ the equation of motion for the membrane potential reads as

$$\frac{d}{dt}u = -\frac{1}{\tau_{RC}}u + \frac{i(t)}{C} + \frac{\xi(t)}{C} \quad . \tag{5.4.10}$$

Here one has $\tau_{RC} = RC$. Gaussian white noise with a zero mean is assumed. In the case of a perfect integrator ($1/RC = 0$) the Fokker Planck equation for the probability distribution for the potential values as a function of time reads as

$$\frac{\partial P(u,t)}{\partial t} = -\left[i_0 + A_0 cos(\Omega t)\right]\frac{\partial P(u,t)}{\partial u} + D\frac{\partial^2 P(u,t)}{\partial u^2} \quad . \tag{5.4.11}$$

The equation states that probability is conserved for the flow in the phase space defined by $u$ and velocity variable $\partial_t u$. Initial values are $P(u = b, t) = 0$ at threshold stating that particle is absorbed at $u = b$. The rate for crossing is given by $r(t) = dP(u = b, t)/dt$.

The distribution function for the inter-spike intervals is given by the mean-first-passage time distribution $\rho$ which is essentially the probability $P(b \rightarrow b)$ that the random walk in the external driving force leads from the point $u = b$ representing the threshold for nerve pulse generation ends up for the first time back to $u = b$. This probability can be calculated using Wiener integral for a particle performing random walk in the external force field defined by the periodic perturbation at the half-line $u \geq b$. The first passage distribution shows a multi-peaked structure with higher peaks suppressed exponentially. For a sufficiently large stimulus the peaks are located at $t_n = nT$, $T = 2\pi/\Omega$. The heights of the peaks decay exponentially. The peaks heights run through a maximum as a function of the noise strength $D$.

This model is unrealistic for several reasons. For instance, the phase of the sinusoidal stimulus is reset after every spike so that the coherence of the stimulus is eliminated.

*4. Neuron firing and threshold crossing*

One can improve the integrate and fire model by allowing the resistance to be finite and modify it by assuming that the phase, rather than being reset, does not change at all in the emission of a nerve pulse [53, 18]. One can solve $u(t)$ from the previous equation in absence of the noise explicitly by assuming that the amplitude of the driving force is so small that the threshold is not crossed in the absence of the noise. This gives at large values of time

$$u_\infty(t) = i_0 R + \frac{A_0 R}{1 + \Omega^2 \tau_{RC}^2} sin(\Omega t - \phi_{RC}) \quad . \tag{5.4.12}$$

Here one has $tan(\phi_{RC}) = \Omega/t_{RC}$. The presence of the ohmic current induces the reduction of the threshold to $b - i_0 R$. Gaussian colored noise is assumed to cause the crossing and the generation of the nerve pulse, which is for simplicity idealized with a delta peak.

The problem of calculating the rate for the threshold crossing can be formulated mathematically as a random walk on half line $u \geq b$ in presence of an external force using a semiclassical approximation for the Wiener integral over all paths. This means a functional integration over small perturbations of an unperturbed solution to give the probability $P(t)$ that an arbitrary path of the particle leads to the threshold $u = b$ during time interval $t$. The rate $r(t)$ for the threshold crossing is given as $r(t) = dP(t)/dt$. In [53] $r(t)$ the threshold crossing rate is estimated for a colored Gaussian noise and one finds stochastic resonance also now. The formulas are not reproduced here: the interested reader can find them in [18].

This model effectively assumes that the membrane potential is driven by an external driving force and that the phase of the membrane potential is not appreciably affected by the emission of the spikes. This is consistent with the idea that there is some deeper control mechanism giving rise to the stochastic resonance and that neural level is only the controlled level.

### 5.4.4 How neuronal stochastic resonance could be realized at quantum level?

There is no doubt that neuronal systems exhibit stochastic resonance. The excellent fit of the inter-spike interval distribution by a return time distribution for a bistable system in the case of the auditory nerve of a cat suggests that genuine bistable system might be somehow involved. It is however not at all clear whether it is possible to understand the emergence of the stochastic resonance without leaving the framework of the standard Hodgkin-Huxley theory.

1. Neuronal systems are excitable media rather than bistable systems and it is not at all obvious whether excitable media allow stochastic resonance.

2. The time scale for the return of a neuron to the resting state is of order milliseconds and can be much shorter than the period of the driving external force. Thus the intuitive picture behind stochastic resonance need not make sense at neuronal level. Perhaps one should turn the attention to a more fundamental level, and interpret nerve pulse activity as a result of quantum control with the bistable system to be identified acting as a control system.

The previous model for sensory receptor applied to hearing suggests that perhaps a plausible model of stochastic resonance could be obtained by including besides neurons also a system able to represent sensory input as evoked potentials giving rise to cognitive and/or emotional representations in the manner discussed. This system could be sensory receptor such has hair cell or an aggregate of glial cells (the possible role of astrocytes for brain functioning has been discussed earlier in [K6]).

As found, periodic signal and white noise affecting bistable system are the key factors in the stochastic resonance. Astrocytes would induce the spiking of nearby neurons whereas spike activity and/or microtubular input would generate perturbations of the astrocyte membrane potential which might perhaps idealizable as a white noise. In the case of sensory receptor the source of white noise could be neuronal and/or microtubular back projection.

The basic prediction is that the frequency of the stochastic resonance has an exponential sensitivity to $1/D$, where $D$ characterizes the intensity of the white noise assumed to be generated by the neural activity. The noise level should correlate with the average firing rate if neurons are responsible for the white noise. Also microtubular white noise could be induced by the neuronal firing. The intensity of the white noise should be under automatic or conscious control so that important frequencies could be spotted out from the sensory input by "tuning to the correct wavelength" by varying the level of (possibly neural) noise. The reduction of the resting potential generates higher level of spontaneous firing so that the level of alertness would correlate directly with the value of the spotted frequency for neural noise option.

In the case of sensory organ the oscillatory signal would be contained in the sensory input represented as an evoked potential. In the case of astrocytes the oscillatory signal would be contained to the sensory signal mediated by microtubuli inducing oscillating evoked membrane potentials $V$. For hearing $V$ could represent electric counterpart of a sound wave with a well-defined frequency. $V$ would affect also $k_{em} = 3$ level EEG since it would appear as an additive component in membrane potential besides membrane voltage. Stochastic resonance should transform a frequency associated with the sensory input $V$ to a peak frequency in the autocorrelation function for spikes so that spike interval distribution would reflect the frequency of the sensory input and its harmonics.

The bistable system would consist of the astrocyte-aggregate and neuron group. Glutamine-glutamate cycle for astrocyte-neuron interaction could relate closely to the bi-stability. The first state of this system would correspond to a situation in which astrocyte aggregate activates glutamate-ergic neuron group and second state to a situation in which this neuron group activates the glutamine-ergic astrocyte aggregate. Quantum entanglement induced by $W$ ME having $W$ exchanges as correlate could mediate a transition between these two states.

Also sensory receptor could serve as a bi-stable system. The transition between the two states would proceed by charge entanglement induced by $W$ ME and the two states would transform to each other by the exchange of $W$ bosons and would have different exotic ionizations and weak or color charges.

## 5.5 Temporal codings

An impressive evidence exists for the temporal coding [28] despite the fact that the dominant view has for long time been that rate coding is all that is involved. The vision about MEs as quantum holograms suggests that nerve pulse patterns are coded to the pulse patterns of the light-like current along ME.

### 5.5.1 TGD based overall view about temporal codings

The following is a summary about TGD inspired attempt to build an overall view about temporal codings.

1. The prevailing neuro-scientific view is that the resonance frequencies of EEG can be assigned to resonances in neural circuits. In TGD inspired picture nerve circuits are not necessary and there are reasons to believe that this kind of resonances are too wide to explain kHz resonances frequency or even sharp EEG resonances.

2. For neurons the rate coding for the intensity of the sensory input is certainly fundamental and would realize genetic code by allowing maximum flexibility. 10 Hz alpha rhythm would specify uniquely the time intervals containing the genetic codons. The discrete value of the firing rate expressed as the number of spikes per period of 10 Hz alpha wave would realize genetic codon as an integer $n \leq 63$.

3. The above discussed "note" and "phoneme" representations defining emotional and cognitive representations would be realized as temporal patterns of evoked potentials at the level of sensory receptors and glial cells. Also now genetic or even memetic code could be realized in case of speech like representations. For these representations the EEG at level $k_{em}+1$ modulates the Josephson frequencies and thus generalized theta and beta frequencies at level $k_{em}$ but not generalized alpha frequencies or their harmonics. Features include also spatial modulation patterns.
   i) At neuronal level temporal coherence allows only $k_{em} = 2$ representation modulated by $k_{em} = 3$ level for which the lowest modulating frequency is around 1 kHz so that nerve pulses do not destroy the modulation patterns.
   ii) Sensory organs would correspond to $k_{em} = 3$ Josephson frequency $2 \times 10^4$ Hz modulated by EEG frequencies.
   iii) The cortical representation of audible frequencies above 1 kHz requires representations using evoked potentials of glial cells and microtubular transfer of sensory input as acoustic/electric oscillations of microtubuli to the glial cells is a necessary prerequisite of this representation. The cortical feedback via outer hair cells expands the audible frequencies above 1 kHz in the case of mammals and makes possible the representations of EEG frequencies as modulations of the Josephson frequency $2 \times 10^4$ Hz of $k_{em} = 3$ EEG. The aggregates of glial cells would correspond to $k_{em} \geq 3$. Short term memories would correspond to $k_{em} = 4$ with 5 Hz Josephson frequency modulated in the time scale of short term memories. This representation would emerge in frontal lobes.

4. Also the coding of (say sound) frequencies based on spike interval statistics is supported by experimental findings and is possible for frequencies below 1 kHz. This representation might be induced from the above discussed representation at the level of glial aggregates and sensory receptors via stochastic resonance. Periodic signal and white noise affecting bistable system are basic elements of stochastic resonance. Astrocytes induce the spiking of nearby neurons whereas neuronal noise affects astrocytes. Suppose that astrocytes receive also sensory signals mediated by microtubuli inducing oscillating evoked membrane potentials $V$ of astrocytes.

   Stochastic resonance would transform $V$ to a peak frequency in the autocorrelation function for spikes. Glutamine-glutamate cycle for astrocyte-neuron interaction could define the neuron-astrocyte interaction. The bistable system would be the complex formed by the astrocyte-aggregate and neuron group. The first state of this system would correspond to a situation in which astrocyte aggregate activates glutamate-ergic neuron group and second state to a situation in which this neuron group activates the glutamine-ergic astrocyte aggregate. Quantum entanglement induced by $W$ ME having $W$ exchanges as correlate could mediate a transition between these two states.

5. Also spike patterns can affect EEG. Neuronal spikes would kick the penduli defined by the aggregates of glial cells. If the kick realized as a perturbation of the membrane potential tends to occur simultaneously and with the same phase as the extremum of the oscillatory voltage perturbation in Josephson current through astrocyte membrane, the corresponding oscillatory perturbation will be amplified.

6. That neural transmitters and modulators could control resonance frequencies in neural circuits is also a natural hypothesis in neuroscience context. Neural transmitters and modulators can affect average firing rates and also the intensity of neural activity experienced by glial cells as white noise and thus control the stochastic resonance frequency for glial cells. A selection of preferred frequencies by controlling the intensity of neural noise would be in question rather than the generation of resonance frequencies.

### 5.5.2 As if time really mattered

Not only physics, but also neuroscience is plagued by the tensions caused by the erratic identification of the subjective time with the geometric time. There are two views about how nerve pulses patterns code for the sensory data. The first, and still dominating, view is that firing frequency codes for the intensity of the sensory experience. Competing view is that temporal patterns of nerve pulses code for the sensory information (fore a review see [28]).

In TGD framework first approach can be seen as emphasizing the dynamics with respect to subjective time whereas temporal patterns with respect to geometric time are neglected. Both memetic code and spectroscopy of consciousness rely crucially on temporal patterns with respect to geometric time. Hence these approaches are in conflict with the standard view about time. The approach based on temporal coding in the framework of the classical field theory forgets the dynamics with respect to subjective time and concentrates on the dynamics with respect to the geometric time. One however ends up with philosophical paradoxes circulating around time-frequency uncertainty relation: it is difficult to understand how communication is possible at all in deterministic classical world.

Quantum jumps between quantum histories view fuses both of these approaches to a more general unified description. The excellent review article "As if time really mattered: Temporal strategies for neural coding of sensory information" by Peter Cariani about temporal coding will be referred to several times in the following discussion. This article also reviews the difficult problems of frequency coding approach [28].

### 5.5.3 Rate coding contra temporal coding

Rate coding is the dominating view about the representation of the sensory data in neuroscience and most neural net models rely on this approach. The approach is based on three assumptions.

1. Rate coding is the whole story: the average rate of firing defined by an interval with duration of ten to few hundred milliseconds codes the intensity of the sensory input.

2. Everything is ultimately coded into spatial patterns and spatial rate differences somehow code all relevant sensory information. The standard coding relies on rate-place scheme: average firing rate increases along one-dimensional axis. In TGD this hypothesis is generalized in the sense that brain is assumed to build miniature virtual world model of the space-time and that magnetic transition frequencies code for the values of the spatial and temporal coordinates.

3. A further element is connectionism: in some manner the architecture of the neural pathways gives rise to qualia associated with it.

Geometric time is completely absent from rate-coding based model of brain. This is what mere quantum statistical determinism neglecting the notion of quantum history and the physics of the classical em fields associated with them would leads to. In particular, EEG is mere epiphenomenon in this approach. What makes the situation so problematic is that neural net models describing information as purely spatial patterns can always reproduce the observed behavioral patterns by brute force by introducing a sufficiently complex neural network. From modelling perspective this might be nice but need not have anything to do with how Nature does it. The situation has been however changing during the last decade. The observations about the correlations of EEG patterns with conscious experience, the successes of neurofeedback [45], the realization of the potential importance of 40 Hz coherent oscillations in binding, and a rigorous experimental proof for the temporal coding of odors [46], are forcing the view about brain as a system in which classical em fields are important.

Temporal coding provides alternative and much more general approach but, as already noticed, has also its problems which relate to the fundamental confusions about the relationship between geometric and subjective time. There is empirical evidence for the occurrence of temporal coding in virtually every sensory system [28]. One can imagine many temporal coding mechanisms but the most important ones rely on spike interval statistics and latency-place representations.

Temporal coding provides solutions to the three basic difficulties of the rate coding paradigm: contrast degradation problem, pattern recognition problem and multiple object problem or "superposition catastrophe". Contrast degradation implied by the saturation of the firing rates at high stimulus intensities. Good example of pattern recognition problem is related to the perception of pitch. Same pitch can be generated in very many manners: by monochromatic sound; by a sequence of clicks; or even by a superposition of multiples of fundamental frequency not involving the fundamental frequency itself as in the case of periodic pitch phenomenon. It is very difficult to understand how the stimulus coded to a spatial representation based on mere firing rates could even contain the information needed to decode the pitch. For temporal coding these problems are almost trivial [28]. Superposition catastrophe is identity problem for different objects of perceptive field. For instance, how it is possible to identify the sound of a familiar person in large crowd of people or distinguish transparent object from a nontransparent one, and how it is possible to group sensory inputs to form objects of perceptive field? In temporal coding approach common temporal structures allow to define objects of perceptive field: for instance, points of perceptive field moving in the same direction or behaving synchronously belong to the same object.

### 5.5.4 Spectroscopy of consciousness favors spike-statistics coding

The idea about temporal coding by spike-interval distributions or by some other distribution of time scales associated with the nerve pulse patterns (say intervals between spike bursts) resonates strongly with the spectroscopy of consciousness idea.

#### Spike-interval statistics and EEG

Nerve pulse patterns are ideal for stimulating EEG waves with desired transition frequencies. This stimulation mechanism is rather robust since ELF selves can carry only harmonics of characteristic fundamental frequency and the only thing needed is that 'kicks' to the em pendulum are given at correct half period. It is not necessary that spike patterns associated with subcortical cells excite EEG waves: it could occur and probably occurs also at the level of cortex. Several experiments described in [28] however suggest that coding could occur also at subcortical level. If this is really the case and spectroscopy of consciousness makes sense, one could perhaps deduce the values of various transition frequencies by studying spike-interval distributions of nerve fibers from sensory organs. Also the identification of ions serving as candidates for various types geometric qualia becomes possible. The basic hypothesis could be also tested by electrical stimulation of sensory pathways by these frequencies and by finding how the change of these frequencies affects conscious experience.

#### Multiplexing

Superpositions of the harmonics of different transition frequencies would represent temporally orthogonal messages. It is known that EEG decomposes to sum of two parts: the part consisting of relatively few fundamental frequencies and their harmonics and the quasi-continuous part, 'noise'.

Both the amplitudes of harmonics and fundamental frequencies fluctuate. The properties of spike interval distribution should be consistent with this decomposition.

**Broadcasting**

Broadcasting is possible: the same message or superposition of messages can be send as em or $Z^0$ waves and only those parts of brain which contain macroscopic quantum phases woken-up by the frequencies present in the message react to the message. This kind of communication mechanism would provide a mass media type communication mechanism depending only weakly on the connectivity of the neural circuitry. Brain as a neuron society metaphor indeed supports the view that besides neural chatting also mass communications are important. In particular, mass communications might be involved with the synchronous firing of the neuron groups. Combined with the possibility of simultaneous superposition of various data in EEG pattern, broadcasting mechanism replaces the rather poorly defined problem of computing the representation of the external world from spatial firing rate patterns by direct experiencing. The computational problem is transformed to understanding how experience of, say, motion is represented by magnetic quantum phase transitions. Of course, the very assumption that computation gives rise to conscious experience is completely ad-hoc hypothesis.

**The role of transmitters and modulators in generating correct EEG frequencies?**

The recovery periods for neurons vary from milliseconds to seconds. Recovery time can be affected by neurotransmitters as well as neuro-modulators. Many axons [28] show triphasic recovery period consisting of refractory period, super-excitable phase and depression phase. Clearly, neuron favors inter-spike intervals for which the next spike arrives in neuron during super-excitable phase. Many-levelled hierarchy of neuronal pathways could thus serve as a sequence of sieves selecting preferred frequencies. Emotions are known to affect strongly the information processing in brain but not to alter the information content. Neurotransmitters and neuro-modulators could control the frequency ranges favored by neurons and thus they would ultimately control the structure of EEG and thus also contents of consciousness. For instance, neuro-modulators realizing emotional modulation chemically could induce temporal scaling of the typical firing patterns generated by neuron but preserving frequency ratios. It is known that 'hippocampal theta frequency' varies in wide limits [43] and that its value correlates with the state of arousal [33].

**Resonant generation of complex motor activities?**

There is also the fascinating possibility that single EEG frequency generates complex field eigenmodes at relatively large space-time sheets and that these modes induce complex self-organization patterns giving rise to the basic building blocks of motor actions. If this is really the case, then EEG frequencies could serve as names for self-organization processes. This idea is of course not new and is expressed eloquently already by Ernst Mach [28].

Perhaps a more feasible option is that superposition of EEG frequencies each coding for a particular spatiotemporal position in the virtual world of brain excites neuron in that particular position and this leads to the generation of a complex spatiotemporal pattern amplified to motor action by puppet in string mechanism.

### 5.5.5 Objections against temporal coding can be circumvented in TGD framework

There are several objections against temporal coding which all involve in an essential manner the relationship between subjective and geometric time.

1. If t=constant snapshot represents the reality, as believed in standard quantum physics, the inclusion of frequencies and temporal patterns does not make sense except phenomenologically. In TGD approach the problem disappears since quantum states are quantum histories. The quantum jump sequence represented by a nerve pulse pattern corresponds to subjective time development as hopping between geometric time developments characterized by EEG patterns. Each nerve pulse affects slightly the EEG pattern.

2. The coding of nerve pulse patterns to EEG frequencies requires high regularities for the spike patterns but there is no guarantee that spike patterns are regular enough in the primary sensory cortex. Also this counter argument melts down. In TGD framework nerve pulse pattern as such does not characterize the EEG pattern but only helps to induce and amplify Fourier components at certain EEG frequencies. Nerve pulse patterns are like kicks to an oscillating pendulum resetting it. When the kick gives the pendulum impulse in the same direction as the momentum of the pendulum, it amplifies the motion but leaves oscillation frequency and harmonic character of motion unaltered in harmonic oscillator approximation (in the case of EEG harmonic approximation is excellent). All that is needed is that nerve pulse is in the half period of duration $T/2$ if $T$ is period for the EEG wave to be stimulated. Thus the coding mechanism is extremely robust and explains why spike-interval statistics correlates so nicely with sensory experience generated by nerve pulse pattern.

3. The kick changes the phase of the pendulum and this means that the Fourier spectrum representing the motion of the pendulum receives higher harmonics although the behavior after kick could be purely harmonic oscillation. This phase increment could be responsible for the observed loss of synchrony accompanying arousal. If the kick corresponds to quantum jump it could only replace EEG Fourier component with a new one such that phase shift occurs also in the geometric past: very limited number (if any) of higher harmonics would appear. EEG component would however suffer phase shift with respect to other EEG components and this would lead to the loss of synchrony. Loss of synchrony is indeed signature of conscious information processing in cortex. As already noticed, temporal phase shift of spike patterns with respect to hippocampal theta frequency has been observed in the hippocampus of rat and might code the motion of rat with respect to surroundings [43]: motion would be mapped to a sequence of kicks given to pendulum.

This raises the question whether EEG record represents the EEG spectrum associated with the space-time surface generated in the last quantum jump or whether it is some kind of an average over the EEG spectra over quantum jumps. If the recording of EEG is completely automatic process, it is updated in every quantum jump and represents EEG at the space-time surface generated in the last quantum jump and, rather paradoxically, is therefore changing all the subjective time. The experiments of Radin and Bierman support this view [56]. Also the experiments related to the timing in active aspects of consciousness suggest that the EEG of the past changes in the interval which is a considerable fraction of second [38] and long time scale compared to the millisecond time scale of nerve pulse patterns.

### 5.5.6 Spike interval coding

Spike interval statistics codes information in the temporal pattern. This information can be information about the temporal or spatial pattern of the sensory stimulus (audition, vibratory sense) or about the non-geometric quale (this might be the case in the case of color vision, tastes and odors).

Empirical data support following type of spike-interval coding. The dominating time interval $\Delta T$ in the spike sequence codes for the heard frequency below kHz: $f = 1/\Delta T$ in the case of audition. The intensity of experience is measured by the ratio of the power in dominant interval to the power in non-dominant intervals [28]. These relationship holds in more general case. This code gives frequency coding by averaging.

The nice feature of temporal coding mechanism is the possibility of multiplex coding: same nerve pulse pattern can contain simultaneously several messages represented by spike patterns which are mutually orthogonal with respect to the inner product defined by Fourier transform. For instance, information about color, shape and temporal pattern of illumination might be coded as a superposition of nerve pulse patterns. In the following some well established examples about this mechanism [28] are discussed.

*1. Hearing*

Hearing involves both spatial coding of frequencies in the sense that special points of cochlea are especially sensitive to frequencies around the center frequency. This is not however the whole story. Rather, it would seem that this frequency serves only as a carrier frequency for amplitude modulated messages generated by the pattern of nerve pulses. The spike sequences for nerve fibers specialized to a given center frequency contain spike intervals which code for various qualities of sound like pitch, timbre and phonemic identity. Rather remarkably, the spike distribution of single nerve fiber contains enough information about speech to make possible speech recognition [28].

In the phenomenon of periodic pitch superposition of the harmonics of fundamental frequency, which is not itself present in the superposition, generates experience of pitch at the fundamental frequency. Periodic pitch has also visual counterpart which can be understood as coding of the visual textures along lines to temporal patterns by scanning. Periodic pitch can be understood if one assumes coding of the temporal patterns to spike patterns. The point is that any superposition of Fourier components not containing constant term is periodic function with a period determined by the fundamental frequency and must have at least one zero in the period since the integral of this function vanishes and must therefore change its sign at least once in the period. Thus sensory stimulus vanishes at least once during the period which means that threshold crossing occurs periodically and generates spike train. This periodicity in turn implies that also EEG contains the fundamental frequency. In TGD framework this argument is not quite enough since nerve pulse patterns are not directly responsible for the experienced pitch. The feedback from cortex via outer hair cells to the inner hair cells is needed to generate fundamental frequency as artificial auditory input.

Two visual/auditory/tactile stimuli are experienced as separate if the time interval between them is longer than 25 ms/.01 ms/5 ms. For hearing the time interval is by a factor 1/100 shorter than the millisecond time scale of nerve pulse which suggests that nerve pulse patterns cannot code for the high frequency part of the auditory stimulus. The representations of the auditory stimulus as evoked potentials at hair cells and glial cells would resolve the problem.

*2. Tactile senses*

Humans can perceive vibrations applied to skin in the range $5 - 1000$ Hz. The so called rapidly adapting receptors code for 5-100 Hz frequency range whereas Pacinian corpuscle receptors code for 30-1000 Hz. There is evidence that this ability relies on or at least involves spike statistics coding. The temporal patterns of the vibratory stimulus are evident in the temporal discharge patterns of all units at all stations in the ascending somatosensory pathway. In TGD framework the spike patterns would reflect the deeper coding in terms of glial evoked potential patterns.

It is known that the ordering of the inter-spike intervals is disrupted by jitter along neural pathway to cortex. If inter-spike distribution is not changed too much, spike sequence can excite magnetic transitions inducing the emotional and cognitive representations at magnetic bodies associated with groups of glial cells. Note that the loss of information about temporal ordering is not important for our sensory experience which is temporal average over quantum jumps over time interval of at least .1 seconds as suggested by the fact that temporal resolution of sensory experience is about .1 seconds. If the time separation between visual,auditory, or tactile stimuli is above 20 ms, their temporal ordering can be perceived correctly. It could be however that the reaction to the sensory input is associated with some lower level self and that at our level averaging over longer time scale occurs.

Spike interval codes has also been reported for pain, touch, temperature and nociception (for more details and references see [28]). These modalities are highly emotional which suggests that higher harmonics code for emotional content whereas fundamental codes for the basic quale.

*3. Chemical senses*

Odor discrimination relies on spatiotemporal coding of odors [46]. The facts about olfaction and gustation does not fit well with the hypothesis that connection structure of the neural pathway somehow codes for the quale. This hypothesis requires that the connection structure should be more or less static. Both taste buds and olfactory neurons have limited lifespans. Cells of taste bud move from center to boundary during the life cycles and are innervated by different axons during their life cycle. In TGD framework these problems disappear.

Taste discrimination experiments [28] have demonstrated that electrical stimulation using the spike patterns stimulated by odorant reproduce the emotional expressions following the perception of the real odor. When temporal pattern is changed by keeping firing rate same, emotional response disappears. This is consistent with the assumption that emotional representations experienced by us are realized at the level of glial cells and that neuronal spike patterns are enough to excited the frequencies involve with these representations. Second type experiments demonstrate that electrical stimulation of an individual taste bud generates taste experience. This would suggest that the frequency giving rise to taste quale is excited automatically by the sensory stimulus and that each cell of taste bud generates it own primary taste.

*4. Vision*

In the case of vision there is psychophysical evidence for the temporal coding of color, texture and form. Color sensations can be produced using achromatic temporal patterns. Any color can be induced by the appropriate pattern of luminal changes. Benham's top is a famous device used to achieve this. Also electric stimulation of retina can directly induce color sensations. In TGD framework the color sensation should result from the back projection from glial cells to the sensory receptors induced by the achromatic temporal pattern communicated to glial cells and would involve genuine generation of photons which could be also dark photons. One can also imagine that the de-coherence of $k_{em} = 4$ dark EEG photons at frequency range 27-47 Hz could generate color stimuli (wavelengths in the range 400-700 nm). 10 Hz dark EEG photons could be assignaed to the so called dark current oscillating at 10 Hz frequency and present even in darkness and giving rise to neural activity: in this case de-coherence would generate infrared light.

In TGD framework color qualia could be seen as coding spatial gradients of the illumination at a particular wavelength (in consistency with the color constancy phenomenon) to subjective experience. The saccadic motion of the eye would code a spatial change in the illumination to a subjecto-temporal gradient represented by the increments of appropriate color quantum numbers in quantum jump. This phenomenon is related to the color sensations stimulated by suitable frequency patterns of achromatic illumination [28]. What would happen that some colors present in the achromatic illumination would be amplified more than others. How precisely the coding of spatial illumination gradients to color qualia occurs is a challenge for TGD approach but it seems obvious that classical color gauge fields accompanying always classical electromagnetic fields must be an essential element of this coding.

If color is indeed experienced and coded to modulations of $k_{em} = 3$ Josephson frequency by EEG frequencies in retina, also multiplex coding suggests strongly itself. Color could be coded to the pitch of the modulation of Josephson frequency.

Scanning and saccadic motion suggests itself as a fundamental mechanism generating at neuronal level temporal maps of the surface texture. Each line of the perceptive field scanned by the saccadic motion could give rise to spikes at those moments when the line is crossed by the saccadic line. Neighboring neurons would in turn code the direction of the line to the direction of a line in space-time-plane: line would be like space-time orbit of particle. There is empirical evidence for multiplex coding of information about visual form and color (for more detail and references see [28]). Also information about changing illumination seems to be coded into spike-statistics.

### 5.5.7 Latency-place representations

Latency-place representations use relative time-of-arrival differences to code information about the intensity of the sensory stimulus. Since latency typically decreases with intensity, the contrast degradation problem is circumvented. As absolute latencies decrease, so do the variances of latency distributions. Latency differences can be amplified more centrally by lateral inhibition since the impulses can excite inhibitory units which can inhibit regions surrounding the region with the shortest latency. This mechanism might be involved with the generation of space-time sheets representing objects of perceptive field. Variants of the latency-place representation can be involved with vision (motion perception), electroception, auditory, somatosensory, olfactory and gustatory systems.

Co-incidence detection is basic mechanism related with the formation of latency-place representations for position or direction. There is evidence that pyramidal neurons in cortex apply co-incidence detection [28]. In the case of hearing, which is the most studied case, co-incidence detection occurs in brain stem. In many vertebrates, inter-aural time differences are used to deduce the azimuthal direction of the sound source at frequencies above kHz whereas at lower frequencies phase differences between waves entering into separate ears are used for this purpose. The general mechanism uses pathways from corresponding positions of right and left ear to an array of co-incidence detectors in brain stem such that the length difference for the pathways varies linearly with the array coordinate. Only that part of array fires for co-incidence for which the delay caused by the length difference between right and left pathways compensates the time lapse between signals to separate ears. The time difference for the arrival times of the signal to two ears is thus coded to spatial coordinate and this coordinate represents information about azimuthal angle characterizing the direction of the sound source.

It is interesting to notice that music metaphor reflects itself also at the level of brain anatomy [28]. Brain resembles piano in that distances along axes coding different temporal or spatial frequencies depend logarithmically on frequency ratios: this guarantees the invariance of the sensation with respect to the scaling of frequencies. It might have also something to do with the hallucinatory states in which objects of the external world are perceived as gigantic or miniature sized: perhaps hallucinatory state leads to anomalous frequency-scales for some objects of the perceptive field.

In TGD the comparison of parallel supra-currents representing sensory inputs to be compared makes possible co-incidence detection at quantum level. When two identical supra currents flowing in parallel super conductors and forming Josephson junctions enter at same time they are in the same phase, resonant Josephson current is generated and wakes up sub-self giving rise to mental image about co-incidence and also generates nerve pulse activity giving rise to further experiences.

### 5.5.8 Why ELF MEs are scanning the cortex?

Alpha waves are known to move along the skull in the anterior-posterior direction with a velocity of about 7 m/s, whereas the alpha waves along the surface of the cortex propagate with a velocity of about 14 m/s [47]. There is evidence that also 40 Hz EEG waves propagate in a similar manner along cortex. The intuitive guess is that this motion corresponds to a scanning analogous to the saccadic motion. A fractal hierarchy of scannings with varying time and length scales is indeed what one might expect. The findings of Revonsuo [39] show that the increase of the intensity of 40 Hz EEG wave is associated with the appearance of a new mental image (holistic pattern of an auto-stereogram in the experiments of Revonsuo) rather than with the mere presence of the mental image. A possible underlying mechanism was discussed in [M1].

In the case of saccadic motion the scanning detects spatial and temporal gradients in the texture and illumination and transforms them to the increments of zero modes and of quantum numbers so that geometric and sensory qualia result. Perhaps the scanning of the cortex is in some sense a scaled up version of the saccadic motion. The scanning would detect geometro-temporal gradients implied by the appearance of a space-time sheet representing a new symbolic representation, and yield a sensation of surprise as the simplest outcome. The scanner could be our personal magnetic magnetic body. The scanning would involve MEs inducing membrane oscillations and/or nerve pulse patterns in turn inducing EEG MEs at cyclotron frequencies.

A possible mechanism of scanning is based on the variation of time dependent classical $W$ field in direction transversal to $W$ ME (and parallel to cortex) inducing a transverse motion of surfaces at which $W$ field intensity is constant. Also the propagation of $Ca^{++}$ waves and nerve pulse conduction could rely on this mechanism.

### 5.5.9 p-Adic transition frequencies and EEG

The generalization of the fundamental p-adic length scale from $l \simeq 10^4$ Planck lengths to a hierarchy $\lambda^k \times l$, where $\lambda$ depends on the p-adic length scale logarithmically and satisfies $\lambda \simeq 2^{11}$ for electron's p-adic length scale ($p = 2^{127} - 1$), means that not only p-adic time scales but also their dark variants define fundamental time scales as natural durations of cognitive codons. Dark matter hierarchy implies also that small-p p-adicity becomes possible even in macroscopic length and time scales and might help to explain why the periods associated with population dynamics tend to be prime multiples of year.

It is quite possible that these time scales can be also realized as cyclotron periods. The realization of genetic codons as the number of spikes per period of alpha wave would represent example of this. The time intervals between cognitive codons can however vary as long as the beginning and/or end of the codon is specified using some kind of start/end bit(s). This would conform with the extreme flexibility of human language. The model for p-adic cognitive codes assumes that also the time scales $T(n,k)/k$ , $k$ prime, of the p-adic timescales define fundamental time scales. Note that 2-adic fractality suggests that p-adic cognitive codons corresponds to octaves of the p-adic frequency $f(n,k) = \hbar/T(n,k)$.

There are several numerical coincidences suggesting that the p-adic length scales associated with $k = 5_2^3, 251, 2^8,\ 127_2, 257, 131_2$ defining fundamental p-adic time scales in EEG range are directly involved with our consciousness. The dark variants of these time scales are not discussed here but might also be important. The table 2 of section 2 listing various primary p-adic time time scales helps to follow the discussion.

In the following all cyclotron frequencies correspond to $B_{end} = .2$ Gauss assignable to dark $k = 169$ flux sheets with $\hbar = 5\hbar_0$ and carrying magnetic flux $2h_5 = 10h_0$. The radius of tubular flux sheets of this kind would be 25 $\mu$m, the size of a large neuron.

1. The level $k = 5_2^3 = 125_2$ corresponds to the frequency $f = 40$ Hz defining the thalamocortical resonance frequency which is of central importance for sensory consciousness in wake-up state. For $k = 251$ the frequency 28.3 Hz associated with $k = 251$ level corresponds to the lower end of gamma band. It is also the resonance frequency of dog's cortex stimulated by sinusoidal light wave [47].

2. The secondary time scale $T_2(127) = .1$ seconds corresponds to $f = 10$ Hz which is average alpha frequency and defines fundamental biological clock. This frequency is also the fundamental associated with the memory recall and storage circuits involving hippocampus and it has been suggested that .1 seconds serves as time quantum in memory circuits [48]. Also harmonics of 10 Hz are present in EEG spectrum: in particular, the fourth harmonic 40 Hz.

3. $k = 2^8$ corresponds to $f = 5$ Hz. Josephson frequency $f_J = 5$ Hz at $k_{em} = 4$ level of dark matter hierarchy explains the narrow EEG resonances at 3,5,7 and 13,15,17 Hz [47] as satellites of cyclotron frequencies in alpha band [M3]. It is known that during mental calculations 5 Hz theta frequency is activated [47]. A possible interpretation is in terms of the scaled down cyclotron frequency 10 Hz assignable to the magnetic flux sheets traversing genomes in right hemisphere and carrying magnetic field $B = B_{end}/2 = .1$ Gauss [M3]. $4 - 5$ Hz frequency band is indeed known to be important frequency band in EEG and could correspond to the scaled down alpha band. Also the cyclotron frequency of $Co_+$ ion is 5 Hz.

4. $k = 257$ correspond to the basic frequency $f = 3.5$ Hz which is the lower end of the (hippocampal) theta band. There are intriguing coincidences supporting the hypothesis is that this level corresponds to a transpersonal level of consciousness.

   i) Second harmonic of this frequency is about $f_2 = 7.1$ Hz and corresponds to the upper end of the (hippocampal) theta band. $n = 3$ harmonic corresponds to $f_3 = 11.0$ Hz. Quite recent experiments of Mark Germine [57] provide evidence for the notion of ELF self and associated collective memory. What was studied was the evoked EEG response to a series of random quantum stimuli which consisted of series of identical sound stimuli with randomly located deviant stimulus. Two subject persons, A and B, were involved. In the case that A observed the differing stimulus 1 second before B, the evoked EEG response of B became incoherent. Since evoked stimulus was oscillation at EEG frequency of about 11 Hz in the case that A had not observed the stimulus, one could understand the mechanism as a direct evidence for transpersonal $k = 257$ 'ELF ME' interacting with brains of both A and B. When transpersonal ELF ME had already heard the stimulus once, it did not react to it in similar manner.

   ii) $n = 4$ harmonic $f_4(257) = 14.1$ Hz is the frequency associated with sleeping spindles. $f_4(257)$ should have same role for the sensory processing at transpersonal level as $n = 4$ harmonic $f(127, 2) = 40$ Hz has at the level of sensory processing at personal level. A possible interpretation is that the activation of these frequencies is associated with the shift of attention from bodily sensory input to transpersonal 'sensory input'. This suggests that sleep state is a state in which attention is shifted to the transpersonal $k = 257$ level. The fact that $k = 257$ fundamental frequency is at the lower end of theta band is consistent with the fact that theta waves dominate during sleep.

   iii) Meditative and creative states of consciousness involve enhanced alpha and theta activity. A fascinating question is what happens in physical death. If we are really selves with at least the size of Earth, physical death could mean only that attention is redirected from body level to higher transpersonal levels or to some other form of bio-life so that there would not be actually no real death (note that several selves can direct their attention to the same physical body and same self could even share its attention between several physical bodies!)

5. The secondary time scale $T_2(131) = 1.6$ s corresponds to the frequency .63 Hz which could be identified as lower end for delta band. Rather interestingly, the development of child involves gradual shift of the peak frequencies from delta band to alpha band during first ten years of

life: as if the development of individual would mean gradual shift of attention from higher transpersonal levels of consciousness to lower levels. Of course, this shift could also reflect the fact that higher harmonics associated with transpersonal levels begin to dominate of lowest harmonic. Perhaps reincarnation occurs gradually!

### 5.5.10 Do brain areas correspond to particular EEG resonance frequencies?

The scaling law of homeopathy inspires the guess that the information processing hierarchy, which starts from the primary sensory organs and contains besides sub-cortical nuclei also primary, secondary, etc... sensory areas, corresponds to a hierarchy of increasing EEG resonance wavelengths. This is consistent with the idea that primary, secondary and higher sensory areas of the cortex correspond to the periods of the periodic table in increasing order such that gamma band corresponds to the primary areas. Similar hierarchy should be realized at the motor areas.

This hierarchy should be realized dynamically by resonantly amplifying the EEG MEs with fundamental frequencies near the resonance frequency associated with a particular brain area. Neural circuits generating nerve pulse patterns, whose autocorrelation function contains the resonance frequency, could form a part of the mechanism. Alfven resonance could be even more important. If the magnetic flux loops associated with the magnetic body of a given brain area have a particular length $L$, one expects that the ELF MEs passing around the magnetic loop acting as a wave guide are amplified, when the fundamental frequency of the ELF ME satisfies certain resonance condition. This passage might involve several reflections but one might hope that only single curvilinear ME parallel to the magnetic flux loop acting as an Alfven wave guide is needed. In this case the length $L$ of the magnetic flux tube would correspond to the resonance frequency $f = c/L$.

The generalization of this argument to the case of super-canonical resonance frequencies would suggest the following scenario.

1. Primary sensory areas correspond to tertiary excitations of $k = 5_2^3$ algebra with the fundamental frequency of 40 Hz to primary excitations of $k = 251$ with fundamental frequency of 28 Hz. It is also possible that $k = 83_3$ excitations with frequency 56 Hz are associated with primary sensory areas and subcortical areas.

2. Secondary sensory areas correspond to secondary excitations of $k = 127$ with fundamental frequency of 10 Hz, average frequency in alpha and fundamental frequency associated with memory.

3. Tertiary association areas turn correspond to $k = 2^8 = 256$ with fundamental frequency 5 Hz belonging to theta band.

4. Unimodal association areas correspond to $k = 257$ with fundamental frequency of 3.5 Hz, the upper end of delta band.

5. Multimodal association areas would correspond to secondary excitations of $k = 131$ with fundamental frequency .63 Hz.

Of course, one could shift the positions of p-adic length scales along cortex but the assignment of 40 Hz to primary sensory cortex suggests that the identification could be correct. The mirror mechanism of long term memories suggests that an analogous hierarchy is realized at much lower frequency scales in terms of MEs and $Z^0$ magnetic flux loops.

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# Chapter 6

# Quantum Model for Hearing

## 6.1 Introduction

The quantum model of hearing has evolved through several twists and turns. For years this model seemed to be one of the stable portions of TGD inspired theory of qualia and, what was remarkable, allowed rather precise quantitative predictions. The model relied crucially on TGD based new physics: in particular, the roles of long ranged dark weak force and of neutrinos was central.

The situation changed dramatically with what might be called dark matter revolution (the recent TGD based view about the role of dark weak interactions is discussed in [F9, F9, J6] and neutrino superconductivity in [J3]). The good news was that the long ranged weak fields are assignable to exotic copies of standard model particles so that the fears about large parity breaking effects in hadronic, nuclear, and atomic scales dissolve while the large parity breaking in molecular length scales can be assigned to the exotic copies of standard model particles giving rise to long range weak and color interactions. The bad news was that the model for the cognitive aspects of hearing relied on the assumption that *ordinary* neutrinos couple to the classical long ranged $Z^0$ fields in condensed matter does not make sense anymore. Dark matter revolution allowed also to develop a model for the interaction between biological body and the hierarchy of magnetic bodies implying a model for how sensory organs, brain, and corresponding magnetic bodies interact. The implication was that the possible role of exotic neutrinos is restricted to the cognitive aspects of hearing.

### 6.1.1 Development of the model of hearing

The quantum model for hearing developed long before the general theory of qualia emerged.

1. One of the impulses leading to the development of the model was the idea about realization of memetic code in terms of cognitive antineutrinos. Of course, also other realization can be considered, for instance realizations based on temporal field patterns, and it has become clear that these realizations would be very natural [M5].

2. Second crucial observation was that only $Z^0$ magnetic fields could allow coding of the audible frequencies to magnetic transition frequencies. Also the idea that the weakness of classical $Z^0$ interaction is what makes possible to isolate verbal cognition from the atomic noise was an important guiding line. Again one must be critical and notice that a direct coding of music and speech like aspects of auditory sensation in terms of em field patterns is possible and must be considered seriously [M5].

3. The concrete calculations demonstrated that, rather miraculously, the anomalous $Z^0$ magnetic moments of neutrinos are such that one can predict correctly the upper bound for the audible frequency range.

4. A cold shower came with the realization that the long ranged classical weak fields predicted by TGD must be due to dark matter and that dark matter could correspond to large $\hbar$ macroscopically quantum coherent phase. This meant a travel to the unknown using as a guideline only p-adic length scale hypothesis and the hypothesis that ordinary or Gaussian Mersennes define

the mass scales of leptons. These hypothesis are indeed enough to deduce the p-adic mass scales of exotic leptons affecting the anomalous $Z^0$ magnetic moment of dark neutrino which serves as the basic parameter of the model.

I made a desperate attempt to save the model, in particular the assumption that $\Delta n = 1$ spin flip with anomalously low frequency is responsible for hearing, by replacing neutrinos with mass $\sim .1$ eV with exotic neutrinos having mass of order electron mass and with some hand-waving managed to save the quantitative arguments [16]. Second modification is that the exotic neutrinos associated with wormhole throats correspond to $k = 127$ so that their mass is of order electron mass. One can however find some justification for this assumption and connect it with the lepto-hadron mechanism explaining the anomalous production of $e^+e^-$ pairs in heavy nucleus scattering just above Coulomb wall [F7] and with the TGD based model of atomic nuclei involving in an essential manner exotic $k = 127$ quarks [F8]. Later it become clear that although the neutrinos are dark the model does not survive thermal stability condition.

Besides this shortcoming also genuine progress occurred.

1. An important step of progress came with a generalization of the capacitor model for the sensory qualia, the general model for how magnetic body controls biological body based on the dark matter hierarchy, and a model for hair cells inspired by several mysterious aspects related to their function led to a concrete model for hearing. This model has rather close connections with experimental facts but it is not yet clear to what degree this model is consistent with the earlier pieces of theory.

2. The most decisive boost came from the increased understanding of quantum TGD itself.

   The crucial stimulus came from the understanding of the dark matter hierarchy in terms of quantized Planck constants based on the generalization of the notion of the imbedding space obtained by gluing imbedding spaces corresponding to different values of Planck constants together along $M^4_\pm$ or $CP_2$ factors [A9]. This makes possible a geometric description of the phase transitions changing the values of Planck constants.

   The identification of the space-time correlates of infinite primes as multi-parton states allowed to identify real and p-adic bosonic partons as correlates for intentions and actions and pairs of real and p-adic fermionic partons as matter and its cognitive representation. This picture is in nice accordance with the identification of the basis of fermionic Fock states quantum variant of Boolean algebra.

   Further steps of progress came with the detailed understanding of super-conformal symmetries via the formulation of quantum TGD in terms of light-like 3-surfaces identified as orbits of partons, via the master formula for S-matrix allowing to construct also S-matrix between different number fields and between different sectors of imbedding space (phase transitions changing the values of Planck constants), and the discovery of zero energy ontology in which physical states compose to positive and negative energy parts such that all net quantum numbers vanish. Zero energy ontology means that one can interpret positive and negative energy fermionic components of the state as Boolean statements and entangled state itself as a representation of a Boolean function.

3. The last step in the evolution of quantum model for hearing was inspired by the new insights listed above and the decision to give up the un-necessary assumption that $\Delta n = 1$ spin flips with anomalously low transition frequency have a special role in hearing. This allows to assume that dark neutrino is a zoomed up copy of the ordinary neutrino with mass $\sim .1$ eV and thermal stability condition can be satisfied. 6-bit genetic code (with phonemes perhaps playing the role of amino-acids) emerges very naturally from the requirement that the energy range for cyclotron transitions is between thermal energy at room temperature and 2 eV representing upper bound for energies of visible photons.

   Feeding in the idea that cognitive codes are responsible for communications between different levels of dark matter hierarchy and that codons are realized most naturally as a linear sequence of ends of $Z^0$ magnetic flux tubes at light-cone boundary leads to rather profound insights about how genetic and memetic codes are realized in terms of $Z^0$ MEs. In particular, memetic code allows a fractal realization involving several levels of dark matter hierarchy (self hierarchy) so that a structured representation involving sequence of abstractions rather than a mere bit sequence is in question.

This newest part of the theory (or rather, a collection of loosely related models) involves only the general vision behind TGD inspired theory of consciousness, and it is not plagued by so many ad hoc assumptions as the earlier model for the memetic code. In any case, there is still a long way to a realistic theory but there are good hopes about being at a correct track.

### 6.1.2 Hearing as a universal frequency quale?

Paradoxically, if the general theory of qualia would have been available from the beginning, it might have been rather difficult to end up with the original proposal for the correlates for the pitch and phoneme like aspects of auditory sensation. The statistical physics vision for qualia inspires the working hypothesis that quantum number increments determine qualia independently of the context (other quantum numbers). This hypothesis, the fact, that hearing is frequency and time sense, and the observation that energy is conjugate to time, together inspires the idea that energy increments determine some essential sub-quale of hearing sensation common to all sensory experiences. Hearing would be the time-like counterpart of force sense and the gradient of total energy would be the physical quantity sensed.

The universal character of energy (or rather power–) quale need not lead to paradoxes. First of all, the hypothesis does not mean that the color like quale associated with the sound-no-sound dichotomy, which is analogous to white-black dichotomy, corresponds to a frequency increment. Rather, the quale in question would relate to the experienced pitch of the sound coded to a frequency increment and is therefore rather geometric quale perhaps experienced as a height in the case of vision. Hearing could be even seen as a sense strongly emphasizing the energy and time aspects of sensation.

### 6.1.3 Does the basic quale of hearing correspond to the increment of electro-weak isospin?

Dark matter hierarchy leads to a concrete model for control and communication functions associated with body parts and corresponding magnetic bodies [M3, M4, M5]. This leads also to fresh vision about hearing. One can consider a generalization of the capacitor model for the sensory qualia such that the generalized discharges giving rise to the sensory qualia occur between the sensory organ and corresponding magnetic body.

The fundamental quale of hearing characterizable by sound-no sound dichotomy would be associated with the increment of the weak isospin and would relate to an exchange of $W$ MEs (massless extremals) between magnetic body of cochlea and cochlea. In a completely analogous manner, visual colors would be assigned with the increments of color quantum numbers and correspond to the exchange of color MEs, which correspond to various color rotated variants of $W$ MEs. Note that these identifications could make sense even if the size scale of the sensory capacitor is that of the sensory organ. The fundamental energy quale would be associated with all sensory qualia although hearing could be in a special position since the typical time scale assignable to the auditory sensation is longer.

The neutral MEs carrying only classical $Z^0$ and em fields are assigned to cognitive and emotional representations whereas $W$ MEs carrying vanishing neutral gauge fields and color fields are assigned to the basic "long range" sensory qualia. These two kinds of MEs represent instances of two basic types of solutions of field equations for which the $CP_2$ projection of the space-time surface belongs a geodesic sphere of $CP_2$. In the first case the geodesic sphere is homologically non-trivial and in the second case trivial (see the appendix of this book).

Cochlea and its magnetic body could give rise not only to auditory qualia but also define low level cognitive and emotional representations of auditory input realized already at the magnetic body of cochlea and realized in terms of cyclotron phase transitions. The right brain signs-left brain talks metaphor leads to an identification of cognitive *resp.* emotional representations as sequences of "phonemes" *resp.* "notes". The construction of the sensory representations involves in an essential manner back projection from brain to outer hair cells. Astrocytes regarded earlier as mere metabolic energy reservoirs are in this model carriers of higher level cognitive and emotional representations: this applies to all qualia. Microtubuli are responsible for mediating auditory input to brain as acoustic/electric signals (also propagating conformational patterns could be involved) and this resolves the mystery of how frequencies above kHz frequency are heard.

### 6.1.4 Infinite primes, cognition and intentionality

Somehow it is obvious that infinite primes must have some very deep role to play in quantum TGD and TGD inspired theory of consciousness. What this role precisely is has remained an enigma although I have considered several detailed interpretations, one of them above.

In the following an interpretation allowing to unify the views about fermionic Fock states as a representation of Boolean cognition and p-adic space-time sheets as correlates of cognition is discussed. Very briefly, real and p-adic partonic 3-surfaces serve as space-time correlates for the bosonic super algebra generators, and pairs of real partonic 3-surfaces and their algebraically continued p-adic variants as space-time correlates for the fermionic super generators. Intentions/actions are represented by p-adic/real bosonic partons and cognitions by pairs of real partons and their p-adic variants and the geometric form of Fermi statistics guarantees the stability of cognitions against intentional action. It must be emphasized that this interpretation is not identical with the one discussed above since it introduces different identification of the space-time correlates of infinite primes.

#### Infinite primes very briefly

Infinite primes have a decomposition to infinite and finite parts allowing an interpretation as a many-particle state of a super-symmetric arithmetic quantum field theory for which fermions and bosons are labelled by primes. There is actually an infinite hierarchy for which infinite primes of a given level define the building blocks of the infinite primes of the next level. One can map infinite primes to polynomials and these polynomials in turn could define space-time surfaces or at least light-like partonic 3-surfaces appearing as solutions of Chern-Simons action so that the classical dynamics would not pose too strong constraints.

The simplest infinite primes at the lowest level are of form $m_BX/s_F + n_Bs_F$, $X = \prod_i p_i$ (product of all finite primes). The simplest interpretation is that $X$ represents Dirac sea with all states filled and $X/s_F + s_F$ represents a state obtained by creating holes in the Dirac sea. $m_B$, $n_B$, and $s_F$ are defined as $m_B = \prod_i p_i^{m_i}$, $n_B = \prod_i q_i^{n_i}$, and $s_F = \prod_i q_i$, $m_B$ and $n_B$ have no common prime factors. The integers $m_B$ and $n_B$ characterize the occupation numbers of bosons in modes labelled by $p_i$ and $q_i$ and $s_F = \prod_i q_i$ characterizes the non-vanishing occupation numbers of fermions.

The simplest infinite primes at all levels of the hierarchy have this form. The notion of infinite prime generalizes to hyper-quaternionic and even hyper-octonionic context and one can consider the possibility that the quaternionic components represent some quantum numbers at least in the sense that one can map these quantum numbers to the quaternionic primes.

The obvious question is whether configuration space degrees of freedom and configuration space spinor (Fock state) of the quantum state could somehow correspond to the bosonic and fermionic parts of the hyper-quaternionic generalization of the infinite prime. That hyper-quaternionic (or possibly hyper-octonionic) primes would define as such the quantum numbers of fermionic super generators does not make sense. It is however possible to have a map from the quantum numbers labelling super-generators to the finite primes. One must also remember that the infinite primes considered are only the simplest ones at the given level of the hierarchy and that the number of levels is infinite.

#### Precise space-time correlates of cognition and intention

The best manner to end up with the proposal about how p-adic cognitive representations relate bosonic representations of intentions and actions and to fermionic cognitive representations is through the following arguments.

1. In TGD inspired theory of consciousness Boolean cognition is assigned with fermionic states. Cognition is also assigned with p-adic space-time sheets. Hence quantum classical correspondence suggets that the decomposition of the space-time into p-adic and real space-time sheets should relate to the decomposition of the infinite prime to bosonic and fermionic parts in turn relating to the above mention decomposition of physical states to bosonic and fermionic parts.

   If infinite prime defines an association of real and p-adic space-time sheets this association could serve as a space-time correlate for the Fock state defined by configuration space spinor for given 3-surface. Also spinor field as a map from real partonic 3-surface would have as a space-time correlate a cognitive representation mapping real partonic 3-surfaces to p-adic 3-surfaces obtained by algebraic continuation.

2. Consider first the concrete interpretation of integers $m_B$ and $n_B$. The most natural guess is that the primes dividing $m_B = \prod_i p^{m_i}$ characterize the effective p-adicities possible for the real 3-surface. $m_i$ could define the numbers of disjoint partonic 3-surfaces with effective $p_i$-adic topology and associated with with the same real space-time sheet. These boundary conditions would force the corresponding real 4-surface to have all these effective p-adicities implying multi-p-adic fractality so that particle and wave pictures about multi-p-adic fractality would be mutually consistent. It seems natural to assume that also the integer $n_i$ appearing in $m_B = \prod_i q_i^{n_i}$ code for the number of real partonic 3-surfaces with effective $q_i$-adic topology.

3. Fermionic statistics allows only single genuinely $q_i$-adic 3-surface possibly forming a pair with its real counterpart from which it is obtained by algebraic continuation. Pairing would conform with the fact that $n_F$ appears both in the finite and infinite parts of the infinite prime (something absolutely essential concerning the consistency of interpretation!).

   The interpretation could be as follows.

   i) Cognitive representations must be stable against intentional action and fermionic statistics guarantees this. At space-time level this means that fermionic generators correspond to pairs of real effectively $q_i$-adic 3-surface and its algebraically continued $q_i$-adic counterpart. The quantum jump in which $q_i$-adic 3-surface is transformed to a real 3-surface is impossible since one would obtain two identical real 3-surfaces lying on top of each other, something very singular and not allowed by geometric exclusion principle for surfaces. The pairs of boson and fermion surfaces would thus form cognitive representations stable against intentional action.

   ii) Physical states are created by products of super algebra generators. Bosonic generators can have both real or p-adic partonic 3-surfaces as space-time correlates depending on whether they correspond to intention or action. More precisely, $m_B$ and $n_B$ code for collections of real and p-adic partonic 3-surfaces. What remains to be interpreted is why $m_B$ and $n_B$ cannot have common prime factors (this is possible if one allows also infinite integers obtained as products of finite integer and infinite primes).

   iii) Fermionic generators to the pairs of a real partonic 3-surface and its p-adic counterpart obtained by algebraic continuation and the pictorial interpretation is as fermion hole pair. Unrestricted quantum super-position of Boolean statements requires that many-fermion state is accompanied by a corresponding many-antifermion state. This is achieved very naturally if real and corresponding p-adic fermion have opposite fermion numbers so that the kicking of negative energy fermion from Dirac sea could be interpreted as creation of real-p-adic fermion pairs from vacuum.

   If p-adic space-time sheets obey same algebraic expressions as real sheets (rational functions with algebraic coefficients), the Chern-Simons Noether charges associated with real partons defined as integrals can be assigned also with the corresponding p-adic partons if they are rational or algebraic numbers. This would allow to circumvent the problems related to the p-adic integration. Therefore one can consider also the possibility that p-adic partons carry Noether charges opposite to those of corresponding real partons sheet and that pairs of real and p-adic fermions can be created from vacuum. This makes sense also for the classical charges associated with Kähler action in space-time interior if the real space-time sheet obeying multi-p p-adic effective topology has algebraic representation allowing interpretation also as p-adic surface for all primes involved.

   iv) This picture makes sense if the partonic 3-surfaces containing a state created by a product of super algebra generators are unstable against decay to this kind of 3-surfaces so that one could regard partonic 3-surfaces as a space-time representations for a configuration space spinor field.

### 6.1.5 Neutrinos, hearing, and cognition

#### Possible roles of neutrinos in hearing

One can imagine several roles for exotic neutrinos in TGD inspired theory of consciousness and it is good to provide an overall summary first.

1. Dark matter hierarchy allows to consider cognitive and emotional representations based on cyclotron phase transitions for Cooper pairs of dark neutrinos at $Z^0$ magnetic flux quanta.

2. The notion of cognitive neutrino pair represents genuinely many-sheeted physics and is the key element of the original quantum model for hearing. The neutrino and antineutrino of the pair correspond to light-like causal horizons defining the throats of a $CP_2$ sized wormhole contact. In condensed matter the pair could have nearly vanishing total energy. Quite generally, many fermion states of the Universe, which have vanishing net fermion numbers, have interpretation as quantum superpositions of Boolean statements with the presence/absence of fermion coding for 1/0. Cognitive neutrino pairs would be a particular example of this representation and naturally related to logical aspects of cognition.

   In the basic variant of the model the frequency increment of the cyclotron transition of exotic neutrino involving also spin flip codes for the pitch of the sound. The basic prediction is that several cognitive (phoneme based) and emotional (pitch based) representations of the auditory input corresponding to various levels of the dark matter hierarchy are possible. Also cognitive neutrino pairs could define this kind of representation and since a rather low level of dark matter hierarchy is in question it is possible that this particular representation does not correspond to the representation of pitch at our level of the dark matter hierarchy.

3. There are two models for memetic codons in terms of temporal sequences of cognitive neutrino pairs. In the first model the existence or non-existence of cognitive neutrino pair (more precisely, the existence of a topological sum contact connecting the neutrino and antineutrino at parallel space-time sheets) in this sequence codes for a bit. The generation of a topological sum contact between $CP_2$ type extremals representing neutrino and antineutrino at parallel space-time sheets would transform 0 to 1. In the second variant of the model spin direction for the cognitive neutrino codes for a bit. In this case wormhole contact must carry spin one and consist of a left handed neutrino and its antineutrino. In this case $Z^0$ magnetic spin-spin interaction is expected to correlate the spin directions tightly and favor parallel spins so that the system behaves like spin one object and both spins flip in the $Z^0$ magnetic field residing at either space-time sheet. Also Coulomb interaction between neutrino and antineutrino at light-like wormhole throats contributes to the binding energy. The long ranged $Z^0$ Coulombic interaction of dark neutrino with dark matter, say dark protons, can induce large Coulombic binding energy and further reduce the mass of cognitive neutrino pair and even change the sign of energy so that cognitive neutrino pairs could be generated spontaneously.

#### Cognitive codes and cognitive neutrino pairs

This conceptual framework leaves a lot of room for detailed models. Perhaps the most realistic view inspired by the general model of cognition [H8] and by the general vision about dark matter is that the memetic codon is represented as $Z^0$ magnetic body as quantum state at $\delta H_\pm = \delta M^4_\pm \times CP_2$. The super-position of zero energy pairs of memetic codons associated with $\delta H_+$ and $\delta H_-$ could be interpreted as a representation of a Boolean function. Therefore the size scale of representation is measured in terms of the photon wavelength associated with the typical frequency in audible range.

Since super-canonical Hamiltonians depend on the radial light-like coordinate of $\delta M^4_+$ via a power law and define logarithmic waves, logarithmic representation of codon is highly suggestive. This would mean that the 3-surface $X^3_k$ representing k:th bit at $\delta H_\pm$ has size proportional to say $2^k$ (also more general scalings are possible). This allows to distinguish between bits, which is essential for generating selective spin flip inducing conscious bit. The most natural mechanism inducing the flip on spontaneously magnetized $X^3_k$ is based on $Z^0$ ME carrying transversal $Z^0$ magnetic field with constant direction and having transversal sizes identical to that of $X^3_k$.

This representation does not favor large numbers of bits, and the requirement that cyclotron energies are in the range defined by thermal energy at room temperature and the energy 2 eV of photons which are still visible, favors 6-bit memetic code.

One can construct more complex $6n$-bit codes (more generally $mn$-bit codes) by allowing several levels of dark matter hierarchy labelled by the values of $\hbar_{eff}/\hbar_0 = 2^{6k}$, $k = k_0, ..., k_0+n$. In this manner it is also possible to construct a fractal variant of the memetic code as a structured representation in which various levels of dark matter hierarchy (self hierarchy) represent m-bit bunches of information at various levels of abstraction. Given level in hierarchy experiences the level below as a mental image and the levels below that level are experienced as averages. This loss of information is an unavoidable consequence of having bird's eye of view.

In the sequel a quantitative model of hearing relying on these ideas is discussed. The first section is devoted to the general model of sensory receptor and its application in the case of hearing. This part of the theory is the least speculative part of the speculative theory. The remaining sections are devoted to neutrino super-conductivity and to the possible role of dark neutrinos in the understanding emotional and cognitive aspects of hearing. It must be emphasized that the model is very general and one could also consider the replacement of neutrinos with electrons. It is only the small mass of dark neutrinos which could make the generation of cognitive neutrino pairs and cognition a spontaneous process and thus given them a unique role. The chapter involves several archeological layers and I cannot guarantee the complete absence of mammoth bones.

## 6.2 Generalization of the model for sensory receptor and new view about hearing

Dark matter hierarchy defines a well-come challenge for earlier speculative models of sensory qualia and sensory organ, and leads to a considerably more detailed view about how sensory qualia, emotion, and cognition are related. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be seriously considered. The question arises whether sensory organs define not only sensory, but also corresponding cognitive and emotional representations. Nerve pulses tend to destroy the temporal coherence of cognitive and emotional representations, and this encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further concrete ideas: in particular, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in case of vision and hearing.

### 6.2.1 General ideas

Consider first general ideas about sensory qualia and capacitor model of the sensory receptor stimulated by the application of dark matter hierarchy.

#### Modification of the capacitor model of sensory qualia

From the time scale of sensory experience it seems obvious that all qualia are realized at the level of dark matter. .1 seconds defines a unit of time for sensory experience which suggests that EEG relates closely to sensory qualia.

A modification of the original capacitor model of sensory receptor must be considered. In the original model the capacitor discharge was associated with the sensory receptor. The time scale .1 seconds characterizing sensory mental images would support the view that the capacitor discharge producing the sensory qualia should be assigned to the Josephson junctions at $k_{em} = 3$ level of dark matter hierarchy rather then cell membrane which corresponds to $k_{em} = 0$ level in the hierarchy of selves.

Charge entanglement by $W$ ME would induce non-local capacitor discharges which can be regarded also as exchanges of virtual $W$ bosons inducing exotic ionization leading to dark plasma oscillation patterns inducing various kinds of physiological activity such as $Ca^{2+}$ waves. .1 seconds could be seen as a period of recurring plasma oscillations. Sharing of mental images by entanglement would result as a by product.

#### Selection of percepts in state function reduction

State function reduction reducing charge entanglement could give rise to the selection of percepts involved for instance with binocular rivalry involving of magnetic body in the scale of brain. This selection means that only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism would guarantee reliable perception.

#### Also the magnetic bodies of sensory organs carry cognitive and emotional representations

Fractality forces the conclusion that also the magnetic bodies associated with the sensory organs carry cognitive and emotional representations. The level of cognition and emotion would be only lower than the cortical level and correspond to $k_{em} = 3$ most naturally. For instance, physical pain and psychological pain would correspond to emotions at different levels of the dark matter hierarchy.

An interesting possibility is that emotions and cognitions correspond to neutral gauge fields (em and $Z^0$ gauge fields and neutral color gauge fields) whereas sensory qualia or at least part of them would correspond $W$ gauge fields and color charged gluon fields. Quite generally, cognition and emotions would have neutral Lie-algebra (or Kac-Moody algebra) generators as correlates whereas charged generators would correspond to sensory qualia.

#### The new view about the role of sensory receptors and glial cells

The starting point is the 4-dimensional view about gradual build-up of 4-dimensional percept as an evoked potential representing genetic, memetic or more general codon or single "note" depending on whether one considers cognitive or emotional representation.

Quite generally, sensory receptor neurons do not fire and the primary sensory input is represented as an evoked potential. That this must be the case is easy to understand if sensory receptor neurons generate cognitive and emotional representations at their magnetic bodies based on modulations of $k_{em} = 3$ frequencies by EEG frequencies. The reason is that nerve pulse would spoil the temporal coherence of the cognitive and emotional representations by cyclotron transition patterns by taking Josephson frequency through zero to a large negative value and back to the original value. This would be like playing entire piano scale from right to left and back inducing cyclotron phase transition sweeping through a large portion of the magnetic body.

This applies also in the case of higher level emotional and cognitive representations and the only reasonable conclusion seems to be that glial cells which do not fire correspond to these representations. I have already earlier suggests this but on different grounds. Glial cells would not be mere metabolic storages but receive the metabolic energy directly because they are primary users of it utilizing it to build generalized EEG and ordinary EEG. T

he leakage of $Ca^{2+}$ ions through sensory receptor cell membrane induced by a plasma oscillation pattern gives rise to temporal patterns of evoked membrane potential. Plasma frequency would correspond to the frequency of recurrence for these patterns. The temporal characteristics of plasma wave patterns should correlate with various codes, in particular memetic code. The same picture would apply at the level of glial cells. Neurons would us much less metabolic energy since supra currents through the cell membrane would not use much of the metabolic energy, and ionic channels and pumps would actually play the role of sensory receptors at neuronal level [J3].

#### Hearing *resp.* vision $\leftrightarrow$ electro-weak *resp.* color interactions

Hearing-vision dichotomy and weak interaction-color interaction dichotomy could correspond to each other. The sensation of hearing could correspond to the change of weak isospin resulting in $W$ exchange. Sound-silence dichotomy ($\Delta I_3^w = \pm 1$) would be completely analogous to white-black dichotomy assignable to color isospin ($\Delta I_3^w = \pm 1$). Similar pairing should occur at the level of cognitions and emotions accompanying auditory and visual percepts and correspond to neutral weak gauge bosons and neutral color bosons.

#### The assignment of scaled up EEG with sensory organs

The assignment of $k_{em} = 3$ variant of EEG to sensory organs suggests itself. In the case of ordinary sensory qualia the scaled up 5 Hz Josephson frequency of ordinary EEG would be $10^4$ Hz. If magnetic field strength associated with DNA is scaled up to .1 Tesla for these representations, alpha band is mapped to $2 \times 10^4$ Hz. Delta band for right/left brain DNA cyclotron transitions at .5 Hz/1 Hz is mapped to 1 kHz/2 kHz. Hence the identification of the 1 kHz synchronization frequency of neural firing as the scaled up cyclotron frequency of DNA must be considered.

The frequency range $20-2\times10^4$ Hz of frequencies audible by humans overlaps with the spectrum $0-10^4$ Hz of sferics known to correlate with consciousness. This coincidence has a natural interpretation in this picture since the $k_{em} = 3$ Josephson junctions (scaled up cell membrane thickness) would correspond to size scale of 80 m and scaled up cell size to the scale 160 km assignable to lito-ionosphere complex in the general model of EEG [M3]. Therefore hearing and also other sensory qualia cold be accompanied by low level cognitive and emotional representations resulting as EEG modulations of the frequencies above kHz: sensory organs would feel and cognize to some extent.

### 6.2.2 TGD based model for hearing

It is very difficult to understand how neural processing could cope with the fast temporal gradients of the auditory input. The basic difficulty is that the time scale of nerve pulses is below millisecond whereas the highest audible sounds correspond to frequencies of about 200 kHz for some sea mammals [22]. Also bats hear very high frequencies. The frequencies below kHz are known to be coded to spike interval distributions [28] but for higher frequencies this is not possible. The mystery is how brain receives the information about higher frequencies.

If sensory representations are realized at the level of sensory organs the problem becomes much easier. Without feedback from cortex one would however end up with difficulties: for instance, the phenomenon of missing fundamental could not be understood. Microtubular communications of sound to and from brain would allow to transform sound waves to signals propagating along axonal microtubuli. Feedback along microtubuli makes possible an active construction of percept so that phenomena like missing fundamental can be explained as being caused by spike interval distribution of nerve pulse patterns associated with feedback. The outcome is a more concrete view about hearing at the level of ear. This aspect have not been discussed in the earlier model which has concentrated on an attempt to understand the cognitive aspects of hearing.

#### The anatomy of cochlea

The ear of mammals involves outer and inner hair cells [22, 23]. Outer hair cells have no axons to brain but there are efferents from cortex to them. The usual interpretation is that outer hair cells act as pre-amplifiers. They make possible feedback from cortex allowing to build sensory percepts already at the level of ear. This makes reasonable the idea that acoustic representations are indeed constructed at the level of sensory organs.

The cochlea for which piano keyboard is a good but not complete metaphor represents the phoneme as a spatio-temporal pattern. The input at a given frequency presses various keys with maximum activation at a key characterized by this frequency. The magnetic body of the entire cochlea experiences the sounds as spatial patterns of cyclotron transitions. Lower level emotional and cognitive components could emerge already here and correspond to rhythm and pitch. Meaning emerges at higher level as phonemes integrate to words and speech and associations are formed.

#### The coupling of hair cells with neurons

The coupling of hair cells with neurons mediating neuronal signals to brain is poorly understood [22, 23].

1. The transmission of neurotransmitters to postsynaptic neuron from the hair cell should be uncannily fast. The existence of unidentified very fast neurotransmitter is postulated.

2. Hair cell contains near presynaptic cleft mysterious structure with ring like shape known as presynaptic dense body. The function of this structure is not known but is believed to be crucial for the transmission of the neural transmitter.

3. There is chronical $Ca^{2+}$ leakage to hair cell. This is also believed to be crucial for the transmission of mystery transmitter.

**TGD based model for hearing**

TGD based model hearing is inspired by the attempt to understand the meaning of the strange findings just listed.

1. It is known whether and it is difficult to understand how the audible frequencies above kHz can be coded by nerve pulse patterns. The representations based on $k_{em} = 3$ scaled up EEG suggests a solution to the problem. The fundamental sensory representations and also low level emotional and cognitive representations are realized at the level of cochlea so that there would be no absolute need to code for high frequencies by nerve pulse patterns. The representation at the level of sensory organs means that the loss of accuracy of representation due to communications with brain can be avoided. The speech and song type representations based on phonemes and sequences of notes with pitch would be realized at the level of cochlea. The feedback from cortex to the outer hair cells is essential and explains phenomena like hearing the missing fundamental.

2. The extreme rapidity of the transfer of the postulated unidentified nerve transmitter from the hair cells to the nerve axons is a mystery. The transmitter is not needed at all if microtubuli mediate the information about evoked potentials at hair cell membrane to brain as microtubular conformal patterns and/or acoustic/electric waves. Acoustic and electric waves would be both present since microtubuli are electrets.

   The transfer of auditory information from hair cells to postsynaptic neuron could occur via acoustic transmission meaning that the time lag spent in this step would be of order $\sim .1$ ns only. The reported extreme sensitivity of of the axonal signal to the evoked potential (the resolution is about $\Delta V \sim .1$ mV) [22] conforms with the view that evoked potential provides a representation of the sensory input.

   The representation and communication of acoustic signals at microtubular level could induce the coding of frequencies sufficiently below 1 kHz to spike interval distributions [28]. The obvious critical question is how badly nerve pulse disturbs microtubular communications. One might argue that these perturbations do not affect conformational waves. As proposed earlier, the microtubular conformational wave patterns could be responsible for long term memories for instance. Acoustic waves could fulfill the same function.

3. The chronic leakage of $Ca^{++}$ believed to relate to the transfer of the postulated fast transmitter. The TGD inspired interpretation would be that $Ca^{++}$ wave is induced by the temporal plasma wave pattern and represents auditory percept cognitively/emotionally. The presynaptic dense body would be involved with the transformation of the temporal pattern represented by the time pattern of $Ca^{2+}$ leakage to a signal propagating along the microtubule. Coupling to the microtubular conformational waves/acoustic signals could be also mechanical and the dense body could generate acoustic oscillations representing the temporal pattern of $Ca^{2+}$ waves.

4. Mammals have two kinds of hair cells [23, 22]: inner hair cells are possessed also by lower life forms and outer hair cells only by mammals. Outer hair cells are thought to act as pre-amplifiers but TGD suggests that the deeper function of outer hair cells is to mediate auditory feedback from cortex. There are indeed efferents from cortex to outer hair cells making possible cortical feedback which sometime can create sounds audible even from outside (otoacoustic sounds).

   The feedback makes possible the realization of the experienced auditory percepts at the level of cochlea. This would explain various phenomena interpreted usually as a support for the hypothesis that sensory qualia are produced by neuronal activity. Consider only the emergence of pitch not present in the primary sensory input such as the missing fundamental when only its harmonics appear in the auditory input [28]. This feedback would of course occur also at the level of other sensory organs and rapid eye movements during REM sleep could be interpreted as being induced by the feedback from visual cortex.

The emergence of the outer hair cells increases the span of audible frequencies. For sea mammals 200 kHz which corresponds to 100 Hz for ordinary EEG. This would be just what would be needed for the representation of memetic codons or EEG patterns as amplitude modulations. This would mean emergence of a new symbolic level distinguishing mammals from lower levels in the evolutionary hierarchy. For frequencies below few kHz, say 3 kHz only pitch representation makes sense. Single formant vowels for which formant frequency is sufficiently below 1 kHz would have representation also as nerve pulse patterns.

Hair cells communicate with cortex using sequences of "phonemes" or "notes" defining amplitude modulations of frequencies above few kHz. At this limit modulation preserves the pitch so that durational and pitch representations are mutually consistent. This explains the unexpected finding that same brain regions, prevalently in right hemisphere, are responsible for the analysis of pitch and durational patterns [24]. Only frequency representation would be realized at the lower frequencies so that the presence of cognitive and emotional amplitude modulations at the level of cochlear would distinguish mammals from lower life forms.

**Why microtubuli are needed?**

The time pattern represented by $Ca^{2+}$ leakage to the inner hair cell could be transferred to the post-synaptic axon and transformed to a signal propagating along the axonal microtubuli. An interesting hypothesis is that left brain utilizes phoneme sequences and right brain note sequences. Also the signals from auditory cortex to the outer hair cells would propagate along axonal microtubuli.

The signals would propagate with a velocity which could be faster than the conduction velocity of nerve pulse and constant to a very high degree unlike the conduction velocity of nerve pulse. The measurement of a time lag of order millisecond for signals arriving to the right and left ear using co-incidence detectors in the brain stem (medulla oblongata) allows to determine the direction of the sound source. The typical time interval between nerve pulses varies and is somewhat more than millisecond, and is not at all clear whether nerve pulse conduction can preserve the time differences accurately enough to allow their meaningful comparison. If the signals from cochlea to brain stem propagate along microtubuli the situation could improve.

**Memetic code, and genetic code as a representation of phonemes?**

The average duration of phonemes is about 140 ms, which is by a factor $\sqrt{2}$ longer than the duration .1 seconds of the memetic codon. Durations vary in the range 60-300 ms. Note that the 250-300 Hz rhythm associated with speech organs defines the pitch of speech but phonemes can be recognized even in the absence of the fundamental. The basic pitch of about 250 Hz implies that the number of memetic codons associated single single period is at most 2.

Phonemes can be classified by the vocal tract mechanism generating them and phonemes can be also recognized by their spectral decomposition.

1. Formants [20, 21] correspond to vowels, approximants (say (r,l) and (j,w)) , and nasals (m and n). Only few resonant frequencies are needed to characterize the formant. Lowest formant is below 1 kHz but higher formants above kHz and frequencies up to 3 kHz are possible. It is easy to understsand that for vowels the frequency distribution does not depend on time for approximants and nasals it does.

2. Fricatives (hiss, buzz). Fricatives lack the formant structure. Both correspond to a repeated time amplitude peak and frequency distribution involves wide range of frequencies with same intensity.

3. Plosives (such as p,b and t,d) correspond to a single peak in the time domain and constant frequency distribution.

All sensory input might be transformed by a feedback circuit to sequences or notes/memetic codons represented as a modulation of the membrane voltage providing a universal cognitive/emotional representations. Also ordinary phonemes and notes would be represented in this manner. Sensory organs correspond naturally to $k_{em} = 3$ level of dark matter hierarchy since .1 seconds represents the basic unit of sensory time. Therefore memetic codons modulating scaled up EEG at $k_{em} = 3$ level would be a good guess for how the sensory input is represented cognitively.

Also other p-adic codes are possible. Phonemes, the number of which is 41 in American english, could correspond to a sub-code reducing to a genetic code with 64 codons. It is important to notice that the temporal distance between memetic codons does not matter. Other memetic codons could code for recognizable sound patterns not representing phonemes and could have meaning at some other levels of self hierarchy.

One can argue that the representations as "notes" and "phonemes" should carry roughly the same amount of information. For frequency representation as sequence of "notes" 10 octaves represents upper limit for the modulation frequencies. For high modulating frequencies the representation tends however to fail since slow modulation is not anymore in question. This would mean that the number of distinguishable "notes" is below $10 \times N$, where $N$ is the maximum number of distinguishable frequencies inside octave. $N = 12$, the number of half notes in octave, would give 120 different "notes", which is not far from 127 and corresponds to $M_7$ allowing $2^7 - 1$ different codons making almost 7 bits with bit duration of 67 ms. Since the first codon in pulse-no pulse representation must be always pulse to tell that the codeword starts, this leaves 6 bits and genetic code. Codons can have varying but long enough pauses between them and the average duration .14 s of phonemes allows this. The association of genetic or memetic codons to characteristic spectrograms of phonemes as a function of time and frequency would result by cortical feedback.

## 6.3 Dark neutrino super conductivity

The new view about dark neutrino super conductivity differs completely in details from the earlier one. The reason is the new interpretation for classical long ranged weak gauge fields as space-time correlates for a hierarchy of exotic weak bosons with scaled down mass scale. The model of dark neutrino superconductivity will be constructed using various empirical guidelines about neutrinos to set quantitative constraints. The model itself is a direct generalization of the model for quantum critical electronic super conductor based on wormholy Cooper pairs generalized to the case of ORMEs so that electrons have large $\hbar$ and nuclei are doubly dark.

Also non-superconducting neutrinos might be important. The negativity of the neutrino energy in the $Z^0$ Coulombic fields created by nuclei possessing anomalous weak charge makes possible creation of neutrino-antineutrino pairs from vacuum by the splitting of $\nu\overline{\nu}$ type wormhole contacts with neutrino and antineutrino at causal horizons. Hence the $\nu\overline{\nu}$ wormhole contacts, in particular those of $k = 151$ neutrinos assignable to cell membranes, could be important. Cognitive neutrino pairs indeed play a key role in TGD based model for cognition. The decay of cognitive neutrino pairs to ordinary neutrino-antineutrino pairs followed by a possible transition to dark neutrino phase provides a possible mode of quantum control by creating and controlling the density of super-conducting dark neutrino Bose-Einstein condensates.

The special feature of the cognitive neutrino pairs is that they have nearly vanishing total energy and other quantum numbers. This makes them ideal candidates for realizing Boolean thoughts as sequences of cognitive neutrino pairs with the spin of cognitive antineutrino coding for the two values of the Boolean statement. Quantum model hearing relies on cognitive neutrino pairs and has been one of the quantitative victories of TGD inspired theory of consciousness and it is interesting to see whether it survives in the new vision.

### 6.3.1 The analogy between superconductors of type I and quantum critical superconductors

The original proposal was that bio-systems correspond to superconductors of type I near criticality. What makes super conductors of type I so interesting is that they allow the penetration of metastable magnetic field configurations destroying super-conductivity. Field configurations are cylindrically symmetric in the length scale $\lambda$ and their cross section has very complicated topology consisting of locally stripe like regions of width of order $\lambda << \xi$ [18]. In general, the cross section consists of several disjoint regions and each region is characterized by two integers in TGD(see the appendix of this book). The magnetic flux obeys a generalized quantization condition of form $\oint(p - 2eA)dl = n2\pi$, where $v$ denotes the velocity field of Cooper pairs and magnetic flux can be smaller than its quantized value.

For superconductors of type I metastability makes the magnetic field structure near critical value of the magnetic field an ideal control tool since the topology of the cross section can be varied easily. This means that both memory dating and simple arithmetic operations are possible since the fusion of two disjoint regions corresponds to the addition of the integers $n_1$. This suggests that both the topology of the magnetized region and integers $n_1$ and/or $n_2$ code the content of the observation at various p-adic levels. In the absence of sensory input the magnetic field reduces to ground state configuration (no super-conducting regions) with related integers perhaps coding long term memories.

Quantum critical superconductors are naturally superconductors of type II but in this case the supra current carrying regions are associated with the boundaries of dynamical stripe like structures so that the situation remains more or less unchanged. The super-conducting regions are associated with the boundaries between regions possessing different value of $\hbar$ and stripes correspond to a larger value of $\hbar$. Wormholy Cooper pairs are at the boundary region of two phases.

The lipid layers of the cell membrane ($k = 149$) and the entire cell membrane itself ($k = 151$) as well as the endoplasma membranes filling the cell interior indeed resemble locally super-conducting regions of quantum critical super conductor since the thickness of the membrane is very small as compared to its typical radius of curvature. The join along boundaries bonds between cells (identified as the so called gap junctions [29]) could give rise to macroscopic super conductor. In nerve cells axons are long cylindrically symmetric configurations of this type.

In accordance with the magnetic metastability, the endoplasma membranes of the cell are known to be dynamical structures, which change their size and connectedness continually. An additional support for the role of the superconductivity in the cellular information processing comes from the empirical observation that strong magnetic fields have harmful consequences for the information processing of the cell. Above critical magnetic field vortices of radius $\xi$ inside which large $\hbar$ phase is transformed to ordinary one would be formed. Cell size gives a good estimate for the value of the coherence length $\xi$ of dark neutrino super-conductor identified as weak length scale.

### 6.3.2 Empirical guidelines

The empirical guidelines are following.

1. p-Adic mass calculations utilizing the information about neutrino mass squared differences support the view that neutrino Compton length scale is about $L(169)$ and neutrinos have mass of $\sim .2$ eV [F3]. There is evidence for other mass scales too, in particular $L(173)$. p-Adic mass calculations [F4] led to the conclusion that also hadronic quarks can correspond to several p-adic primes, even in the case of low mass hadrons. The TGD based model for nuclear physics assumes that color bonds having $k = 127$ quarks at their ends with MeV mass scale connect nucleons to nuclear strings. These findings encourage to ask whether also Gaussian Mersennes $k = 151, 157, 163, 167$ would define mass scales of neutrinos. The corresponding dark mass scales for $\hbar \rightarrow \hbar/v_0 \simeq 2^{11}\hbar$ correspond to $k_{eff} = 173, 179, 185, 189$ and span the length scale range 20 $\mu$m-.5 cm.

   The earlier model of neutrino superconductivity and cognitive neutrino pairs was based on $k = 151$ ordinary neutrinos having long ranged weak interactions. The new view about long range weak interaction requires much more massive neutrinos having dark Compton length around $L(151)$. Since both electron and nuclear exotic quarks [F8] correspond to Mersenne prime $M_{127}$, the natural guess is that also neutrinos can exist in $k = 127$ state with electron neutrinos having scaled up .55 MeV rather near to electron mass. A possible explanation for the special role of $M_{127}$ that it is largest Mersenne prime corresponding to a non-super-astrophysical length scale. One can also consider interpretation in terms of almost unbroken electro-weak symmetry for fermions. The corresponding dark length scale would be $L(k_{eff} = 149)$ and would correspond to the thickness of the lipid layer of cell membrane.

2. The model for the anomalies of water [F9] led to the conclusion that one fourth of hydrogen atoms of water are in dark matter phase with large value of $\hbar$ and that hydrogen atoms form linear super nuclei. This hypothesis allows to estimate the Coulombic $Z^0$ interaction energy of dark neutrinos with water molecules. The large density of anomalous $Z^0$ charge for doubly dark matter with $L_w \simeq n^3 \times .2$ $\mu$m does not however require neutrino screening since color force can compensate the weak force as discussed in [F9]. The argument below shows that even in $k = 127$ neutrinos effective screening would require relativistic dark neutrinos since the density of dark neutrinos should be roughly one half of the density of water molecules for complete screening and too large by about three orders of magnitude.

3. The model for tritium beta decay anomaly gives the estimate $1/\mu m^3$ for the density of dark neutrinos in condensed matter. The density could of course be also higher in living matter. The requirement that dark neutrinos are non-relativistic implies strong bound on their density via Fermi momentum. One obtains

$$E_F \ll m_\nu \ , \tag{6.3.1}$$

which by using the expression for $E_F$ gives for effective dimensions $D = 1, 2, 3$ the bounds for $n_{\nu,D}$

$$\begin{aligned} n_{\nu,1} &\ll \frac{1}{\sqrt{2}\pi}\frac{m_\nu}{\hbar} \ , \\ n_{\nu,2} &\ll \frac{1}{2\pi}\frac{m_\nu^2}{\hbar^2} \ , \\ n_{\nu,3} &\ll \frac{1}{6\pi^2}\frac{m_\nu^3}{\hbar^3} \ . \end{aligned} \tag{6.3.2}$$

In large $\hbar$ phase the dark neutrino density is scaled down by a large factor. In 1-D case the 3-D density is obtained by dividing by the transversal area $S$ of the linear structure involved. The transversal size scale must at least be of the order of dark neutrino Compton lengths so that only numerical constants distinguish between the 3-D density in various effective dimensions.

Even for $k = 127$ the conditions guaranteing non-relativistic Fermi energy are non-trivial and read as

$$\begin{aligned} n_{\nu,1} &\ll \sqrt{2}x\frac{1}{L(151)} \ , \\ n_{\nu,2} &\ll 2\pi x^2\frac{1}{L^2(151)} \ , \\ n_{\nu,3} &\ll \frac{8\pi}{6}x^3\frac{1}{L^3(151)} \ , \\ x &\simeq 11.3 \ . \end{aligned} \tag{6.3.3}$$

The order of magnitude is few neutrinos per nm length scale which means that dark neutrino Cooper pairs with minimum size $L(151)$ have overlap which makes Bose-Einstein condensation possible. The upper bound for the density of Cooper pairs is considerably lower than the density of dark hydrogen nuclei if 1/4:th of hydrogen nuclei are in doubly dark phase: the ratio of 3-D densities is smaller than $(5.7, 8, 60) \times 10^{-4}$ for $D = 1, 2, 3$ if 1/4:th of hydrogen atoms are in dark phase and if all dark hydrogen atoms make a phase transition into a doubly dark phase in a given region. Therefore dark neutrinos cannot screen anomalous weak charge. Neutrino screening is not needed since long range color forces can compensate the repulsive weak force.

For $k \geq 151$ situation the conditions guaranteing non-relativistic Fermi momentum cannot be satisfied for dark neutrino density $\sim 1/\mu m^3$. Hence the conclusion seems to be that $k \geq 151$ dark neutrinos are most naturally relativistic.

4. $Z^0$ force is automatically vacuum screened above length scale $L_w$, which is about $3-6$ Angstroms for dark nuclear matter with $n = 3$ and $1.8 - 3.6$ $\mu$m for doubly dark case. In the latter case the screening condition does not pose condition on neutrino density. For $k \geq 151$ the condition implies that dark neutrinos are relativistic.

   $Z^0$ magnetic penetration length $\lambda_Z$ is obviously not longer than $L_w$. If there is active screening by supra currents one has $\lambda_Z < L_w$. This gives using $\lambda^2 = m_\nu/4\pi g_Z^2 n_c$

$$
\begin{aligned}
n_{\nu,1} &> m_\nu L_w \times \frac{S}{4\pi g_Z^2 L_w^2}\frac{1}{L_w} \ , \\
n_{\nu,2} &> m_\nu L_w \times \frac{d}{4\pi g_Z^2 L_w}\frac{1}{L_w^2} \ , \\
n_{\nu,3} &> m_\nu L_w \times \frac{1}{4\pi g_Z^2 L_w^3}
\end{aligned}
\tag{6.3.4}
$$

Here $S$ resp. $d$ is the transversal area resp. thickness of effectively 1-D resp. 2-D super conductor. Notice that this conditions does not involve $\hbar$ at all and it seems that the large value of $\hbar$ automatically implies that $L_w$ gives the magnetic penetration length. For $k = 151$ the 3-dimensional densities are in all cases of order few neutrinos per $L^3(151)$ so that the together with the conditions guaranteing non-relativistic Fermi energy these conditions force dark neutrino density to a rather narrow range. For $d = L(151)$ and $S = L(151)^2$ the lower bound for 3-D density is same in all cases and given by $n_{\nu,3} > .3/L(151)^3$ for $m(\nu_e) = .55$ MeV. The lower bound is by three orders of magnitude below the upper bound from the requirement that situation is non-relativistic. The upper bound for the 3-D density give the rough lower bound $\lambda > 10^{-3/2}L_w \simeq 6L(151) > \xi_T \simeq L(151)$, where $\xi_T$ is estimate for the transversal coherence length so that in the transversal direction type II superconductor would be in question. In longitudinal direction the coherence length $\xi_L = L_w > \lambda$ identified as a length of Cooper pair flux tube structure would mean type I super conductivity. The interpretation could be as follows. If axonal membrane is this kind of mixed superconductor, overcritical $Z^0$ magnetic field parallel to axon, would penetrate in flux quanta parallel to axon. For type I case transversal $Z^0$ magnetic field near criticality would penetrate into the axonal membrane as stripe like patterns with stripes of width $\lambda$.

The Compton length of neutrino gives lower bound for the thickness of the magnetic flux tube of the dark neutrino Cooper pairs.

1. $L(149)$ and $L(151)$ would correspond to lower bounds for thickness and length of the flux tubes for dark $k = 127$ neutrinos.In effectively 1-D case $k = 127$ with $S = L^2(149)$ neutrinos give for the neutrino density a lower bound which is of order one neutrino per $1/\mu m$. This would suggest that the lipid layers of cell membrane correspond to the pair of magnetic flux tubes defining the wormholy neutrino Cooper pairs.

2. One can also consider the possibility that the height of Cooper pairs is scaled up to $L(k_{eff} = 151 + 22) = L(173) = 20$ $\mu$m would give the length of the flux tube and axons between cell membranes are good candidates here. The vacuum screening of weak interaction above $L_w$ however strongly suggests $\xi < L_w$.

### 6.3.3 Dark neutrino superconductor as a quantum critical superconductor

The scarcity of the empirical guide lines forces the use of the model of quantum critical electronic superconductivity as the basic format. For $k = 127$ neutrinos the generalization of the wormholy model for electron Cooper pairs is not completely straightforward task since the finite range $L_w \simeq n^3 \times .2$ $\mu$m of exotic weak interactions causes delicacies.

#### The case of $k = 127$ neutrinos

The following arguments fix the generalization of the model for dark neutrino Cooper pairs in the case of $k = 127$ neutrinos.

1. Since the relevant length and mass scales of neutrinos and electrons are essentially identical, the dark neutrino Cooper pairs are expected to have similar sizes and are both associated with the boundaries between doubly dark and ordinary nuclear matter. In the case of cell cell interior and exterior would naturally correspond to these phases of matter. Of course, only partial darkness is possible: the model explaining the anomalies of water [F9] suggests that 1/4:th of hydrogen ions is in doubly dark phase in the cell interior and in dark phase in cell exterior.

2. The model of ORMEs as superconductors assumes that dark electrons have large $\hbar$ with $k_{eff} = 149$ and nuclei are in doubly dark phase with $k = 127$ dark quarks coupling to doubly dark $k = 113$ weak bosons possessing range of order $L_w \simeq n^3 \times .2$ $\mu$m. The wormholy Cooper pairs of dark electrons and neutrinos can be assumed to have same transversal size $L(149)$ as ordinary Cooper pairs.

3. The expression for the energy of Cooper pair has the general form $E = a/L^2 - b/L$ corresponding to kinetic energy and Coulombic interaction energy. The scaling up of $\hbar$ in the stability condition of for Cooper pairs discussed in [J1] amplifies the contribution of the kinetic energy by a factor $2^{22}$. This means that this factor also scales up the length of the Cooper pair to about 4 cm.

The situation is not quite this simple however. The most obvious implications of the finite range of the exotic weak force are $\lambda \simeq L_w$ and $\xi \leq L_w$, which is rather near to $L(167) = 2.5$ $\mu$m for $n = 3$. It simply does not make sense to talk about coherence and correlations above the weak length scale $L_w$. Therefore the energy of the Cooper pair is minimized subject to the constraint $L \leq L_w$ for the length of the Cooper pair which gives $L = L_w$. Situation remains the same even in the case of triply dark nuclear matter giving $L_w = n^3 \times .4$ mm.

Cell membranes and the dynamical endoplasma membranes within cell have interpretation as stripe like regions to which super-conducting dark electrons and neutrinos can be associated naturally. Macroscopic quantum coherence is often assigned to the ordered water in cell interior and the question is whether ordered water could correspond to doubly dark phase. One can also wonder whether the phase transitions between sol and gel phases associated with nerve pulse activity could correspond to transitions between dark and doubly dark phases. Since the transversal length scale of chromosomes and micro-tubules is also characterized by $L(151)$, it is natural to expect that dark electrons and neutrinos play key role in the dynamics of these structures.

**Is neutrino superconductivity possible for $k \geq 151$?**

For $k \geq 151$ the doubly dark coherence lengths are much longer than $L_w$ for doubly dark matter. One would however expect that the coherence length for Cooper pairs should be longer than the Compton length. Situation changes if dark nuclei correspond to triply dark nuclei with $L_w \simeq 3.6$ mm for $n = 3$ triply dark nuclei. The requirement that coherence length is longer than Compton length is satisfied up to $k = 157$ and for $k = 163, 167$ $L_w$ defines naturally the height of Cooper pair space-time sheet.

By the naive scaling the radius of the flux tube associated with neutrino Cooper pair would be $L(k + 22)$, $k = 151, 157, 163, 167$. The naive scaling of $L(151)$ giving the height of the flux tube would give for the height of neutrino Cooper pair $L(k + 44)$ which is longer than $L_w$ for triply dark matter. As in the previous case $L_w$ would be the upper bound for the height and would correspond to a maximal binding energy. These length scales would determine the transversal and longitudinal coherence lengths $\xi_T$ and $\xi_L$ of neutrino superconductor.

As already found, it is not possible to have non-relativistic Cooper pairs for reasonable values of dark neutrino density. Also stability condition assuming non-relativistic dark neutrinos leads to contradiction. Hence the energy of neutrino is difference of relativistic energy $E = 2\pi/L$ and $Z^0$ Coulombic interaction energy behaving in the same manner with respect to scalings. This implies that minimum energy is achieved for $L = L_w$. The scale of zero point kinetic energy would be $E = 2\pi/L_w \simeq E = 3.4$ K.

Unless ordinary and dark space-time sheets are thermally isolated, the BE condensate is thermally unstable for $k > 151$. For $k = 151$ dark neutrinos the critical temperature determined by $E_0 \sim 2\pi/L(151) \simeq 800$ K and gives critical temperature of order room temperature. Thermal isolation in reasonable time scales might be however possible since only de-coherence phase transition mediates interactions between ordinary matter and dark neutrinos.

The large values of these scales would mean that dark neutrino super-conductivity would relate to the control of smaller structures of size of order neutrino Compton length $\sim L(k)$ by structures of size $L(k + 22)$. The de-coherence transition in which dark neutrino Cooper pairs decay to ordinary neutrinos would certainly be an essential aspect of this transition. The creation of ordinary neutrinos by the splitting of $\nu\overline{\nu}$ wormhole contacts (cognitive neutrino pairs) would be another facet of the quantum control.

### 6.3.4 Structure of brain and neutrino super conductivity

The structure of the brain affords evidence for the p-adic hierarchy of super-conductor structures associated with coherence lengths $\xi$ and suggests that sensory stimulus represents itself regions of larger $\hbar$ at various levels of the condensate containing cells activated by the sensory stimulus. Regions carrying magnetic fields could correspond to both the weak magnetic fields guaranteing effective one-dimensionality of the super conductor or magnetic fields associated with the defects of the super conductor.

Perhaps the entire organism could be regarded as a hierarchy of quantum critical super-conductors with super-conducting regions identifiable as boundaries between regions having different values of $\hbar$: the large the structure the larger the value of $\hbar$. The radius of curvature of cell membrane is so large that locally the magnetic field has constant direction.

In the absence of sensory input the condensate levels carry some preferred magnetic field configuration. The simplest possibility is the presence of constant magnetic or $Z^0$ magnetic field. The magnetic field of the flux tube containing the Bose-Einstein condensate of wormholy Cooper pairs does not destroy the super-conductivity based on spin 1 Cooper pairs. Topological field quanta are quite generally characterized by frequency type parameters $\omega_1, \omega_2$ and integers $n_1, n_2$ assignable to the increments of phases of $CP_2$ complex $CP_2$ coordinates around homologically nontrivial loops and analogous to angular momentum values [D7]. In particular, the integers $n_1$ could be carrier of biologically relevant information.

A fascinating possibility is that the Gaussian and ordinary Mersennes associated with $k = 113, 127, 151, 163, 167$ define the fundamental p-adic length scales and the large $\hbar$ satellites of these length scales could give rise fractal copies of the structures in these length scales scaled up by powers of $n/v_0 \simeq n \times 2^{11}$. In particular, the Mersennes $k = 127, 151, 157, 163, 167$ span 40 half octaves whereas the Mersennes $89, 107, 113, 127$ span 39 half octaves. Therefore one can wonder whether the biologically most relevant length scale range could contain a scaled down copy of elementary particle physics such that $k = 167, 163, 157$ correspond to three charged lepton generations.

Be as it may, the two lowest levels in the dark hierarchy cover the length scales associated with living organisms. Second fascinating possibility is that the twin primes $k, k+2$ might be of special biological relevance as the appearance of various twin structures in bio-matter would suggest. In the following the empirical evidence supporting these hypothesis is discussed.

#### Structures in the cell length scale, miracle length scales, and twin primes

The miracle length scales defined by Gaussian Mersennes should make themselves manifest in cell length scales.

1. The two-layered structure of the cell membrane and of endoplasma membranes would naturally correspond to $k = 149$ and $k = 151$ p-adic levels. Membranes could be identified as regions between large $\hbar$ phase in the interior of cell and ordinary phase in the exterior of cell carrying wormholy Cooper pairs of electronic and neutrino type quantum critical superconductors and containing also cognitive neutrino pairs.

2. The interior of the cell contains structures, which might be identified with condensate levels $k = 163$ and $k = 167$, and might correspond to some higher levels in the information processing hierarchy of the cell. Cell nucleus with size in the range $5 - 10$ $\mu$m can accommodate all the miracle length scales. Biophotons [31] have energies in visible range and ultraviolet and visible wavelengths thus almost cover miracle length scales. For large $\hbar$ variants the wavelengths would be scaled up by powers of $n/v_0$ and these photons might be involved with quantum control of short length scales by longer length scales. The formation of Bose-Einstein type condensate of bio-photons could relate to the formation of gap junctions between cells.

3. The next level corresponds to a pair of length scales $L(167) = 2.5$ $\mu$m (lower bound for the cell size) and $L(169 = 13^2) = 5$ $\mu$m allowed if one generalizes length scale hypothesis so that it allows $k$ to be power of prime. The size of cell nucleus varies in the range 5-10 $\mu$ and one can wonder whether this length scale pair and corresponding Cooper pairs could relate to the twin structures formed by chromosomes and to the doubling of DNA during cell division.

4. Epithelial sheets consist of double cell layers and appear very frequently in multicellular biosystems (skin, glands, sensory organs, etc.). It would be natural to interpret them as region in large $\hbar$ phases can be present. Eye provides an example of this kind of structure [29]: eye can be regarded as a composite structure consisting of single cell layer (rods and cones) and two-layered structure consisting of layers of bipolar cells and ganglion cells Great variety of super-conductors are possible at this length scale. These structures might involve doubly dark neutrino and electron super conductivity with transversal length scales $L(149+22) = L(171) = 10\ \mu$m and $L(151+22) = L(173) = 20\ \mu$m.

**Scaled up variants of cell membrane?**

The information processing of the brain could involve dynamical membrane like structures inside the brain as dynamical units with electron and neutrino super-conductivity playing key role in the functioning of the structure. This would mean that the couplings between cells of the brain understood as neural net should have tendency to form dynamical two-dimensional surface like structures.

These higher level membranes could have functions analogous to those of ordinary cell membranes. Action potential between the cell layers and nerve pulse might be well defined concepts. These membranes could form cell like structures filled with dynamic "endoplasma" membranes. For instance, the twin primes $k = 179, 181$ could define generalized cell membrane like structure of thickness $L(181) \simeq 320\ \mu$m.

Generalizing the ideas of TGD one might speculate that these membranes could act as Josephson junctions and communication between the structures should take place via counterparts of ordinary nerve pulses: also the existence of the counterpart of EEG is suggestive. Various parameters characterizing exotic nerve pulse and EEG should be related by simple scaling to those characterizing ordinary nerve pulse and EEG.

**Cortical structures and first level satellites of miracle length scales**

The obvious place for the identification of large scale super conducting structures of is cortex. The relatively small thickness of the cortex (about 1 mm) implies that curvature effects do not mask the local cylindrical symmetry. Cortex is indeed known to possess columnar organization. For instance, in visual cortex there are two columnar structures with very complicated cross section perhaps identifiable as stipe like structures associated with quantum critical super-conductivity at higher level of dark matter hierarchy. These structures have also binary structure characteristic for the wormholy Cooper pairs.

*1. Field axis orientation columns*

The first columnar structure [29] in the visual cortex corresponds to the so called field axis orientation columns consisting of locally stripe like regions of cells (see Fig. 6.3.4), which preferentially react to the orientation of a bar of light in the visual field. The width of the stripes with fixed orientation is about $20-50\ \mu$m [29].

The first large $\hbar$ satellite of $L(151)$ is indeed $L(173) = 20\ \mu$m. A possible interpretation is that continued stimulus with fixed orientation creates at $k = 173$ level a cylindrical magnetic field configuration, which leaves only the regions reacting to this particular orientation in super conducting state. Doubly dark electronic and neutrino super conductors for which the length scales corresponding to $k = 171$ and 173 would appear naturally in the large $\hbar$ scaling of the cell membrane. It should be noticed that $k = 171$ corresponds to the upper bound 10 $\mu$m for the size of nucleus varying in the range 5-10 $\mu$m.

*Ocular dominance columns*

Ocular dominance regions consist of cells reacting appreciably to the stimulus from the second eye only, and form columnar structures [29] with complicated cross section and become visible via a continued stimulation of one eye only (see Fig. 6.3.4). The typical width of the stripe in the region is about $200-500\ \mu$m.

The weak length scale of triply dark nuclear matter corresponds to $k_{eff} = n^3 \times 400\ \mu$m so that $n = 1$ would make sense. The large $\hbar$ satellite of $L(157)$ is 160 $\mu$m.

The levels $k = 179$ and $k = 181$ forming a pair with $L(179) \simeq 160\ \mu$m might be the relevant p-adic levels now. The ocular dominance columns associated with right and left eye alternate and the regions formed by right-left pairs of ocular dominance columns is a natural candidate for the double layered structure at level 179 involving Bose-Einstein condensate of wormholy Cooper pairs.

*3. Hyper columns*

The visual cortex contains also larger structures, "hyper columns" [29], which form basic units for the processing of visual information (and sensory information in general). These structures have roughly the size of order 1 mm, the thickness of the cortex. The large $\hbar$ satellite of $L(163)$ is 1.28 mm. $L(167)$ would give to large $\hbar$ satellite $L(167+22) = L(189) = .5$ cm. Also structures with this size scale could also appear in brain.

**Structures in the length scale of body and second level satellites of miracle length scales**

In contrast to the prevailing view in neuroscience, in TGD framework entire body is seat of consciousness and brain only builds symbolic representations about sensory data. Also the idea about body as a passive receiver of commands from brain is given up and brain and body can be said to react to the desires of the magnetic body serving as a space-time correlate for the intentional me. Hence it makes sense to consider the possibility that also structures with scales larger than typical brain structures could be of importance for understanding conscious experience and functioning of living system.

The higher large $\hbar$ satellites of $k = 151, 157, 163, 167$ are $k = 195, 201, 207, 211$ and correspond to length scales 4 cm, 32 cm, 2.5 m, 10 m. k=163 and 167 could correspond to quantum critical super-conductivity in large sized organisms. These length scales could be also important for the structural organization of bio-systems. The fourth level in the hierarchy of dark nuclear matters would correspond to $L_w = n^4 \times .8$ m and might have relevance for information processing in the length scale of human body.

Double layered structures (both $k$ and $k+2$ primes) might appear in these length length scales.

1. For $k = 191, 193$ one has $L(191) \simeq 1$ cm.
2. $k = 197, 199$ is the largest doublet, which might be realized in bio-systems one has $L(197) \simeq 8$ cm. One cannot exclude the possibility that right and left brain hemispheres correspond to the condensation level $k = 197$ and whole brain to the condensation level $k = 199$.
3. For the next pair ($k = 227, 229$) (note the large gap in development) one has $L(227) \simeq 2500$ m, which is probably not realized in bio-systems at the level of organisms. One can of course ask whether biological organisms could form super organisms involving these higher levels.

4

OCULAR DOMINANCE COLUMNS IN MONKEY CORTEX demonstrated by injection of radioactive proline into one eye. (A) and (B) are autoradiographs photographed with dark field illumination in which the silver grains appear white. (A) This horizontal section first passes through the visual cortex at right angles to the surface displaying columns cut perpendicularly, then in the center horizontally through layer IV cutting columns tangentially. (B) Reconstruction made from numerous horizontal sections of layer IVC in another monkey in which the ipsilateral eye had been injected (no single horizontal section can encompass more than a part of layer IV of the cortex because of its curvature). Dorsal is above, medial to the right. In both (A) and (B), the ocular dominance columns appear as stripes of equal width supplied by one eye or the other. (C) Reconstruction of the pattern of ocular dominance columns over the entire exposed part of layer IVc. Scale 5 mm. (A and B from LeVay, unpublished, photos by courtesy of S. LeVay; C from LeVay, Hubel, and Wiesel, 1975.)

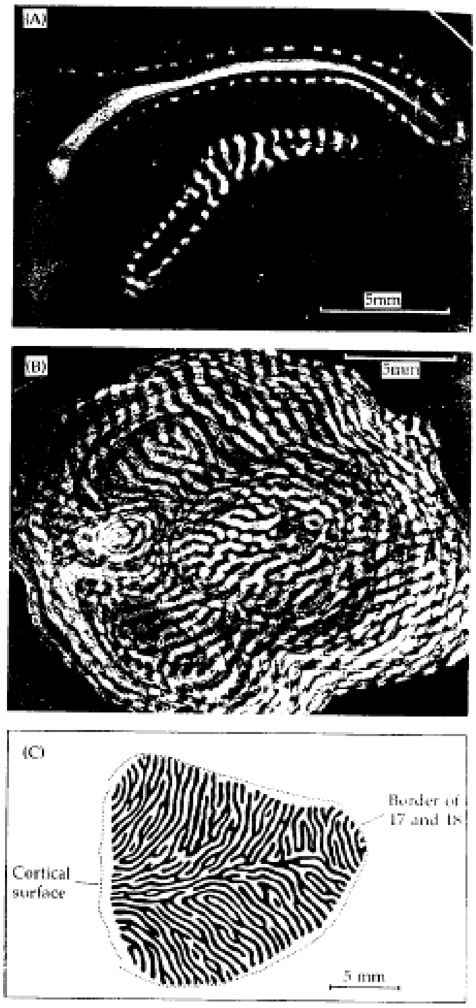


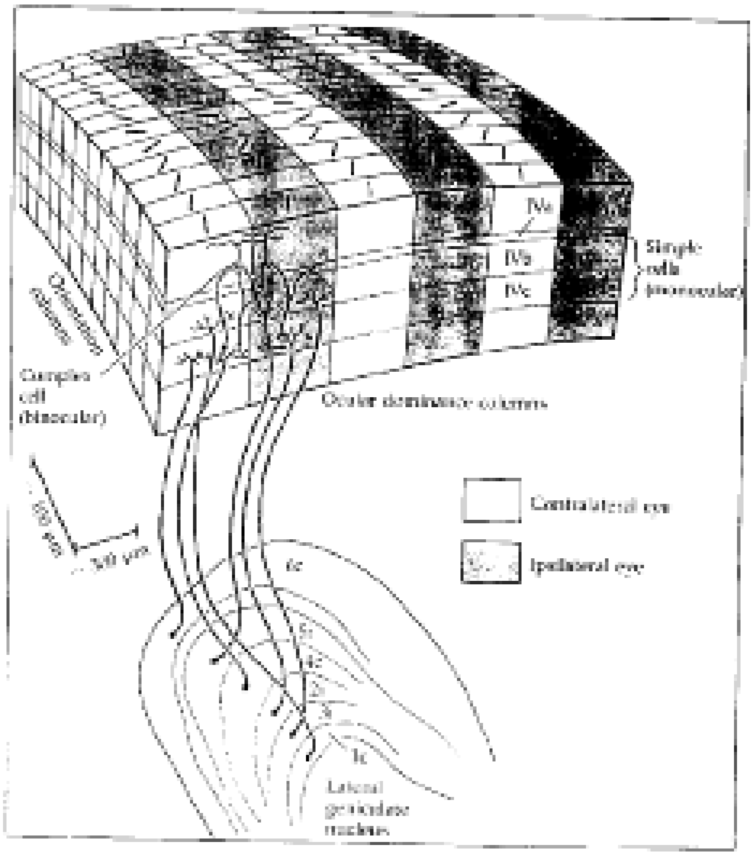

Figure 6.1:

## 6.4 Dark neutrinos and quantum model for hearing and cognition

The quantum model for hearing and cognition (for the original version see [16]) has been one of the trouble maker ideas from the very beginning. The original idea was based on wrong interpretation of the long range electro-weak gauge fields predicted by TGD as being associated with ordinary atomic nuclei.

The realization that long ranged electro-weak could be assigned to the particles of dark matter hierarchy in length scales below the scaled up Compton length of charged ew bosons, resolved the interpretational problem and predicted entire dark hierarchy of electro-weak physics with same mass spectrum. Of course, also electro-weak bosons with masses characterized by some other p-adic primes than $M_{89}$ can be considered.

The intriguing and encouraging outcome of the original model of memetic code [16] was that the $\Delta n = 1$ spin flip transitions for which frequency is vanishing at the limit of vanishing $Z^0$ magnetic moment of neutrino corresponds to frequency in audible range if $Z^0$ magnetic field is of same order of magnitude as Earth's magnetic field. The problem is that thermal stability condition is not satisfied for




7 RELATION BETWEEN OCULAR DOMINANCE and orientation columns. Scheme in which the ocular dominance and orientation columns run at right angles to each other. An example of a complex cell is shown in an upper layer, receiving its inputs from two simple cells that lie in adjacent ocular dominance columns but share the same orientation columns. (From Hubel and Wiesel, 1972.)

Figure 6.2:

ordinary value of Planck constant and since the frequency of $\Delta n = 1$ spin flip transition is proportional to $\Delta g_Z$ and thus to $\alpha_Z$ thermal stability condition fails even when one allows large vales of Planck constant. The reason is that the frequency of $\Delta n = 1$ spin flip transition is proportional to $\alpha_Z$ and therefore reduced in the scaling of $\hbar$ by a factor $n_a/n_b$ meaning that the energy of transition is invariant in the scaling of $\hbar$. To obtain a correct scaling one should assume that $Z^0$ magnetic field is scaled up by a factor $n_a/n_b$ and this would require a gigantic value of $Z^0$ magnetic field.

In this kind of situation it is difficult to make the decision whether to throw all of it to the dust bin or to just continue to play with all imaginable alternatives. The question is whether dark neutrinos could still play the proposed role in cognition and hearing.

I decided to continue without giving up $\Delta n = 1$ spin-flip and made a desperate attempt to save the model by replacing neutrinos with mass $\sim .1$ eV with exotic neutrinos having mass of order electron mass and with some hand-waving managed to save the quantitative arguments [16]. It cannot exclude dark exotic neutrinos with electron mass since $M_{127}$ is completely exceptional as the largest Mersenne prime not giving rise to super-astronomical length scale and there is evidence for dark exotic quarks with mass of order electron mass and they play key role in TGD based model of atomic nucleus providing also explanation for tetra-neutron [F8]. The model does not however satisfy the thermal stability criterion since the value of Planck constant is $\hbar_{eff} = 2^{11}\hbar_0$.

As far as hearing is considered, the most obvious option is that cyclotron transitions of Cooper pairs of neutrinos or of spin one wormhole contacts carrying quantum numbers of left handed neutrino and antineutrino at the light-like throats of the contact are responsible for the emotional and cognitive aspects of hearing identified as qualia of $Z^0$ magnetic body. This assumption fixes the magnitude of $Z^0$ magnetic field once neutrino mass is known and it is possible assume mass of order .1 eV and thus minimize the number of ad hoc assumptions. The coding could based on varying value of $Z^0$ magnetic field strength or coding by harmonics of the cyclotron frequency. The wormhole contact option is especially interesting because it could be interpreted in terms of information transfer between two space-time sheets or even between different levels of dark matter hierarchy.

### 6.4.1 General Ideas

**Some whys and hows related to cognitive codes**

Consider first the basic questions and ideas behind the model of the memetic/genetic code and cognitive codes in general.

1. It is perhaps a good idea to ask what the purpose of the memetic/genetic code could be. A transmission of information which becomes conscious at the receiving end suggests itself. Higher levels of dark matter hierarchy are the most natural receivers of this information. So perhaps an information transmission from lower to higher levels in dark matter hierarchy is in question so that two different branches of imbedding space rather than only 2 different space-time sheets would be involved. The information would be most naturally about space-time behavior of magnetic or $Z^0$ magnetic field in the case that bits are represented by spins.

2. At more mundane level, memetic/genetic code would correspond to the cognitive aspect of hearing and language. The coding of sounds by temporally ordered bit sequences would be in question and give them meaning. It must be admitted that the original idea about 126-bit memetic code could quite well be un-realistic as far as understanding of language is considered. There are good reasons to believe that 6-bit genetic code might be enough to understand phoneme structure of language.

3. Fermion number (1/0) or spin direction could represent bit. Spin seems the more natural option. Spin one Cooper pairs of neutrinos, if possible, could code for the direction bit. Cognitive neutrino pairs represented as spin one wormhole contacts, define an attractive option since in this case there would be a double representation of code words having interpretation in terms of a binary communication between two space-time sheets. The bit sequence would transmit information about the external $Z^0$ magnetic field determining the sequence of bits by spontaneous magnetization mechanism. Single bit could correspond to large number of cognitive neutrino pairs. Spontaneous magnetization is achieved for large values of Planck constant since energy minimization fixes the direction of spin to be parallel to $Z^0$ magnetic field.

4. Both options seem to require some kind of temporally ordered lattice which contains the cognitive neutrino pairs. The problem is how to realize this temporal lattice. The original model of memetic code was based on linear temporal sequence with each bit represented by a time interval of equal length. The basic law of sensory physiology however says that sensation depends logarithmically on the physiological intensity of stimulus. This would suggest that the linearity is achieved for the logarithm of the Minkowski time coordinate. The logarithmic realization memetic code with 127 bits requires a range of time scales varying with a scale factor $2^{127}$ whereas genetic code with 6 bits is quite a realistic looking option.

**Fermions, bosons, cognition and intention**

Before saying anything about cognitive neutrino pairs, the more recent ideas about role of fermions in cognition must be discussed. Fermionic Fock state basis defines in a natural manner a quantum version of Boolean algebra and thus fermions could relate to Boolean cognition. This quantal Boolean algebra should have space-time time correlate by quantum-classical correspondence and p-adic space-time sheets should somehow enter into the game.

The general model for cognition suggests strongly that real fermionic parton and its p-adic counterpart correspond to a pair of space-time sheets obeying same algebraic equations and define particle and its cognitive representation. This picture follows naturally from the identification of space-time correlates of infinite primes and integers in terms of many-parton stats and in this picture the pair is completely analogous to a hole particle pair resulting when negative energy fermion is kicked from Dirac sea. Real and p-adic bosonic partons would in turn correspond to actions and intentions so that boson-fermion dichotomy would have profound role in the theory of consciousness.

One could define the classical conserved charges of p-adic parton to be same as those for the real parton in the case that they are algebraic numbers belonging to the algebraic extension of p-adics considered. It is not clear whether one can talk about sums of real and p-adic energies classical conserved quantities in this case. Even if this is the case, it seems that real fermion and its p-adic counterpart cannot form zero energy states so that energy conservation would hold true for then separately and real stats would have vanishing net quantum numbers. In p-adic sector the conservation laws are not absolute for field equations and p-adic states might have vanishing net quantum numbers.

#### Zero energy ontology as a further guideline

The quantum model for the cognitive aspects of hearing was based on the coding of information to bit sequences formed by cognitive neutrino pairs whose proper identification is a story in itself. An essential element was quantum non-determinism represented at space-time level as a failure of complete determinism of Kähler action. Cognitive neutrino pairs would have nearly zero energy which would allow them to pop up from vacuum spontaneously, exist for some time, and disappear. These temporal sequences could be regarded as bit sequences with spin or mere existence of non-existence of neutrino coding for bit. The proposed mechanism was based on the negative Coulombic interaction energy with condensed matter cancelling the rest mass of neutrino.

Zero energy ontology, which forms the basis of quantum TGD its recent form, allows to interpret the vanishing of energy much more generally. In zero energy ontology physical states have vanishing net quantum numbers and positive *resp.* negative energy components of the states reside at the boundaries of lightcones $M^4_+$ *resp.* $M^4_-$ such that various cones $M^4_+$ ($M^4_-$) are nested past within each other. At the level of quantum TGD the tips of these lightcones correspond to arguments of n-point functions. Also more than one past directed light cones are possible. In the case of cognitive representations there is temptation to interpret positive and negative many neutrino states as Boolean statements. By allowing these states to entangle one would obtain quantal representation of Boolean function. If this picture is correct then the time interval between positive and negative energy components of the zero energy states should correspond to the time scale of human thought so that zero energy ontology would be experienced directly.

#### Why neutrinos are so special?

If fermions quite generally are responsible for cognition as it seems to be the case, one must ask, why neutrinos are so special. An essential element in the model of cognitive neutrino pair was the small mass of neutrino so that these pairs have very small or even vanishing or negative energy. The negative energy could be due to the $Z^0$ Coulombic field created by condensed matter. This allows to play with the idea that cognitive representations emerge spontaneously. This assumption could still be kept although the notion of zero energy ontology implies that at fundamental level all physical states have vanishing total quantum numbers.

#### Thermal stability as a new constraint and fractal hierarchies of dark matter

The work with dark matter related ideas inspires the conservative condition that the energies associated with the cyclotron frequencies of biologically important ions (neutrinos) are above thermal energy in magnetic ($Z^0$ magnetic) fields considered. If one takes seriously the argument suggesting that favored values of $n_a$ and $n_b$ correspond to n-polygons constructible using only compass and ruler, powers of two can define fractal hierarchies for Planck constants defined as $n_a/n_b = 2^{mk}$, $k = 0, 1, 2, ...$

For the hierarchy of EEGs the Planck constant hierarchy $n_a/n_b = 2^{11k}$ ($m = 11$) seems to be preferred. For cyclotron frequencies in dark magnetic field of $B_d = .2$ Gauss cyclotron energy is above thermal threshold for $k \geq 4$. Also other hierarchies are possible. For instance, the basic facts about music experience suggest $n_a/n_b = 2^k$ ($m = 1$) hierarchy. Genetic code in turn suggests $n_a/n_b = 2^{k6}$ ($m = 6$) hierarchy considered already earlier on basis of some numerical co-incidences. 6-bit genetic could and be enough to explain phonemes as a representation of genetic codons analogous to amino-acids.

If the cyclotron transitions of cognitive neutrinos in $Z^0$ magnetic field correspond to ELF frequencies, the hierarchy $2^{k6}$ of genetic codes is definitely preferred, with $k = 6$ the largest value of $k$. The Compton length of cognitive neutrino would thus be of order $3 \times 10^5$ m and $W$ boson Compton length of order of $L_w(k = 6) = 2^{36} L_w \simeq 1.6$ $\mu$m below which ew gauge fields would behave like massless fields.

One could also consider the possibility that ELF frequencies for classical electro-weak gauge fields correspond to an energy of order of $W$ boson mass so that these fields can induce electro-weak transitions. This would be guaranteed for $n_a/n_b = 2^{7\times 11}$ defining the longest electromagnetic cyclotron time scale which for $B = .2$ Gauss is below the typical duration of life cycle. In this case the Compton length of W boson would be of order Earth size (this size scale would correspond to the size of $Z^0$ magnetic body).

### 6.4.2 Neutrinos and hearing

The sensation of hearing would correspond to $Z^0$ cyclotron transitions. Higher cyclotron harmonics could representing higher harmonics of the fundamental or define the audible frequencies in the case that the value of $Z^0$ magnetic field is not variable. There are several constraints on the model of hearing which forces to modify the original model.

#### What particles form the macroscopic quantum phase?

Concerning the building blocks of the cyclotron condensate there are two options to consider.

1. Cooper pairs for dark variants of ordinary neutrinos could form the cyclotron condensate.

2. $\nu_L \overline{\nu}_L$ wormhole contacts possessing spin are good candidates for realizing cognitive codes and conceptual economy favors these.

#### What is the interaction between sound waves and $Z^0$ magnetic field?

$Z^0$ magnetic transition frequencies code for audible frequencies and this fixes order of magnitude for $Z^0$ magnetic field to fT range if one assumes neutrino mass to be of order .1 eV. Magnetic fields of this strength are known to correlated with brain functioning.

The interaction between sound waves and $Z^0$ magnetic flux quanta is expected to involve some kind of resonance. What comes in mind first is that the wavelength of sound wave equals to the radius of the $Z^0$ magnetic flux tube determined by quantization of $Z^0$ magnetic flux. This gives a reasonable estimate for the thickness of flux tube. $B_Z = 10^{-11} B_d$, $B_d = .2$ Gauss corresponds to $f_c = 20$ Hz cyclotron frequency defining the lower bound of audible frequencies. The wavelength of sound is in this case 15 m for $v_s = 300$ m/s. That hearing would not be completely inside-head phenomenon could relate to our ability to directly experience sounds as belonging to the world external to our head and would conform with the general vision.

Nerve pulse patterns only generate a symbolic representation of what is experienced as sensory qualia. Nerve pulse patterns should give rise to a representation in terms of genetic code words using cognitive neutrino pairs but also this seems to involve $Z^0$ magnetic body in an essential manner. For kHz frequency one would have $\lambda \sim .3$ meters, roughly the size scale of head appearing also as resonance frequency in synchronous neuronal firing. The thickness of the magnetic flux tube would code for the fundamental frequency and could quite well vary. Fractal hierarchy in powers of 2 suggests itself.

#### Thermal stability

Thermal stability in strong sense that also dark matter is assumed to be at room temperature provides a tight constraint to the model. If the lowest audible frequency, about 20 Hz, corresponds to thermal energy $\sim .03$ eV at room temperature, one could understand why lower frequencies are not heard. Of course, explanation might also rely on the fact that it is we who do not experience these frequencies consciously but that it is the next level of dark matter hierarchy which is able to hear these frequencies. If a higher level of dark matter hierarchy is the experiencing conscious entity, it might be possible to understand why the non-audible sounds created by say organ music induce deep spiritual experiences also at our level.

1. In non-relativistic case magnetic transition frequencies do not depend on the value of Planck constant and energies scale as $n_a/n_b$. If given frequency range corresponds a fixed energy range one must have $B_Z \propto n_a/n_b$. For $n_a/n_b = 2^{km}$, $k = 1, 2, ...$ fundamental frequency range would correspond to $m$ octaves. $m = 6$ corresponding to genetic code and $m = 11$ corresponding to hierarchy of EEG:s are the basic candidates.

2. Small neutrino mass and large value of Planck constant however imply that the magnetic interaction energy contributes significantly to the rest mass. This implies that cyclotron frequency behaves as $(n_a/n_b)^{-1/2}B_Z^{1/2}$ and cyclotron energy as $(n_a/n_b)^{1/2}B_Z^{1/2}$. The implication is that $B_Z$ must scale as $(n_a/n_b)^{-1/2}$ to guarantee that the energy range to which frequency range is mapped remains invariant under the change of Planck constant. As a consequence, frequency range is scaled down by $n_a/n_b$ as in non-relativistic situation. $n_a/n_b = 2^{k6}$ give a hierarchy of ranges consisting of 6 octaves each.

   $k = 4$ would result for $2^{k11}$ hierarchy for ELF frequency range and assuming non-relativistic magnetic interaction energies: the frequency of cyclotron photon with thermal energy would be around $f_c = .5$ Hz for $k = 4$ level. The audible frequency range however starts from 20 Hz. This can be understood for $n_a/n_b = 2^{k6}$ if $k = 6$ corresponds to audible frequencies in the 6-octave range 20-1280 Hz assuming reasonable values for neutrino mass and the strength of $Z^0$ magnetic field. The invariance of energy range under changes of $k$ requires that frequency range is scaled down by $2^6$ under $k \rightarrow k+1$. In music 8 tone system would mean that 6-octaves contain 18 bits of information.

**Upper bound for the energies of dark cyclotron photons**

If the energies of dark cyclotron photons are too high, their transformation to ordinary photons might induce disastrous biological effects. In absence of anything better, a reasonable guess is that energies cannot be above energies of visible photons. This would give upper bound of $E \leq 2$ eV. The range $[.03, 2]$ eV spans approximately 6 octaves which supports $m = 6$ hierarchy inspired by genetic code. For $m = 11$ hierarchy the upper bound would be 64 eV which not look promising. The range 20-1280 Hz would correspond to 64-fold scaling. Note that 1260 Hz corresponds to the duration of the bit of the linear model of memetic code assuming that total duration of 126-bit codon corresponds to 10 Hz frequency. $f \sim 1$ kHz is also critical frequency for hearing and appears as resonance frequency in synchronous neuronal firing.

**The dependence of $Z^0$ magnetic interaction energy and corresponding frequency on $\hbar$**

For large values of $n_a/n_b$ since the change of rest mass must be taken into account in the calculation of the cyclotron energy and frequency. The reason is that the magnetic interaction energy modifies the rest mass of neutrino. If the cognitive neutrino is at rest the magnetic interaction energy $E_n$ in cyclotron state can be simply added to the rest mass: $m_\nu \rightarrow m_\nu + E_n$. The formula for magnetic interaction energy is modified to

$$\begin{aligned} E_n &= n \times (n_a/n_b) \times \omega_c \times \frac{m_\nu}{m_\nu + E_n} \ , \\ \omega_c &= \frac{\hbar_0 Q_Z(\nu) J g_Z B_Z}{m_\nu} \ . \end{aligned} \tag{6.4.1}$$

From this one obtains

$$\begin{aligned} E_n &= \frac{m_\nu}{2}\left(-1 \pm \sqrt{1 + 4n(n_a/n_b)(\omega_c/m_\nu)}\right) \ , \\ f_n &= \frac{n_b}{n_a} m_\nu \left(-1 \pm \sqrt{1 + 4n(n_a/n_b)(\omega_c/m_\nu)}\right) \ . \end{aligned} \tag{6.4.2}$$

$E_n$ contains spin interaction energy, harmonic oscillator zero point kinetic energy and cyclotron contribution. Zero point energy and spin interaction energy cancel each other for the lower energy states.

At non-relativistic limit one obtains

$$\begin{aligned} E_n &= n \times (n_a/n_b) \times \omega_c \ , \\ \omega_c &= \frac{Q_Z g_Z J B_Z}{m_\nu} \ . \end{aligned} \tag{6.4.3}$$

The resulting asymptotic formulas for $E_n$ and $f_n$ at the limit of large $n_a/n_b$ are given by

$$\begin{aligned} E_n &= \sqrt{n} \times \sqrt{n_a/n_b} \times \sqrt{Q_Z(\nu) g_Z J B_Z} \ , \\ f_n &= \frac{1}{2\pi}\sqrt{n} \times (n_b/n_a)^{1/2} \times \sqrt{Q_Z(\nu) J g_Z B_Z} \ . \end{aligned} \tag{6.4.4}$$

Note that there is no dependence on neutrino mass so that the coding at this limit is in some sense universal. Somewhat unexpectedly, frequencies scale as $(n_b/n_a)^{1/2}$ and energies as $(n_a/n_b)^{1/2}$. Energy range remains invariant if $g_Z B_Z$ scales as $n_b/n_a$ as is clear from the defining condition for $E_n$.

The correspondence between thermal energy and lower limit for audible frequencies fixes the value of $n_a/n_b$ to $n_a/n_b = 2^{6\times 6}$ so that genetic code results. For $Q_Z(\nu) g_Z B_Z/e \simeq .4$ fT the energy range is in a reasonable approximation $[.07, 4.5]$ eV for the frequency range $[20, 1280]$ Hz. Magnetic fields of order fT are known to correlate with brain functioning so that the result makes sense. Note that .07 eV and .05 eV are the Josephson energies associated with the neuronal resting potential and activation potential. The frequencies above 1280 Hz correspond to $k < 6$. For $k = 5$ $g_Z B_Z$ is scaled up by a factor $2^6$. For humans $k = 6, 5$ cover frequencies up to 80 kHz containing the 10-octave audible range $[20, 20 \times 10^3]$ Hz. $k = 6, 5, 6$ covers the frequencies up to 5 MHz. Usually the sounds produced by bats are in the range 20-200 kHz. Operating regime is around 30 kHz but horseshoe bats can detect echo fluctuations at 83 kHz caused by the wing flutter of an insect. This frequency is just at the lower bound of the $k = 4$ representation.

**Some intriguing observations**

The following observations might not represent mere accidents.

1. The biologically especially relevant range of p-adic length scale spanned by $L(173) = 20$ $\mu$m defining the size of large neuron and by $L(149) = 5$ nm defining thickness of lipid layer of cell membrane corresponds to $2 \times 6$ octaves (the range of audible frequencies is 10 octaves).

2. For $n_a = 2^{4\times 11}$ the p-adic length scale $L_{M_{89}}$ characterizing weak bosons is scaled up to $L(89 + 88 = 177) \simeq 80$ $\mu$m and is differs by a factor $1/\sqrt{2}$ from the secondary p-adic length scale $L(2, 89) = L(178) = \sqrt{2}L(177)$. This supports the view that something deep is involved with $k = 4$ level which also corresponds to the ordinary EEG. For $n_a/n_b = 2^{7\times 6}$ the dark length scale is $L(89 + 78) = L(167) = 2.5$ $\mu$m and corresponds to a Gaussian Mersenne.

3. Also the scales $L(k)$, $k = 151, 157, 163$ correspond to Gaussian Mersennes. These length scales which I have assigned with the coiling hierarchy of chromosomes. Intriguingly, if magnetic field scales as $1/L(k)^2$, these primes define three levels in $n_a/n_b = 2^{k6}$ hierarchy assignable to the genetic code.

### 6.4.3 Cognitive codes based on cognitive neutrino pairs

The previous discussion provide a good background for the attempt to formulate of the model for cognitive (memetic/genetic) codes.

### Cognitive neutrino pairs as wormhole contacts

It is good to list the basic assumptions of the model.

1. It is assumed that real-padic fermion pairs provide fundamental cognitive representations. The aspects of the model related to the presence of p-adic space-time sheet are neglected in the sequel. The fermions in question can appear also as fermion-antifermion pairs assignable to the light-like throats of wormhole contact.

2. Zero energy ontology is assumed and the sequences of cognitive fermions at future and past directed light-cones are interpreted as inputs and outputs of Boolean functions with Boolean functions represented in terms of entangled states. Note that zero energy ontology allows superposition of arbitrary fermion numbers for positive energy states since net fermion numbers vanish.

3. The representation as states at lightcone boundary brings naturally in logarithmic waves and it is assumed that the temporal durations of bits would come as powers of 2 or more generally prime $p$. Logarithmic accuracy poses strong limits on the number of bits of the codon.

4. Dark matter hierarchies $n_a/n_b = 2^{mk}$, $k = 0, 1, 2..$ are considered. The cases $m = 11$ (hierarchy of EEGs) and $m = 6$ (genetic code) are of special interest. Memetic codons with 126 bits could in principle be represented using $m = 6$ hierarchy if one allows 21 layers in this hierarchy $k = 21$. This would however correspond to a huge scaling factor $2^{126} \sim 10^{38}$ requiring all p-adic length scales between $CP_2$ size the secondary p-adical length scale $L(2, 127)$. This looks unrealistically large.

Wormhole contacts have boson like characteristics and can be scalars, vectors, and perhaps even antisymmetric tensors with 2 physical components by generalization of gauge invariance so that antisymmetric tensor replaces gauge potential. Entire variety of new kinds of vector particles is predicted and should play a role in condensed matter physics. What is interesting is that these wormhole contacts can also connect space-time sheets belonging to different sectors of the imbedding space characterized by different values of $M^4_\pm$ Planck constants.

1. Cognitive neutrino pair is interpreted as spin one $\nu\overline{\nu}$ wormhole contact. Between-two-worlds character motivates partially this assumption and bit sequence could code by spontaneous $Z^0$ magnetization the spatio-temporal behavior of $Z^0$ magnetic field at either space-time sheet to a bit sequence and transmit the information to the other space-time sheet.

2. A strong correlation between spin directions of neutrino and antineutrino is highly desirable. For scalar second neutrino would be right handed and it is difficult to imagine correlation between spin directions since there is no interaction. Furthermore, for scalar standard rules of angular momentum addition preclude definite spin direction for $\nu_L$. This leaves only spin one into consideration. In this case strong correlation between spins mediated by electro-weak gauge fields defined by $CP_2$ spinor connection is possible. Therefore the spin flip of either neutrino induces spin flip of both $\nu_L$ and $\overline{\nu}_L$. The field affecting the wormhole contact would be effectively the difference of $Z^0$ gauge fields at the two space-time sheets. Assuming complete correlation between spin directions, the spin appearing in the cyclotron frequency is $J = 1$.

3. The rest mass of vector wormhole contact could be very low. The attractive $Z^0$ Coulombic and $Z^0$ magnetic interactions between neutrino and antineutrino could generate strong binding energy and make the state very light. The need for small rest mass could explain why neutrino wormhole contacts. Also the large negative $Z^0$ Coulombic interaction energy make with dark condensed matter could be reduce the rest mass and make possible spontaneous generation of pairs from vacuum. One can ask whether it is possible to regard wormhole contact as a massless particle below dark weak scale.

### Ideas about representation of memetic/genetic codons

It is best to approach the model of memetic code by listing some tentative ideas.

1. Space-like bit sequence at one space-time sheet could correspond to a time-like bit sequence at another space-time sheet. In TGD Universe this is possible by warping and anomalous time dilation even in the absence of classical gravitation (in terms of warped isometric imbeddings of $M^4$ to imbedding space). Strong warping of dark space-time sheet could make time like sequence space-like.

   The weird properties of graphene [33] include high conductivity, massless conduction electrons, and reduction of light velocity to $c/300$. The model explaining these findings is relies on dark electron concept, general p-adic mass mass formulas, and warping [J1].

   Space-like sequence could be transformed to a time-like sequence or vice versa if cognitive neutrinos are realized as wormhole contacts connecting space-time sheets along a curve which is space-like at the first sheet and space-like at the other sheet. This kind of transformations would be very much analogous to reading or writing, and might represent fundamental aspects of cognition.

2. One could also consider assigning light-like bit sequences with light-like partonic 3-surfaces whose dynamics is basically random since light-likeness is the basic dynamical constraint. Thus information storage on geometry could be considered with p-adic length scale defining a natural unit of length. The properties of the generalized eigenstates of the modified Dirac operator support the hope about linear representation of the memetic code. The braiding for the number theoretical braid defined by algebraic points in the intersection of real and p-adic partonic 2-surfaces is the natural representation of information in this case and could related directly to topological quantum computation type activities [E9].

3. One could try to assign a temporal lattice structure with the preferred light-like direction of $\delta M^4_+ \times CP_2$ defining the quantization axis of spin at the level of generalized imbedding space geometry. The transitions affecting Planck constant would occur via partonic 2-surfaces having at most projection in 2-D time-like plane defined by this direction. Super-canonical Hamiltonians have power dependence on the radial light-like coordinate $r$: logarithmic waves are in question. This favors (possibly fractally nested) logarithmic coding using octaves of the some fixed value of the light-like coordinate $r$.

   More generally, logarithmic coding of physiological intensities to conscious experiences could be understood quite generally if fundamental sensory representations are assigned with light cone boundaries and super-canonical partial waves have a fundamental role in the representation of physical states. Memetic/genetic codon could correspond to a quantum state containing partons with light like separations with respect to $M^4_\pm$ metric along the preferred light-like ray but having space-like separations with respect to the induced metric.

4. Phase transitions changing Planck constant are possible for the bits of memetic codon and the bits of the codon can belong to different branches of the imbedding space. The neutrino and antineutrino at the contacts of spin one wormhole contact could belong to different branches of imbedding space with different values of $\hbar(M^4_\pm) = n_a\hbar_0$. In this manner a higher level of dark matter hierarchy could receive information from the lower level.

**Is it possible to realize memetic code?**

$Z^0$ magnetic body should experience memetic/genetic codons somehow. Perhaps only changes of memetic/genetic code words induced by temporal and spatial dependence of $Z^0$ magnetic field are experienced consciously. This would not be a problem if there is background $Z^0$ field reducing the codon to a fixed reference state representing spontaneous magnetization with all spins in same direction. This is achieved if $Z^0$ magnetic tubes represent bits. In the time/length scale of single bit $B_Z$ would be constant and would force cognitive neutrino pair to have same spin direction as $B_Z$. Population of cognitive neutrino pairs would allow to achieve statistical determinism.

*1. Logarithmic realization of genetic code*

Logarithmic waves suggest a fractal structure with temporal durations of bits coming as powers of $2^k$ along the preferred light-like radial direction. For the hierarchy of genetic codes 6-bits would form the basic structure. The higher the level of dark matter hierarchy characterized by $n_a/n_b = 2^{k6}$, the longer the duration of bit so that more and more abstracted representations would result from $Z^0$ magnetic field. The increasing duration of the bit would also uniquely characterize its position in the bit sequence.

For a six bit genetic codon with duration of $T(127) = .1$ seconds, the bits would have durations $T(127)/2^k$, $k = 1, 2, .., 6$ with slowest duration equal to 15.6 ms, safely above the ms duration of nerve pulse. The lowest bit would correspond to 20 Hz frequency.

The realization of the bit sequence along a light-like geodesic at light-cone boundary could be based on ZEG. The field pattern of $Z^0$ $ME$ (topological light ray) is constant in the radial light-like direction so that it can carry a $Z^0$ magnetic field pulse with a constant direction of transversal $B_Z$. The $Z^0$ ME possibly inducing a spin flip of $k$:th bit, call it $ME_k$, should affect only the 3-surface $X^3_k \subset \delta M^4_+ \times CP_2$ representing $k$:th bit. If the transversal sizes of $ME_k$ and $X^3_k$ are same and scale like (say) $2^k$, a selective resonant interaction could become possible.

*2. Fractal realization of memetic codons*

Linear coding along light-cone boundary would allow 126-bit memetic codons. The time span of existence for the bit translates to the light-like radial extension of partonic 2-surface which would be about 1/1.260 milliseconds which somewhat shorter time span than the basic ms time scale of neuronal activity. For light-like coordinate this would correspond to a distance of about $3 \times 10^5$ meters between two bits represented as $\nu\overline{\nu}$ wormhole contacts. The problem is that the radial dependence of super-canonical Hamiltonians is essentially given by power law so that logarithmic coding is favored over linear coding.

One can however imagine also a logarithmic realization of memetic codon using dark matter hierarchy. One obtains a hierarchy of codes corresponding to the levels of dark matter of $n_a/n_b = 2^{6k}$. In this realization the duration of the bit at the level $k + 1$ of dark matter hierarchy is duration of the 6-bit codon at the previous level. This encourages to consider a fractal structure in the sense that each bit 6-bit structure at the next level corresponds to 6-bit in an improved resolution. Two-level hierarchy would give $6^2 = 36$ bits and three-level hierarchy $6^3 = 216$ bits so that the realization of menetic code or something very near to it would not be a problem in this kind of framework. For instance, 3-level hierarchy using 5 bits giving 125 bits and by adding one additional bit (start/end bit) one would obtain 126 bits.

The fractal memetic codon involving several branches of the imbedding space would define a structured representation of information rather than mere sequence of bits. The most obvious interpretation would be that 6 bit representation at highest dark matter level gives a rough over all view and lower dark matter levels add details to the representation.

## 6.5 More general view about cognition

The model of Penrose and Hameroff [30] postulates the reduction of our conscious experiences and cognition to micro-tubular level whereas TGD postulates in some sense just the opposite of this: our magnetic bodies could have astrophysical size.

These views are actually not mutually exclusive. The mental images at magnetic bodies could directly entangle with sub$\cdots$subselves with sizes smaller than cell length scales. Geometrically this would mean the formation of join along boundaries bonds between ELF space-time sheets and sub-cellular space-time sheets, say micro-tubular, protein and DNA space-time sheets. Also the not conscious-to-us information processing occurring at these levels could be crucial for our consciousness and somewhat analogous to the machine language of computer programs. The length scales of micro-tubules suggest that they could be also seats of cognitive antineutrinos. Penrose and Hameroff also speculate with the possibility that micro-tubules could act as quantum computers. It is interesting to find how these speculations relate to TGD based views about bio-system and consciousness. This is especially so because in TGD framework entire universe can be formally regarded as a quantum computer in some very general sense. The following considerations indeed suggest that DNA, micro-tubules and axonal membrane form an integrated cognitive (or to be precise, symbolic structure; cognitive and symbolic representations correspond to p-adic and real numbers in TGD terminology) structure.

### 6.5.1 Micro-tubules and information transfer from cell membrane to nucleus

TGD suggests a generalization of the basic views about genetic code: in particular Boolean mind could also emerge at DNA level. This raises the question about the relationship of DNA self-consciousness (predicted by TGD) to our consciousness. The basic new ingredient is the notion of the manysheeted DNA. The notion of many-sheeted DNA means that the space-time sheet of DNA has wormhole contacts and join along boundaries contacts with the space-time sheets of the entire hierarchy of space-time sheets. The concept of many-sheeted DNA allows new views about how genetic code is expressed in morphogenesis and one cannot exclude the possibility that genetic program could give rise to Boolean mind already at DNA level (see the chapter "Many-sheeted DNA"). An attractive hypothesis is that genes represent long term beliefs which become conscious when gene is active and transcribed to mRNA. Biofeedback realized by connecting 'our' space-time sheets to gene space-time sheets by join along boundaries bonds, might make gene level cognition conscious to us. A variant of this hypothesis is that intronic portion of DNA represents memes consisting of segments of 21 DNA triplets representing memetic codons and translated to field patterns of MEs forming basic control commands and basic elements of language at much more general level than the spoken language, which would represent only a tip of an iceberg

That DNA might be directly involved with neural processing is suggested by several findings. It is known that biofeedback to DNA level is possible and it is also claimed that music affects directly DNA. In the chapter "Genes and Memes" a model for the interaction of the cell membrane dynamics with the intronic portion of DNA representing memes as sequences of memetic codons consisting of 21 DNA triplets is discussed. This interaction would translate memes to field patterns associated with MEs. It would be much faster than the translation of genes to proteins and an essential part of what happens in postsynaptic neuron.

Memes transcribed to $Z^0$ MEs could generate nerve pulse patterns and membrane oscillations. Conversely, nerve pulse patterns could modulate the light-like vacuum currents of the massless extremals possibly associated with the radial micro-tubules having direct contacts with the neuronal cell membrane (but not with ordinary cell membranes!) and connecting it with the nuclear region of neuron and in this manner nerve pulse patterns would be communicated to DNA level. The effect of some anesthetics (say noble gases), usually interpreted as a support for the identification of our consciousness as a micro-tubular consciousness, could be due to the failure of this communication induced by the effects of the anesthetics at the micro-tubular level. Unconscious state not able to self-organize at micro-tubular level could have dramatic effects to our consciousness also in TGD framework.

### 6.5.2 DNA, micro-tubules, and cell membrane as cognitive structures?

Cognitive antineutrinos are crucial for TGD based model of cognition. They are associated with the defects of $Z^0$ super conductor and involve strong $Z^0$ magnetic fields. There are three types of neutrinos having nearly degenerate masses and this suggests the possibility of three basic types of cognition. DNA, micro-tubular and cell membrane could be seats for all or some of these three types of cognition. $Z^0$ magnetic system with linear structure like micro-tubule can be in three different phases corresponding to ferromagnetic phase, spin glass phase and the phase in which directions of the cognitive neutrino spins are random. In the proposed model of DNA (ee the chapter 'Many-sheeted DNA') exons and introns correspond to ferromagnetic phase and are thus ideal for the storage of long term memories (they could code both the matter– and mind like hardware of living matter). The model of EEG and nervepulse suggests that axonal cell membranes correspond to random phase ideal for communication purposes. Micro-tubule interiors or surfaces or both could in turn correspond to spin glass phase ideal for short term working memory storage: this function would explain the maximation of the lengths of the sensory axons. Of course, if micro-tubules are near criticality, they can also be in ferromagnetic and random phases depending on situation. Indeed, micro-tubules could have both memory storage and information transfer functions and serve as a bridge between DNA and cell membrane cognition.

Micro-tubules have outer and inner radii equal to $1.25 \times L(151)$ and $.75 \times L(151)$ so that the thickness of the micro-tubular surface is $L(149) = L(151)/2$. The area of the micro-tubular surface is quantized to the area $\pi L(151)^2$ of a cylinder with radius $L(151)$. This geometric quantization rule might not be a mere accident. One can consider the possibility that either the micro-tubular surface itself, micro-tubular interior or entire micro-tubule or some of them correspond to a defect of neutrino super conductor and is carrier of cognitive antineutrinos. The higher density of matter at micro-tubular surface suggests that it is a good candidate for a seat of $k = 149$ cognitive antineutrino pairs. Of course, also micro-tubule interior could be a carrier of cognitive antineutrinos. For instance, the hypothesis that the space-time sheet associated with micro-tubular surface contains odd number of cognitive antineutrinos per tubulin dimer would mean quite huge information storage capacity made possible by antineutrino spin. In the following the idea about DNA, micro-tubules and axonal membrane as seats of cognition is discussed at quantitative level.

### Criterion for the spontaneous generation of cognitive neutrino pairs from vacuum

The formation of cognitive antineutrino pairs could be basically due to the instability of vacuum. At $k = 169$ space-time sheet cognitive neutrinos could form bound states with nuclear $Z^0$ charge associated with the structure in question. The original hypothesis that cognitive antineutrinos can condense on $k = 151$ space-time sheets only, could be too restrictive and one can consider a more general criterion stating that the rest mass of cognitive antineutrino condensed on given space-time sheet and determined by the p-adic prime characterizing it, is nearly equal to the binding energy of a cognitive neutrino on $k = 169$ space-time sheet:

$$m(\nu, k < 169) = E(\nu, 169) \ .$$

The value of the binding energy depends on the local density of the biomatter and varies in wide limits from the density of water to the density of matter in DNA strand and micro-tubular surface.

In case of DNA the naive expectation is that defects must correspond to DNA threads with thickness of few Angstroms characterized by $k = 139$. This need not be however the case since many-sheeted space-time concept allows DNA threads to have thickness of, say, $L(149)$, (nucleosomes around which DNA thread winds correspond to $k = 149$ and have radius $L(149)$). In fact, many-sheeted space-time concept suggests a rather science fictive solution to the problem how DNA replication is possible on the surfaces of the nucleosomes: since nearby portions of DNA thread do not correspond to same space-time sheet, the opening of DNA double strand can occur without any problems. Consider now the estimate.

1. Electron neutrino rest mass is given by

$$m(\nu_e, k) = 2^{(169-k)/2} m(\nu_e, 169) \simeq 2^{(139-k)/2} \times .74 \times 10^4 \ eV \ .$$

2. The rest mass should be compensated by the negative $Z^0$ interaction energy of neutrino at $k = 169$ space-time sheet. The energy in question is the interaction energy of neutrino with neutrons of biomatter and both DNA thread, nucleosome consisting of histone octamers and neutrinos themselves contribute to this energy. The non-vanishing negative value of interaction energy results from the localization of the nuclear $Z^0$ charge as opposed to the even distribution of neutrino $Z^0$ charge. An order of magnitude estimate for the interaction energy of the neutrino is obtained from the parametrization

$$E(\nu, 169) = k_1 \frac{\alpha_Z Q_Z^2(\nu) N(n)}{d} \ .$$

$N(n)$ denotes the total number of neutrons in the vicinity of neutrino and $d$ denotes the average distance to the nearest neighbor. $k_1$ denotes numerical constant. $d \simeq 10^{-10}$ meters is good guess and $N(n)$ has order of magnitude equal to the number of neutrons in a typical atom of biomolecules involved. This gives

$$E(\nu, 169) = k_1 \times \alpha_Z Q_Z^2(\nu) N(n) \times .81 \times 10^4 eV \ .$$

3. Cancellation condition implies

$$\begin{aligned} k_1 \times N(n) &= .91 \times \frac{1}{\alpha_Z Q_Z^2(\nu)} \simeq 210 \ \text{ for } k = 139 \ , \\ k_1 \times N(n) &= .91 \times \frac{1}{32 \alpha_Z Q_Z^2(\nu)} \simeq 6.6 \ \text{ for } k = 149 \ . \end{aligned}$$

For $k = 139$ neutrinos the number $N(n)$ of nearest neighbor neutrons should be of order 200: this value is quite too large. For $k = 149$ the condition gives rather reasonable order of magnitude estimate $k_1 N(n) \sim 7$. Similar estimate applies in case of micro-tubules and allows to assign $k = 149$ to the micro-tubule surface and $k = 151$ to micro-tubule interior.

4. The net $Z^0$ charge of cognitive antineutrinos is smaller than nuclear $Z^0$ charge since there is net neutrino density on $k = 169$ space-time sheet and cognitive neutrinos represent additional contribution to neutrino background generated from vacuum. The requirement that net average $Z^0$ charge density vanishes implies $n(\overline{\nu}_c) = n(neutron) - n(\nu)$, where $\nu$ refers to a ordinary neutrino and $\nu_c$ refers to a cognitive neutrino. The resulting upper bound for the density of cognitive antineutrinos is

$$n(\overline{\nu}_c) \leq n(neutron)$$

and can be used as a constraint for the model.

**Estimate for the density of cognitive antineutrinos needed to generate $Z^0$ magnetic field**

Flux quantization for the strength of the $Z^0$ magnetic field associated with the micro-tubular surface gives idea about the neutrino density per unit length needed assuming that cognitive antineutrinos serve as the source of the $Z^0$ magnetic field. The conditions

$$g_Z B_Z 2 q_Z(\nu) = \frac{m\times 2\pi}{S} \quad , m = 0, 1, 2, \cdots \quad ,$$

$$g_Z B_Z = \frac{1}{4\pi} g_Z \frac{\mu_Z(tot)}{V} = \frac{1}{4\pi} g_Z \frac{dN(\nu)}{dL} \frac{1}{S} \frac{g_Z Q_Z(\nu)}{2m(\nu,k)}$$

give

$$\frac{dN(\nu)}{dL} = \frac{m\times 4\pi}{\alpha_Z} m(\nu, k) \quad ,$$

$$\alpha_Z = \frac{\alpha}{sin(\theta_W)cos(\theta_W)} \quad , \quad \alpha \simeq \frac{1}{137} \quad , \quad sin^2(\theta_W) \simeq .23 \quad .$$

Micro-tubule interior corresponds to $k = 151$ whereas micro-tubular surface corresponds most probably to $k = 149$. Note that this estimate does not depend on whether the micro-tubular surface, interior or entire micro-tubule is assumed to be the carrier of cognitive antineutrinos. Estimates holds also true for DNA thread which should have $k = 149$ by the previous estimate. The estimate for the linear density of cognitive antineutrinos is about 21 cognitive antineutrinos per Angstrom for the minimal value of the $Z^0$ magnetic field. This value means roughly 30 cognitive antineutrinos per tubulin dimer having parallel spin. This number is considerably smaller than the total number of neutrons per tubulin dimer. One can also consider liquid crystal like structure: micro-tubule could consist of layers such that cognitive antineutrinos in each layer have two possible directions of $Z^0$ magnetization.

If the DNA space-time sheet containing cognitive antineutrinos has the thickness of DNA thread about 2.5 Angstroms, the criterion would give linear density of $64 \times 21$ antineutrinos per Angstrom, which is nonsensical and the only possibility would be that $Z^0$ magnetic field is wormhole magnetic field having $Z^0$ wormholes as sources [J5]. If DNA thread has radius $L(149)$ there are $k = 42$ cognitive antineutrinos per Angstrom, which looks rather reasonable. The rather large number of cognitive antineutrinos means that DNA molecules can be regarded as $Z^0$ magnetized objects. This means that spin flip for cognitive antineutrinos must be a phase transition like process.

**Spin flip frequencies for cognitive antineutrinos**

Cognitive neutrino spin flip is crucial for cognition. For unmixed tau neutrino associated with the micro-tubule interior spin flip frequency does not depend on the p-adic prime characterizing antineutrino and is obtained by scaling the lower bound for the corresponding frequency in case of $\tau$ neutrino associated with the axonal membrane by the ratio of the areas of flux tubes involved.

$$f_L(structure) = \frac{S(membrane)}{S(structure)} f(membrane) \quad .$$

For muonic and electronic neutrino the corresponding frequencies are scaled down by a factor depending on mass ratios:

$$f(\nu_L) = \frac{m(L)}{m(\tau)} \times \frac{m_0(\nu_L)}{m_0(\nu_\tau)} f(\nu_\tau) \ , \quad L = e, \mu \ .$$

Note that the frequencies do not depend on the mass scale of neutrino and are thus scaling invariant quantities in a well defined sense. This universality could have deep consequences as far as consciousness is considered. The table gives frequencies for $(n+1, up) \leftrightarrow (n, down)$ transitions in case of DNA thread, micro-tubular surface and cell membrane.

An interesting possibility is that the three unmixed almost mass degenerate neutrino families, predicted by TGD to have masses $m(\nu_e) = .23$ eV, $m(\nu_\mu) = .4$ eV and $m(\nu_\tau) = .87$ eV, correspond to three different levels of cognition. Each of them could be associated with both DNA, micro-tubules and cell membrane.

1. The frequency and time scales associated with micro-tubules are rather interesting. $\overline{\nu}_\tau$ corresponds to $f_L \simeq 7.2$ Hz which is within uncertainties involved the frequency scale defined by the duration of the memetic codeword. For muonic neutrinos one has $T_U(\nu_\mu) = 5.1$ seconds. Rather interestingly, Comorosan effect occurs when organic molecules are radiated by a time which is multiple of 5 seconds [J5]. The fact that Comorosan effect occurs very generally suggests that 5 seconds is 'universal' time scale in biosystems. Perhaps $Z^0$ magnetic defects with dimensions of micro-tubular surface assocated with self-organization of liquid crystals serve as templates for the formation of micro-tubular surfaces and are involved with the bio-catalysis even in absence of micro-tubules. The requirement $T_U(\nu_\mu) = 5$ seconds reduces $T_U(\nu_e) \simeq 31.5$ to 30.88 minutes which is twice the period of about 15 minutes for the electric oscillations of DC currents flowing along the meridians of the meridian system discovered by Becker [32]. For micro-tubule interior the corresponding time scale would be 17.8 minutes.

2. In case of DNA the thickness of DNA thread is larger than $L(149)$ but smaller than $L(151)$. The first guess is that geometric average of these length scales is in question. The guess is motivated by the fact that also the p-adic time scale associated with memetic code is the geometric average of p-adic length scales associated with twin primes $k$ and $k+2$. For this choice $T_U \simeq 15.75$ minutes for electronic neutrinos is quite near to the period of about 15 minutes for the electric oscillations of DC currents flowing along the meridians of the meridian system discovered by Becker [32]. The requirement $T_U(\nu_\mu) = 5$ seconds in case of micro-tubular surface (Comorosan effect) implies $T_U(\nu_e) = 15.44$ seconds which is the period of electrical oscillations in the meridian system. The scaling factor 2 relating micro-tubular and DNA length scales suggests strongly that there is direct interaction and communication between DNA and micro-tubules.

3. The upper bounds for various time scales in case of cell membrane are rather long and could be perhaps identified as basic time scales of neuronal consciousness.

| Structure | DNA | micro-tubule surface | cell membrane |
|---|---|---|---|
| $f_L(\nu_e)/Hz$ | $10^{-3}$ | $5.29 \times 10^{-4}$ | $5.14 \times 10^{-7}$ |
| $T_U(\nu_e)$ | 15.75 $min$ | 31.5 $min$ | 22.2 $d$ |
| $f_L(\nu_\mu)/Hz$ | .39 | .195 | $1.895 \times 10^{-4}$ |
| $T_U(\nu_\mu)$ | 2.55 $sec$ | 5.1 $sec$ | 87.9 $min$ |
| $f_L(\nu_\tau)/Hz$ | 14.4 | 7.2 | $7 \times 10^{-3}$ |
| $T_U(\nu_\tau)$ | .07 $sec$ | .14 $sec$ | 2.4 $min$ |

Table 8. Lower bounds for the frequencies of $(n+1, up) \leftrightarrow (n, down)$ transitions from the quantization of $Z^0$ magnetic flux for DNA thread (thickness $\sqrt{2}L(149)$); micro-tubular surface of thickness 5 nm and inner radius 1.5 nm and cell membrane taken to have inner radius $R = L(169) \simeq 4.4$ $\mu m$ and thickness $L(151)$. Also the corresponding time scales $T_U$ are given.

### 6.5.3 Micro-tubules as quantum computers?

Penrose and Hameroff have also speculated with the possibility that micro-tubules could act as quantum computers such that each tubulin corresponds to one bit. One could argue that quantum computers represent too advanced technology to be realizable in living matter. Be as it may be, the consideration of this option in TGD framework is instructive since it throws also light into the relationship between quantum TGD and ordinary quantum mechanics. When subsystem has overcritical entanglement with its environment, it does not perform quantum jumps and should be analogous to a quantum system obeying Schrödinger equation. That this expectation is correct, is not at all obvious due to the radically different view about time provided by TGD.

1. As long as one can neglect the effects of other quantum jumping subsystems and treat the entire universe as nonquantum jumping system, each quantum jump involves the action of a unitary S-matrix $U$ on the state of subsystem and its complement and one has

$$\psi \rightarrow U\psi \quad .$$

   In this approximation the effect of $n$ subsequent quantum jumps on system and its complement is given by

$$\psi \rightarrow U^n\psi \quad .$$

2. Since single quantum jump corresponds to average ingrement $\tau \simeq 10^4$ Planck times, it makes sense to express $U$ as an exponential of a Hamiltonian effectively generating discretized unitary time development with the duration $\tau \simeq 10^4$ Planck times of chronon.

$$U_0 = exp(i\tau H) \quad .$$

   From this one obtains that a period of entanglement with duration $t$ corresponds to the time development operator

$$U = U_0^n \quad , \quad n = \frac{t}{\tau} \quad .$$

   Subsystem can never behave as an ideal quantum computer and the best one can achieve is that the entanglement with external world is just above the critical entanglement to prevent the occurrence of quantum jumps.

The basic problem of biosystem as a quantum computer idea is the realization of almost dissipation free systems in the hot, wet and noisy environment provided by brain. Cognitive antineutrinos associated with, say micro-tubules, might be ideal in this respect since dissipative effects are very small. Of course, also other superconductor predicted by TGD could serve the same purpose. Quantum computer like system should be extremely flexible in order to allow the realization of a Hamiltonian associated with a given computation. Spin glasses are indeed systems of this kind since the values for the basic couplings of spin glass like system, rather than being 'fundamental constants', obey probability distribution. In TGD framework entire universe is quantum spin glass so that the prospects for the possibility of quantum computation look good. Perhaps micro-tubules in spin glass phase could provide a realization for quantum computers based on cognitive antineutrinos.

### 6.5.4 Cognition at the level of the entire body?

Under the assumptions made, memetic code could in principle be realized everywhere in the nervous system, the intronic portion of DNA could code memes as sequences of 21 DNA triplets, and neutrino based cognition could be present in some primitive form in the entire nervous system. What is required for transcription of the nerve pulse patterns to the memetic codewords is the presence of $Z^0$ magnetic field of order one .5 Tesla in axons. Thus the receipe for building intelligent biomatter would be simple: provide axons with $Z^0$ magnetic field having critical value giving rise to neutrino spin flip frequency of order $10^3$ Hz. One could however consider also the possibility that the mere presence of the cognitive anti-neutrinos is enough and that language is only a more refined form of cognition. Thus in principle our organs, in particular sensory organs, and skin could be much more intelligent creatures than our brains are accustomed to think!

In the chapter "Biosystems as superconductors" it was shown that cognitive neutrino pairs can be created from vacuum only if there are free neutrino vacancies at $k = 169$ space-time sheet and that these vacancies could be created by the excitation of nuclei by phonons in turn interacting with neutrinos via the classical $Z^0$ force. Perhaps the needed acoustic energy could be generated by blood flow. Indeed, intensive blood flow to various parts of body accompanies situations, where those parts of our body are active. Consider only what happens, when person flushes. 'Pinocchio effect' in which blood flows into the nose of a person who is lying, is second example. The blood flow into genitals during sexual arousal could be also regarded as a signal for higher level of cognitive consciousness in parts of body, to which we usually do not assign very high intelligence quotient. What is remarkable that blood flow revealed by PET (positron emission tomography) scan would provide a direct measure for the presence of 'our' consciousness and one could build quite reliable 'our consciousness' maps. Oxygen consumption revealed by fMRI (functional magnetic resonance imaging) might in turn serve as a measure for the presence of lower levels of consciousness ('sub-conscious' from our point of view).

Cognitive neutrino pairs could be present also in the ordinary cell membranes. The presence of strong $Z^0$ magnetic field necessary for the mechanism generating generating cognitive neutrino pairs in cell membrane regions implies spontaneous magnetization of antineutrinos and freezes these degrees of freedom. Information storage is possible only if there is some mechanism changing the direction of the antineutrino spin. The small frequency difference between $(n+1, up)$ and $(n, down)$ states makes this kind of mechanism possible. What is needed is $Z^0$ magnetic pulse of correct duration in ELF range and it might be that solitons of various ionic superconductors having correct duration could induce spin flip.

One can consider also other representations of information using cognitive neutrinos at cellular space-time sheets (as opposed to cognitive antineutrinos at cell membrane space-time sheets discussed in this chapter). For instance, the spin direction of the nonrelativistic *neutrino* member of the cognitive neutrino pairs at $k = 169$ space-time sheet, or some larger space-time sheet, could be controlled by the weak $Z^0$ magnetic fields generated by blood – and cytoplasmic flows. The magnetization direction of the cognitive neutrinos would provide kind of not-conscious-to-us map of the $Z^0$ magnetic fields at the cellular $k = 169$ space-time sheets. Since memetic codewords would be involved, temporal aspect would be also present. This kind of map could generate intra-cellular self-consciousness: cell is full of endoplasma membranes so that his map would be rather faithful. This consciousness would in turn contribute to body consciousness. Perhaps it is worth mentioning that I have personally experienced an altered state of consciousness during which my visual field contained as a background an extremely complicated and beautiful flow consisting of dots: I interpreted it as a representation for either liquid flow or of magnetic field. A possible interpretation for the experience is as 'biofeedback' to cellular level making it possible to experience what it is to be a cell.

One can wonder what happens in the ordinary liquid flow, in which $Z^0$ magnetic fields and neutrinos are also present. Can one assign conscious intelligence with the flow of the ordinary water? Is here the fundamental explanation for why life originated in sea and why we are actually 70 per cent of sea water?

1. Quantum jumps and moments of consciousness do certainly occur in hydrodynamics flow. Dissipation in liquid flow is signature for the occurrence of quantum jumps between histories and ordinary dissipative flow is only a phenomenological description replacing the sequence of quantum jumps between non-dissipative hydrodynamical flows with single dissipative hydrodynamical flow. The mechanism of dissipation proposed in [D7] is based on the decay of vortices to smaller vortices and involves implicit assumption about the presence of quantum jumps in length scales characterized by vortex sizes.

2. One possibility is that neutrino magnetization generating defects of the neutrino super conductor (temporal sequences of cognitive neutrino pairs are not involved now) gives rise to a primitive self-conscious representation of the liquid flow. This representation would give no conscious information about the time development of the flow as memetic codewords do. Cell membranes would have evolved from these defects.

3. One could have even more. The model for sensory qualia suggest strongly that axon interior is

the carrier of Earth's magnetic field whereas the model for cognition implies that cell membrane able to cognize is the carrier of the $Z^0$ magnetic field: one cannot however exclude the presence of a small magnetic field also in cell membrane. This implies that average magnetic fluxes per axon area, and hence also macroscopic average fields, are of same order of magnitude for magnetic and $Z^0$ magnetic fields necessary for the generation of cognitive neutrino pairs. This raises the possibility that Earth has also $Z^0$ magnetic field quantized in flux tubes with geometry of hollow cylinder and dimensions of axon so that conditions making possible some form of Boolean mind might be normal. This assumption is consistent with the fact that $Z^0$ magnetic fields correspond to the defects of the neutrino super conductor. If this is indeed the case then even ordinary liquid flow could involve rudimentary cognition and cell membranes could be regarded as structures evolved around the hollow $Z^0$ magnetic flux tubes. Thoughts would precede brain!

This picture suggests also some guidelines for the possible future attempts to construct artificial life.

1. Strong electric fields are needed to generate cognitive resources if the proposed interpretation of quantum criticality is correct [H1]. Weak magnetic fields are needed to build up the needed effectively one-dimensional superconductors at non-atomic space-time sheets.

2. A further necessary prerequisite is varying liquid flow creating sufficiently strong $Z^0$ magnetic fields generating automatically stripe like defects serving as templates for cell membrane like structures serving as seats for cognition. One cannot exclude the spontaneous generation of mindlike space-time sheet pairs carrying the strong $Z^0$ magnetic fields associated with cell membrane: in fact, Earth's $Z^0$ magnetic field could already contain these structures. The complexity of liquid flow should correlate with the complexity of neutrino cognition possibly present in the system.

3. ELF em fields oscillating with magnetic transition frequencies might be of considerable help in the enterprise. Besides these ingredients simple carbon compounds serving as basic building blocks of artificial life should be present.

4. The mechanism for the creation of cognitive neutrino-antineutrino pairs relies crucially on the cancellation of the rest mass + kinetic energy of the cognitive antineutrino at $k = 151$ space-time sheet and Coulombic $Z^0$ interaction energy of the cognitive neutrino at $k = 169$ space-time sheet. This mechanism is possible only under very restricted range of $Z^0$ charge densities for matter and water containing organic compounds in right proportions is probably crucial for achieving this condition.

Putting all these together and letting the soup to quantum self-organize, the first signs of life would sooner or later emerge (provided I have not forgot some item from the list!). It would be also interesting to study the interaction of living cells interacting with sufficiently complicated water flow, possibly in presence of strong electric field.

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# Appendix A

# Appendix

## A-1 Basic properties of $CP_2$

### A-1.1 $CP_2$ as a manifold

$CP_2$, the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space $C^3$ under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \ . \tag{A-1.1}$$

Here $\lambda$ is any nonzero complex number. Note that $CP_2$ can also regarded as the coset space $SU(3)/U(2)$. The pair $z^i/z^j$ for fixed $j$ and $z^i \neq 0$ defines a complex coordinate chart for $CP_2$. As $j$ runs from 1 to 3 one obtains an atlas of three charts covering $CP_2$, the charts being holomorphically related to each other (e.g. $CP_2$ is a complex manifold). The points $z^3 \neq 0$ form a subset of $CP_2$ homoeomorphic to $R^4$ and the points with $z^3 = 0$ a set homeomorphic to $S^2$. Therefore $CP_2$ is obtained by "adding the 2-sphere at infinity to $R^4$".

Besides the standard complex coordinates $\xi^i = z^i/z^3$ , $i = 1, 2$ the coordinates of Eguchi and Freund [2] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it \ , \\ \xi^2 &= x + iy \ . \end{aligned} \tag{A-1.2}$$

These are related to the "spherical coordinates" via the equations

$$\begin{aligned} \xi^1 &= rexp(i\frac{(\Psi + \Phi)}{2})cos(\frac{\Theta}{2}) \ , \\ \xi^2 &= rexp(i\frac{(\Psi - \Phi)}{2})sin(\frac{\Theta}{2}) \ . \end{aligned} \tag{A-1.3}$$

The ranges of the variables $r, \Theta, \Phi, \Psi$ are $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively.

Considered as a real four-manifold $CP_2$ is compact and simply connec- ted, with Euler number 3, Pontryagin number 3 and second Betti number $b = 1$.

### A-1.2 Metric and Kähler structures of $CP_2$

In order to obtain a natural metric for $CP_2$, observe that $CP_2$ can be thought of as a set of the orbits of the isometries $z^i \rightarrow exp(i\alpha)z^i$ on the sphere $S^5$: $\sum z^i\bar{z}^i = R^2$. The metric of $CP_2$ is obtained by projecting the metric of $S^5$ orthogonally to the orbits of the isometries. Therefore the distance between the points of $CP_2$ is that between the representative orbits on $S^5$. The line element has the following form in the complex coordinates

$$ds^2 = g_{a\bar{b}} d\xi^a d\bar{\xi}^b \quad , \tag{A-1.4}$$

where the Hermitian, in fact Kähler, metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K \quad , \tag{A-1.5}$$

where the function $K$, Kähler function, is defined as

$$\begin{aligned} K &= lnF \quad , \\ F &= 1 + r^2 \quad . \end{aligned} \tag{A-1.6}$$

The representation of the metric is given by

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2\sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} \quad , \tag{A-1.7}$$

where the quantities $\sigma_i$ are defined as

$$\begin{aligned} r^2\sigma_1 &= Im(\xi^1 d\xi^2 - \xi^2 d\xi^1) \quad , \\ r^2\sigma_2 &= -Re(\xi^1 d\xi^2 - \xi^2 d\xi^1) \quad , \\ r^2\sigma_3 &= -Im(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) \quad . \end{aligned} \tag{A-1.8}$$

The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A \quad , \tag{A-1.9}$$

are given by

$$\begin{aligned} e^0 &= \tfrac{dr}{F} \quad , \quad & e^1 &= \tfrac{r\sigma_1}{\sqrt{F}} \quad , \\ e^2 &= \tfrac{r\sigma_2}{\sqrt{F}} \quad , \quad & e^3 &= \tfrac{r\sigma_3}{F} \quad . \end{aligned} \tag{A-1.10}$$

The explicit representations of vierbein vectors are given by

$$\begin{aligned} e^0 &= \tfrac{dr}{F} \quad , & e^1 &= \tfrac{r(sin\Theta cos\Psi d\Phi + sin\Psi d\Theta)}{2\sqrt{F}} \quad , \\ e^2 &= \tfrac{r(sin\Theta sin\Psi d\Phi - cos\Psi d\Theta)}{2\sqrt{F}} \quad , & e^3 &= \tfrac{r(d\Psi + cos\Theta d\Phi)}{2F} \quad . \end{aligned} \tag{A-1.11}$$

The explicit representation of the line element is given by the expression

$$ds^2/R^2 = dr^2/F^2 + (r^2/4F^2)(d\Psi + cos\Theta d\Phi)^2 + (r^2/4F)(d\Theta^2 + sin^2\Theta d\Phi^2) \quad . \tag{A-1.12}$$

The vierbein connection satisfying the defining relation

$$de^A = -V_B^A \wedge e^B \quad , \tag{A-1.13}$$

is given by

$$
\begin{array}{lllllll}
V_{01} & = & -\frac{e^1}{r} \ , & V_{23} & = & \frac{e^1}{r} \ , \\
V_{02} & = & -\frac{e^2}{r} \ , & V_{31} & = & \frac{e^2}{r} \ , \\
V_{03} & = & (r-\frac{1}{r})e^3 \ , & V_{12} & = & (2r+\frac{1}{r})e^3 \ .
\end{array} \qquad (A-1.14)
$$

The representation of the covariantly constant curvature tensor is given by

$$
\begin{array}{lllllll}
R_{01} & = & e^0\wedge e^1 - e^2\wedge e^3 \ , & R_{23} & = & e^0\wedge e^1 - e^2\wedge e^3 \ , \\
R_{02} & = & e^0\wedge e^2 - e^3\wedge e^1 \ , & R_{31} & = & -e^0\wedge e^2 + e^3\wedge e^1 \ , \\
R_{03} & = & 4e^0\wedge e^3 + 2e^1\wedge e^2 \ , & R_{12} & = & 2e^0\wedge e^3 + 4e^1\wedge e^2 \ .
\end{array} \qquad (A-1.15)
$$

Metric defines a real, covariantly constant, and therefore closed 2-form $J$

$$
J = -ig_{a\bar{b}}d\xi^a d\bar{\xi}^b \ , \qquad (A-1.16)
$$

the so called Kähler form. Kähler form $J$ defines in $CP_2$ a symplectic structure because it satisfies the condition

$$
J^k_{\ r}J^{rl} = -s^{kl} \ . \qquad (A-1.17)
$$

The form $J$ is integer valued and by its covariant constancy satisfies free Maxwell equations. Hence it can be regarded as a curvature form of a $U(1)$ gauge potential $B$ carrying a magnetic charge of unit $1/2g$ ($g$ denotes the gauge coupling). Locally one has therefore

$$
J = dB \ , \qquad (A-1.18)
$$

where $B$ is the so called Kähler potential, which is not defined globally since $J$ describes magnetic monopole.

It should be noticed that the magnetic flux of $J$ through a 2-surface in $CP_2$ is proportional to its homology equivalence class, which is integer valued. The explicit representations of $J$ and $B$ are given by

$$
\begin{array}{lll}
B & = & 2re^3 \ , \\
J & = & 2(e^0\wedge e^3 + e^1\wedge e^2) = \frac{r}{F^2}dr\wedge(d\Psi + cos\Theta d\Phi) + \frac{r^2}{2F}sin\Theta d\Theta d\Phi \ .
\end{array} \qquad (A-1.19)
$$

The vielbein curvature form and Kähler form are covariantly constant and have in the complex coordinates only components of type (1,1).

Useful coordinates for $CP_2$ are the so called canonical coordinates in which Kähler potential and Kähler form have very simple expressions

$$
\begin{array}{lll}
B & = & \sum_{k=1,2} P_k dQ_k \ , \\
J & = & \sum_{k=1,2} dP_k\wedge dQ_k \ .
\end{array} \qquad (A-1.20)
$$

The relationship of the canonical coordinates to the "spherical" coordinates is given by the equations

$$
\begin{array}{lll}
P_1 & = & -\frac{1}{1+r^2} \ , \\
P_2 & = & \frac{r^2 cos\Theta}{2(1+r^2)} \ , \\
Q_1 & = & \Psi \ , \\
Q_2 & = & \Phi \ .
\end{array} \qquad (A-1.21)
$$

### A-1.3 Spinors in $CP_2$

$CP_2$ doesn't allow spinor structure in the conventional sense [5]. However, the coupling of the spinors to a half odd multiple of the Kähler potential leads to a respectable spinor structure. Because the delicacies associated with the spinor structure of $CP_2$ play a fundamental role in TGD, the arguments of Hawking are repeated here.

To see how the space can fail to have an ordinary spinor structure consider the parallel transport of the vierbein in a simply connected space $M$. The parallel propagation around a closed curve with a base point $x$ leads to a rotated vierbein at $x$: $e^A = R^A_B e^B$ and one can associate to each closed path an element of $SO(4)$.

Consider now a one-parameter family of closed curves $\gamma(v) : v \in (0,1)$ with the same base point x and $\gamma(0)$ and $\gamma(1)$ trivial paths. Clearly these paths define a sphere $S^2$ in M and the element $R^A_B(v)$ defines a closed path in $SO(4)$. When the sphere $S^2$ is contractible to a point e.g., homologically trivial, the path in $SO(4)$ is also contractible to a point and therefore represents a trivial element of the homotopy group $\Pi_1(SO(4)) = Z_2$.

For a homologically nontrivial 2-surface $S^2$ the associated path in $SO(4)$ can be homotopically nontrivial and therefore corresponds to a nonclosed path in the covering group Spin(4) (leading from the matrix 1 to -1 in the matrix representation). Assume this is the case.

Assume now that the space allows spinor structure. Then one can parallelly propagate also spinors and by the above construction associate a closed path of Spin(4) to the surface $S^2$. Now, however this path corresponds to a lift of the corresponding $SO(4)$ path and cannot be closed. Thus one ends up with a contradiction.

From the preceding argument it is clear that one could compensate the nonallowed $-1$- factor associated with the parallel transport of the spinor around the sphere $S^2$ by coupling it to a gauge potential in such a way that in the parallel transport the gauge potential introduces a compensating $-1$-factor. For a $U(1)$ gauge potential this factor is given by the exponential $exp(i2\Phi)$ , where $\Phi$ is the the magnetic flux through the surface. This factor has the value $-1$ provided the $U(1)$ potential carries half odd multiple of Dirac charge $1/2g$. In case of $CP_2$ the required gauge potential is half odd multiple of the Kähler potential $B$ defined previously. In the case of $M^4 \times CP_2$ one can in addition couple the spinor components with different chiralities independently to an odd multiple of $B/2$.

### A-1.4 Geodesic submanifolds of $CP_2$

Geodesic submanifolds are defined as submanifolds having common geodesic lines with the imbedding space. As a consequence the second fundamental form of the geodesic manifold vanishes, which means that the tangent vectors $h^k_\alpha$ (understood as vectors of $H$) are covariantly constant quantities with respect to the covariant derivative taking into account that the tangent vectors are vectors both with respect to $H$ and $X^4$.

In [3] a general characterization of the geodesic submanifolds for an arbitrary symmetric space $G/H$ is given. Geodesic submanifolds are in 1-1-correspondence with the so called Lie triple systems of the Lie-algebra $g$ of the group $G$. The Lie triple system $t$ is defined as a subspace of $g$ characterized by the closedness property with respect to double commutation

$$[X,[Y,Z]] \in t \ \text{ for } \ X,Y,Z \in t \ . \tag{A-1.22}$$

$SU(3)$ allows, besides geodesic lines, two nonequivalent (not isometry related) geodesic spheres. This is understood by observing that $SU(3)$ allows two nonequivalent $SU(2)$ algebras corresponding to subgroups $SO(3)$ (orthogonal $3\times3$ matrices) and the usual isospin group $SU(2)$. By taking any subset of two generators from these algebras, one obtains a Lie triple system and by exponentiating this system, one obtains a 2-dimensional geodesic submanifold of $CP_2$.

Standard representatives for the geodesic spheres of $CP_2$ are given by the equations

$$S^2_I \ : \ \xi^1 = \bar{\xi}^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Psi = 0) \ ,$$

$$S^2_{II} \ : \ \xi^1 = \xi^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Phi = 0) \ .$$

The nonequivalence of these submanifolds is clear from the fact that isometries act as holomorphic transformations in $CP_2$. The vanishing of the second fundamental form is also easy to verify. The first geodesic manifold is homologically trivial: in fact, the induced Kähler form vanishes identically for $S^2_I$. $S^2_{II}$ is homologically nontrivial and the flux of the Kähler form gives its homology equivalence class.

## A-2 Identification of the electroweak couplings

The delicacies of the spinor structure of $CP_2$ make it a unique candidate for space $S$. First, the coupling of the spinors to the $U(1)$ gauge potential defined by the Kähler structure provides the missing $U(1)$ factor in the gauge group. Secondly, it is possible to couple different $H$-chiralities independently to a half odd multiple of the Kähler potential. Thus the hopes of obtaining a correct spectrum for the electromagnetic charge are considerable. In the following it will be demonstrated that the couplings of the induced spinor connection are indeed those of the GWS model [4] and in particular that the right handed neutrinos decouple completely from the electroweak interactions.

To begin with, recall that the space $H$ allows to define three different chiralities for spinors. Spinors with fixed $H$-chirality $e = \pm 1$, $CP_2$-chirality $l, r$ and $M^4$-chirality $L, R$ are defined by the condition

$$\begin{aligned} \Gamma\Psi &= e\Psi \ , \\ e &= \pm 1 \ , \end{aligned} \tag{A-2.1}$$

where $\Gamma$ denotes the matrix $\Gamma_9 = \gamma_5 \times \gamma_5$, $1 \times \gamma_5$ and $\gamma_5 \times 1$ respectively. Clearly, for a fixed $H$-chirality $CP_2$- and $M^4$-chiralities are correlated.

The spinors with $H$-chirality $e = \pm 1$ can be identified as quark and lepton like spinors respectively. The separate conservation of baryon and lepton numbers can be understood as a consequence of generalized chiral invariance if this identification is accepted. For the spinors with a definite $H$-chirality one can identify the vielbein group of $CP_2$ as the electroweak group: $SO(4) = SU(2)_L \times SU(2)_R$.

The covariant derivatives are defined by the spinorial connection

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) \ . \tag{A-2.2}$$

Here $V$ and $B$ denote the projections of the vielbein and Kähler gauge potentials respectively and $1_{+(-)}$ projects to the spinor $H$-chirality $+(-)$. The integers $n_\pm$ are odd from the requirement of a respectable spinor structure.

The explicit representation of the vielbein connection $V$ and of $B$ are given by the equations

$$\begin{aligned} V_{01} &= -\frac{e^1}{r} \ , & V_{23} &= \frac{e^1}{r} \ , \\ V_{02} &= -\frac{e^2}{r} \ , & V_{31} &= \frac{e^2}{r} \ , \\ V_{03} &= (r - \frac{1}{r})e^3 \ , & V_{12} &= (2r + \frac{1}{r})e^3 \ , \end{aligned} \tag{A-2.3}$$

and

$$B = 2re^3 \ , \tag{A-2.4}$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying $\Sigma^0_3$ and $\Sigma^1_2$ as the diagonal (neutral) Lie-algebra generators of $SO(4)$, one finds that the charged part of the spinor connection is given by

$$A_{ch} = 2V_{23}I^1_L + 2V_{13}I^2_L \ , \tag{A-2.5}$$

where one have defined

$$
\begin{aligned}
I_L^1 &= \frac{(\Sigma_{01} - \Sigma_{23})}{2} \ , \\
I_L^2 &= \frac{(\Sigma_{02} - \Sigma_{13})}{2} \ .
\end{aligned}
\tag{A-2.6}
$$

$A_{ch}$ is clearly left handed so that one can perform the identification

$$
W^{\pm} = \frac{2(e^1 \pm ie^2)}{r} \ , \tag{A-2.7}
$$

where $W^{\pm}$ denotes the charged intermediate vector boson.

Consider next the identification of the neutral gauge bosons $\gamma$ and $Z^0$ as appropriate linear combinations of the two functionally independent quanties

$$
\begin{aligned}
X &= re^3 \ , \\
Y &= \frac{e^3}{r} \ ,
\end{aligned}
\tag{A-2.8}
$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$
\begin{aligned}
\bar{\gamma} &= aX + bY \ , \\
\bar{Z}^0 &= cX + dY \ ,
\end{aligned}
\tag{A-2.9}
$$

where the normalization condition

$$
ad - bc = 1 \ ,
$$

is satisfied. The physical fields $\gamma$ and $Z^0$ are related to $\bar{\gamma}$ and $\bar{Z}^0$ by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$
\begin{aligned}
A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\
&+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0 \ .
\end{aligned}
\tag{A-2.10}
$$

Identifying $\Sigma_{12}$ and $\Sigma_{03} = 1 \times \gamma_5 \Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that $\gamma$ couples vectorially leads to the condition

$$
c = -d \ . \tag{A-2.11}
$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$
A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.12}
$$

Here the electromagnetic charge $Q_{em}$ and the weak isospin are defined by

$$
\begin{aligned}
Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} \ , \\
I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} \ .
\end{aligned}
\tag{A-2.13}
$$

The fields $\gamma$ and $Z^0$ are defined via the relations

$$\begin{aligned} \gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX+bY) \ , \\ Z^0 &= 4(a+b)\bar{Z}^0 = 4(X-Y) \ . \end{aligned} \qquad \text{(A-2.14)}$$

The value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{3b}{2(a+b)} \ , \qquad \text{(A-2.15)}$$

and is not fixed completely. Observe that right handed neutrinos decouple completely from the electroweak interactions.

The determination of the value of Weinberg angle is a dynamical problem. The angle is completely fixed once the YM action is fixed by requiring that action contains no crossterm of type $\gamma Z^0$. Pure symmetry nonbroken electroweak YM action leads to a definite value for the Weinberg angle. One can however add a symmetry breaking term proportional to Kähler action and this changes the value of the Weinberg angle.

To evaluate the value of the Weinberg angle one can express the neutral part $F_{nc}$ of the induced gauge field as

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) \ , \qquad \text{(A-2.16)}$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0\wedge e^3 + e^1\wedge e^2) \ , \\ R_{12} &= 2(e^0\wedge e^3 + 2e^1\wedge e^2) \ , \\ J &= 2(e^0\wedge e^3 + e^1\wedge e^2) \ , \end{aligned} \qquad \text{(A-2.17)}$$

in terms of the fields $\gamma$ and $Z^0$ (photon and $Z$- boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \qquad \text{(A-2.18)}$$

Evaluating the expressions above one obtains for $\gamma$ and $Z^0$ the expressions

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{03} \ , \\ Z^0 &= 2R_{03} \ . \end{aligned} \qquad \text{(A-2.19)}$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + sin^2\theta_W Z^0) \ . \qquad \text{(A-2.20)}$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + fJ^{\alpha\beta}J_{\alpha\beta} \ , \\ L_{sym} &= \frac{1}{4g^2}Tr(F^{\alpha\beta}F_{\alpha\beta}) \ , \end{aligned} \qquad \text{(A-2.21)}$$

where the trace is taken in spinor representation, in terms of $\gamma$ and $Z^0$ one obtains for the coefficient $X$ of the $\gamma Z^0$ crossterm (this coefficient must vanish) the expresssion

$$\begin{aligned} X &= -\frac{K}{2g^2}+\frac{fp}{18} \ , \\ K &= Tr\left[Q_{em}(I_L^3 - sin^2\theta_W Q_{em})\right] \ , \end{aligned} \tag{A-2.22}$$

In the general case the value of the coefficient $K$ is given by

$$K = \sum_i \left[-\frac{(18+2n_i^2)sin^2\theta_W}{9}\right] \ , \tag{A-2.23}$$

where the sum is over the spinor chiralities, which appear as elementary fermions and $n_i$ is the integer describing the coupling of the spinor field to the the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{9\sum_i 1}{(fg^2+2\sum_i(18+n_i^2))} \ . \tag{A-2.24}$$

In the scenario where both leptons and quarks are elemantary fermions the value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{9}{(\frac{fg^2}{2}+28)} \ . \tag{A-2.25}$$

The bare value of the Weinberg angle is 9/28 in this scenario, which is quite close to the typical value 9/24 of GUTs [6].

## A-2.1 Discrete symmetries

The treatment of discrete symmetries C, P, and T is based on the following requirements:
a) Symmetries must be realized as purely geometric transformations.
b) Transformation properties of the field variables should be essentially the same as in the conventional quantum field theories [1].

The action of the reflection $P$ on spinors of is given by

$$\Psi \rightarrow P\Psi = \gamma^0\otimes\gamma^0\Psi \ . \tag{A-2.26}$$

in the representation of the gamma matrices for which $\gamma^0$ is diagonal. It should be noticed that $W$ and $Z^0$ bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P.

The guess that a complex conjugation in $CP_2$ is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$\begin{aligned} m^k &\rightarrow T(M^k) \ , \\ \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \gamma^1\gamma^3\otimes 1\Psi \ . \end{aligned} \tag{A-2.27}$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in $CP_2$:

$$\begin{aligned} \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \Psi^\dagger\gamma^2\gamma^0\otimes 1 \ . \end{aligned} \tag{A-2.28}$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

## A-3 Space-time surfaces with vanishing em, $Z^0$, Kähler, or $W$ fields

In the sequel it is shown that space-times for which either em, $Z^0$, or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers ($\omega_1$ and $\omega_2$) are frequency type parameters, two ($k_1$ and $k_2$ ) are wave vector like quantum numbers, two of the quantum numbers ($n_1$ and $n_2$) are integers. The parameters $\omega_i$ and $n_i$ will be referred as electric and magnetic quantum numbers. The existence of these quantum numbers is not a feature of these solutions alone but represents a much more general phenomenon differentiating in a clear cut manner between TGD and Maxwell's electrodynamics.

The simplest manner to avoid surface Kähler charges and discontinuities or infinities in the derivatives of $CP_2$ coordinates on the common boundary of two neighboring regions with different vacuum quantum numbers is topological field quantization, 3-space decomposes into disjoint topological field quanta, 3-surfaces having outer boundaries with possibly macroscopic size.

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional $CP_2$ projection, only vacuum extremals and space-time surfaces for which $CP_2$ projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing $W$ fields and homologically non-trivial sphere to non-vanishing $W$ fields but vanishing $\gamma$ and $Z^0$. For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has U(1) holonomy.

### A-3.1 Em neutral space-times

Em and $Z^0$ neutral space-times are especially interesting space-times as far as applications of TGD are considered. Consider first the electromagnetically neutral space-times. Using spherical coordinates $(r, \Theta, \Psi, \Phi)$ for $CP_2$, the expression of Kähler form reads as

$$\begin{aligned} J &= \frac{r}{F^2}dr\wedge(d\Psi+cos(\Theta)d\Phi)+\frac{r^2}{2F}sin(\Theta)d\Theta\wedge d\Phi \ , \\ F &= 1+r^2 \ . \end{aligned} \tag{A-3.1}$$

The general expression of electromagnetic field reads as

$$\begin{aligned} F_{em} &= (3+2p)\frac{r}{F^2}dr\wedge(d\Psi+cos(\Theta)d\Phi)+(3+p)\frac{r^2}{2F}sin(\Theta)d\Theta\wedge d\Phi \ , \\ p &= sin^2(\Theta_W) \ , \end{aligned} \tag{A-3.2}$$

where $\Theta_W$ denotes Weinberg angle.

The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$\begin{aligned} \Psi &= k\Phi \ , \\ (3+2p)\frac{1}{r^2F}(d(r^2)/d\Theta)(k+cos(\Theta)) &+ (3+p)sin(\Theta)=0 \ , \end{aligned} \tag{A-3.3}$$

hold true. The conditions imply that $CP_2$ projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$\begin{aligned} r &= \sqrt{\frac{X}{1-X}} \ , \\ X &= D\left[|\frac{(k+u}{C}|\right]^{\epsilon} \ , \\ u &\equiv cos(\Theta) \ , \ C=k+cos(\Theta_0) \ , \ D=\frac{r_0^2}{1+r_0^2} \ , \ \epsilon=\frac{3+p}{3+2p} \ , \end{aligned} \tag{A-3.4}$$

where $C$ and $D$ are integration constants. $0 \leq X \leq 1$ is required by the reality of $r$. $r = 0$ would correspond to $X = 0$ giving $u = -k$ achieved only for $|k| \leq 1$ and $r = \infty$ to $X = 1$ giving $|u + k| = [(1 + r_0^2)/r_0^2)]^{(3+2p)/(3+p)}$ achieved only for

$$sign(u+k) \times [\frac{1+r_0^2}{r_0^2}]^{\frac{3+2p}{3+p}} \leq k+1 \ ,$$

where $sign(x)$ denotes the sign of $x$.

Under rather general conditions the coordinates $\Psi$ and $\Phi$ can be written in the form

$$\begin{aligned} \Psi &= \omega_2 m^0 + k_2 m^3 + n_2\phi + \text{Fourier expansion} \ , \\ \Phi &= \omega_1 m^0 + k_1 m^3 + n_1\phi + \text{Fourier expansion} \ . \end{aligned} \tag{A-3.5}$$

$m^0$,$m^3$ and $\phi$ denote the coordinate variables of the cylindrical $M^4$ coordinates) so that one has $k = \omega_2/\omega_1 = n_2/n_1 = k_2/k_1$. The regions of the space-time surface with given values of the vacuum parameters $\omega_i$,$k_i$ and $n_i$ and $m$ and $C$ are bounded by the surfaces at which the electromagnetically neutral imbeddings become ill-defined, say by $r > 0$ or $r < \infty$ surfaces.

The space-time surface decomposes into regions characterized by different values of the vacuum parameters $r_0$ and $\Theta_0$. At $r = \infty$ surfaces $n_2$,$\omega_2$ and $m$ can change since all values of $\Psi$ correspond to the same point of $CP_2$: at $r = 0$ surfaces also $n_1$ and $\omega_1$ can change since all values of $\Phi$ correspond to same point of $CP_2$, too. If $r = 0$ or $r = \infty$ is not in the allowed range space-time surface develops a boundary.

This implies what might be called topological quantization since in general it is not possible to find a smooth global imbedding for, say a constant magnetic field. Although global imbedding exists it decomposes into regions with different values of the vacuum parameters and the coordinate $u$ in general possesses discontinuous derivative at $r = 0$ and $r = \infty$ surfaces. A possible manner to avoid edges of space-time is to allow field quantization so that 3-space (and field) decomposes into disjoint quanta, which can be regarded as structurally stable units a 3-space (and of the gauge field). This doesn't exclude partial join along boundaries for neighboring field quanta provided some additional conditions guaranteing the absence of edges are satisfied.

The vanishing of the electromagnetic fields implies that the condition

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \ , \tag{A-3.6}$$

is satisfied. In particular, the ratio $\omega_2/\omega_1$ is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter $n_1$ and $n_2$ ($\omega_1$ and $\omega_2$) in general generates magnetic field and therefore these integers will be referred to as magnetic (electric) quantum numbers.

The expression for the Kähler form and $Z^0$ field of the electromagnetically neutral space-time surface will be needed in sequel and is given by

$$\begin{aligned} J &= -\frac{p}{3+2p} X du \wedge d\Phi \ , \\ Z^0 &= -\frac{6}{p} J \ . \end{aligned} \tag{A-3.7}$$

The components of the electromagnetic field generated by varying vacuum parameters are proportional to the components of the Kähler field: in particular, the magnetic field is parallel to the Kähler magnetic field. The generation of a long range $Z^0$ vacuum field is a purely TGD based feature not encountered in the standard gauge theories.

The effective form of the $CP_2$ metric is given by

$$\begin{aligned} ds^2_{eff} &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s^{eff}_{\Theta\Theta}d\Theta^2 + s^{eff}_{\Phi\Phi}d\Phi^2] \ , \\ s^{eff}_{\Theta\Theta} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] \ , \\ s^{eff}_{\Phi\Phi} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] \ , \end{aligned} \tag{A-3.8}$$

and is useful in the construction of electromagnetically neutral imbedding of, say Schwartchild metric. Note however that in general these imbeddings are not extremals of Kähler action.

### A-3.2 Space-times with vanishing $Z^0$ or Kähler fields

The results just derived generalize to the $Z^0$ neutral case as such. The only modification is the replacement of the parameter $\epsilon$ with $\epsilon = 1/2$ as becomes clear by considering the condition stating that $Z^0$ field vanishes identically also the relationship $F_{em} = 3J = -\frac{3}{4}\frac{r^2}{F}du \wedge d\Phi$ is useful.

Also the generalization to the case of vacuum extremals is straightforward and corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral space-times. In this case classical em and $Z^0$ fields are proportional to each other:

$$\begin{aligned} Z^0 &= 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u)\frac{\partial r}{\partial u}du \wedge d\Phi = (k+u)du \wedge d\Phi \ , \\ r &= \sqrt{\frac{X}{1-X}} \ , \ X = D|k+u| \ , \\ \gamma &= -\frac{p}{2}Z^0 \ . \end{aligned} \tag{A-3.9}$$

For vanishing value of Weinberg angle ($p = 0$) em field vanishes and only $Z^0$ field remains as a long range gauge field. Vacuum extremals for which long range $Z^0$ field vanishes but em field is non-vanishing are not possible.

For vacuum extremals with vanishing induced Kähler form classical em field $\gamma$ and $Z^0$ field satisfy

$$\gamma = -\frac{sin^2(\theta_W)}{2}Z^0 \simeq -\frac{Z^0}{8}$$

for $\sin^2(\theta_W) = .23$.

### A-3.3 Induced gauge fields for space-times for which CP$_2$ projection is a geodesic sphere

For space-time sheets for which CP$_2$ projection is $r = \infty$ homologically non-trivial geodesic sphere of $CP_2$ one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \ .$$

The induced $W$ fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

For homologically trivial geodesic sphere a standard representative is obtained by using for the phase angles of standard complex $CP_2$ coordinates constant values. In this case induced em, $Z^0$, and Kähler fields vanish but induced $W$ fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP$_2$ projection color rotations and weak symmetries commute.

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