

Introduction

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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 millennium the basic three strongly interacting threads in the tapestry of quantum TGD.

For few years 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.

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.

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 [17, 18, 19, 20]. 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 .

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.

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 universes" of GRT) and the nonconservation of energy in GRT corresponds to the transfer of energy between the topological condensate and vapor phase.

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.

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.

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 puzzles 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 grew 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.

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].

3.3.1 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'.

3.3.2 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.

3.3.3 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).

3.3.4 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.

3.3.5 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.

3.3.6 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 $p = 2, 3, 5, \dots$. 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 binary 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 binary 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 $p = 2^k - n$ binary 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.

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 compactification 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.

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.

3.5.1 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].

3.5.2 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.

3.5.3 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 $p = 2^{127-1}$, $k = 0, 1, 2, \dots$ [M3]. Also integer valued sub-harmonics and integer valued sub-harmonics of λ 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 λ depending logarithmically on p-adic prime [C6]. Also the value of \hbar_0 has spectrum characterized by Beraha numbers $B_n = 4\cos^2(\pi/n)$, $n \geq 3$, 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 τ 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 τ_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 τ [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.

4 Bird's eye of view about the topics of the book

The basic notions TGD inspired theory of consciousness, the topics of this book, are quantum jump as a moment of consciousness, and the notion of self and self hierarchy. Dark matter hierarchy, the levels of which are labelled by increasing quantized value of Planck constant, suggests that the geometric durations for the

moments of consciousness form an increasing hierarchy so that the highest level associated with a given self would correspond to single moment of consciousness.

The anatomy of quantum jumps must be consistent with the notions of state preparation, state function reduction, and unitary evolution and this leads to a detailed view what quantum jump means for quantum states of the Universe identified as classical spinor fields in configuration space, the "world of classical worlds". The zero modes of the configuration space geometry which do not contribute to its metric and thus do not quantum fluctuate, correspond to classical observables. Obviously, a direct connection with quantum measurement theory emerges.

Negentropy Maximization Principle states that the negentropy gain in quantum jump is maximal. The allowance of a number theoretic variant of Shannon entropy making sense for rational or algebraic entanglement probabilities implies that quantum jump can also generate or increase the amount of entanglement. The interpretation is in terms of bound state entanglement to which conscious information can be assigned.

Natural characterization of the fundamental qualia is in terms of quantum number increments associated with the quantum jump. The classical non-determinism of Kähler action (in the usual sense of the world) means that the contents of the conscious experience of a given self comes from a 4-dimensional space-time region rather than representing 3-D snapshot of space-time. This together with the new view about energy and time (negative energies and communications to the geometric past are predicted) leads to a new vision about memory, intentional action, and also metabolism.

p-Adic physics as physics of cognition and intentionality is a genuinely new element as compared to the existing theories of consciousness and forces to give up the view that cognition is localized in the sense of real physics. Indeed, p-adic space-time sheets representing intentions have literally infinite size since most p-adic integers, in particular those which are infinitesimally small, have infinitely large as real numbers. Cognition would quite literally see the real cosmos from outside. The transformations of p-adic space-time sheets to real ones in quantum jump define an attractive view about what happens when intention transforms to an action and is consistent with TGD based view about energy (also negative inertial energies are possible and the density of inertial energy vanishes in cosmological length scales). The discrete rational projection of p-adic space-time sheets to the real imbedding space is excellent candidate for the realization of cognitive representations at the level of space-time since p-adic numbers define very naturally a generalization of binary logic and for primes satisfying p-adic length scale hypothesis the resulting logic has also Boolean interpretation as a logic in which certain number of statements are taboos so that the number of allowed statements is reduced from 2^k to $p = 2^k - n$.

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.

5 The contents of the book

5.1 Part I: Basic ideas of TGD inspired theory of consciousness

5.1.1 TGD inspired quantum theory of consciousness and of biosystems: an overall view

5.1.2 Matter, Mind, Quantum

The chapter is devoted to the TGD inspired theory of consciousness, which can be also regarded as a generalization of quantum measurement theory. The basic elements of the theory are following.

1. Physical realities correspond to quantum histories, configuration space spinor fields, which can be regarded as generalized Schrödinger amplitudes in the world of classical worlds identified as space-time surfaces. The quantum jump between deterministic quantum histories is identified as a moment of consciousness. Quantum jump begins with the step $\Psi_i \rightarrow U\Psi_i$, where U is informational "time development" operator defining S-matrix. There is actually no real time development involved. The requirement that quantum jump involves a state function reduction in the sense of quantum field theories implies that the unitary time development is followed by a localization in zero modes: $U\Psi_i \rightarrow \Psi_{f_0}$. Hence Ψ_{f_0} corresponds to a quantum superposition of space-time surfaces which are perceptively equivalent, and the world of conscious experience looks classical in space-time degrees of freedom.

The localization in zero modes is followed by a cascade of self measurements $\Psi_{f_0} \rightarrow \dots \Psi_f$ leading to a minimally entangled product state: this sequence affects the state only in quantum fluctuating degrees of freedom. Only bound state entanglement is stable against self measurements. This process is 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 su-bsystem 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.

Also p-adic-real (or cognitive) entanglement makes sense if entanglement coefficients are algebraic numbers. In this case a number theoretical definition of the entanglement entropy is possible. The number-theoretical entanglement entropy can be also negative, and in this case self measurement cannot reduce entanglement. A very attractive identification for the cognitive entanglement with positive entanglement negentropy is as a correlate for the experience of understanding.

2. The concept of self is absolutely essential for the understanding of the

macroscopic aspects of consciousness. Self corresponds to a subsystem able to not generate bound state entanglement during quantum jumps. It is assumed that the experiences of the self after the last 'wake-up' sum to single average experience. This means subjective memory identifiable as a conscious short term memory. Selves form infinite hierarchy with entire Universe, God, at the top.

A natural hypothesis is that self X experiences the experiences of its subselves as kind of abstracted experience: the experiences of subselves X_i are not experienced as such but represent kind of averages $\langle X_{ij} \rangle$ of sub-subselves X_{ij} . Entanglement between selves, most naturally realized by the formation of join along boundaries bonds between the space-time sheets, provides a mechanism building wholes from parts at the level of mental images represented by subselves. The fusion of mental images gives rise to what might be called stereo consciousness (stereo vision is the basic example of this). The notion of sub-system motivated by the many-sheeted space-time concept allows the sub-selves of un-entangled selves to entangle. This makes possible fusion and telepathic sharing of mental images. Self can be regarded as a statistical ensemble consisting of quantum jumps and various qualia are identified as statistical averages for the increments of quantum numbers and zero modes over the sequence of the quantum jumps defining self.

3. The quantum theory of self-organization is based on the identification of quantum jump as the basic iterative step of self-organization. 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 slaving hierarchy. 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. The possibility of the reversal of the arrow of geometric time (negative energy space-time sheets) below p-adic time scales means that the second law of thermodynamics is broken below p-adic time scale with respect to the geometric time although it still holds true with respect to subjective time. There are good reasons to expect that the temporal reversal of the arrow of geometric time in various p-adic time scales is a crucial element in the function of living matter and identifiable as a universal healing mechanism.
4. p-Adic physics provides the physics cognition and intentionality. TGD space-time decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, \dots$. p-Adic space-time 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 glueing together regions for which integration constants are genuine constants. The natural interpretation of the p-adic regions is as cognitive representations of real physics. p-Adic spacetime sheets are also correlates of intentionality and the transformation of p-adic space-time sheet to a real one in the quantum jump has interpretation as a transformation of intention to action. The freedom of imagination is basically due to the p-adic non-determinism. p-Adic regions perform mimicry and make possible for the Universe to form cognitive representations about itself. Real resp. p-adic space-time sheets are interpreted as symbolic resp. cognitive space-time correlates for conscious experience.

5. Quantum-classical correspondence is absolutely essential for the interpretation of the theory and understanding of how psychological time emerges. The classical non-determinism of Kähler action makes it possible to interpret space-time surfaces as symbolic representations for the contents of consciousness (not faithful). In particular, the concepts of association sequence and mindlike space-time sheet are made possible by the classical non-determinism. Association sequences relate closely with the mindlike 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 mindlike space-time sheet. The gradual drift of the mindlike space-time sheets to the direction of future force by the geometry of the future lightcone explains the arrow of psychological time. Simplest dimensional estimate gives for the average increment τ 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. Psychological time can be also interpreted as a temporal coordinate for the front of a p-adic-to-real phase transition proceeding to the direction of the geometric future and representing the transformation of intentions to actions.
6. The new view about space-time is crucial for the understanding of brain consciousness. Bio-systems are identified as macroscopic quantum systems and the quantum criticality of TGD Universe predicts the existence of quantum systems in all length scales and fractality. The notion of many-sheeted space-time provides several mechanisms making bio-systems macroscopic quantum systems. The generation of bound state entanglement makes possible macrotemporal quantum coherence implying that decoherence time increases from CP_2 time to a macrotemporal time interval. An essential prerequisite of the macrotemporal quantum coherence is the quantum spin glass degeneracy of TGD Universe and classical gravitation is essentially involved with the mechanism. Macrotemporal quantum coherence implies a genuine breaking of the second law of thermodynamics

since dissipation is effectively absent in quantum coherent degrees of freedom, and processes analogous to quantum computation become possible in the time scales relevant to human consciousness. From the point of view of consciousness this means that a sequence of moments of consciousness effectively integrates to a single moment of consciousness of macrotemporal duration, and that various qualia defined as subjectotemporal averages for the increments of quantum numbers and zero modes stay sharp.

Topological field quantization forces to assign to any material system also a field body, in particular magnetic and Z^0 magnetic bodies. The notion of the magnetic body plays a pivotal role in the understanding of how sensory representations, long term memories, and motor actions are realized. Living organisms become in TGD Universe essentially objects of astrophysical size.

The fractal hierarchy of massless extremals (MEs) represents genuinely quantum gravitational states at a more abstract level of existence than ordinary quantum states. MEs interacting with fractal hierarchy of magnetic flux tube structures in many-sheeted ionic flow equilibrium with ordinary bio-matter at the atomic space-time sheets provide the hardware of bio-consciousness. The sign of energy depends in TGD Universe on the time orientation of the space-time sheet. Negative energy MEs serve as space-time correlates for bound state entanglement, and allow to understand an amazing variety of phenomena related to consciousness and biocontrol. The models of long term memory, sensory experience, and motor actions rely crucially on negative energy MEs serving as quantum entanglers and positive energy MEs serving as tools of precisely targeted classical communications.

5.1.3 Negentropy Maximization Principle

In TGD Universe the moments of consciousness are associated with quantum jumps between quantum histories. The localization in zero modes guarantees that the world of conscious experience looks classical. Together with the assumption that the unitary operator U acts effectively as a flow in zero modes, this implies standard quantum measurement theory with zero modes playing the role of macroscopic effectively classical variables and quantum fluctuating degrees of freedom correspond to quantum degrees of freedom. Contrary to original belief there is however no need to assume that this localization occurs in each quantum jump and might also be governed by Negentropy Maximization Principle, whose formulation is the basic topic of this chapter.

The localization in zero modes (state function reduction) is assumed be followed by a sequence of self measurements in quantum fluctuating degrees of freedom. Self measurement is repeated again and again and eventually leads to a product state: only bound state entanglement is stable against this process. Obviously the process is equivalent with state preparation. Negentropy Maximization Principle provides the dynamical law governing state preparation and,

as is has turned out, also state function reduction.

1. Consider a given unentangled system S . The basic assumption is that the density matrix of the subsystem of S , or equivalently, of its complement, is the fundamental observable measured in self measurement. NMP applies separately inside each system of this kind and states that for given system the quantum measurement occurs for that subsystem-complement pair for which the reduction of the entanglement entropy in self measurement is largest.
2. The original belief was that self measurement leads to an un-entangled state. It is however possible to assign a negative entanglement entropy to an entanglement characterized by entanglement probabilities in finite extension of rationals. Thus NMP allows also a reduction to this kind of state. The natural interpretation of this kind of state is as a bound state. The density matrix must be unit matrix for the outcome if one requires that a measurement of density matrix is in question.

There are important technicalities involved with the formulation of NMP.

1. The definition of sub-system concept remains a highly nontrivial challenge for TGD. The reason is the classical non-determinism of Kähler action. A 3-surface acting as a causal determinant of Kähler action is the most general definition of the sub-system at space-time level. Causal determinants can be light like surfaces $X_l^3 \subset H$ (elementary particle horizons) or space-like 3-surfaces inside light like 7-surfaces $X_l^3 \times CP_2 \subset M_+^4 \times CP_2$ analogous to the boundary $\delta M_+^4 \times CP_2$ of H . The reason is that these surfaces act as quantum holograms and representations of super-canonical and quaternion conformal algebras.
2. The many-sheeted space-time concept forces to modify the naive definition of subsystem as a tensor factor: two un-entangled systems can have sub-systems, which are entangled. The length scale dependent notion of subsystem allows to see this kind of entanglement as an entanglement invisible in the length scale resolution of the un-entangled systems.
3. Concerning the precise definition of negentropy there are three cases to be discussed.
 - i) In the situation in which entanglement probabilities reduce to a finite extension of rationals (discrete number field) a purely number theoretic definition of the entanglement entropy is possible using a p-adic variant of logarithm with argument replaced by its p-adic norm. Entanglement entropy can be defined as the maximally negative entanglement entropy S_p resulting in this manner: this assigns a unique p-adic prime p to the entanglement. The resulting real-valued entanglement entropy is negative and the entanglement is stable against self measurements and NMP. This negentropic entanglement could be identified as a correlate for the experience of understanding.

- ii) In the second case entanglement probabilities are genuinely real or p-adic numbers. For real entanglement Shannon entropy works. The modification of p-based logarithm preserving the additivity of negentropy allows to define in p-adic case a p-adic valued entanglement entropy, which can be mapped to a non-negative real number by canonical identification.
4. The highly non-trivial observation is that the entanglement between systems belonging to different number fields is possible provided the states are orthonormalized. Furthermore, entanglement coefficients can belong to any number field. This means that the character of entanglement does not depend at all on the character of the entangled systems and is thus a typical category theoretic notion (relationship or "arrow" in the slang of category theory).

These findings lead to the idea state function reduction and preparation are number theoretic necessities. Unitary process U creates a formal superposition of states with entanglements in various number fields. State function reduction and preparation realized as a sequence of self measurements reduce the entanglement to a finitely extended rational entanglement interpreted as an information carrying bound state entanglement. Quantum jump can therefore be regarded as an elementary act of cognition in which unitary process is followed by analysis yielding as an outcome bound state entanglement giving rise to an experience of understanding. State function reduction and preparation can also occur in quantum parallel manner in various scales. This view modifies dramatically the interpretation of what de-coherence means. De-coherence removes only the entropic non-bound entanglement and preserves and even generates bound state entanglement. This obviously forces totally new view about second law of thermodynamics.

There are good reasons to expect that finitely extended rational entanglement is a basic characteristic of living and intelligent systems and crucial for the understanding of the information theoretic aspects of life. Negentropic bound state entanglement due to the quantum spin glass degeneracy provides mechanisms of macro-temporal quantum coherence making possible quantum computation type processes. The possibility of quantum parallel dissipation also forces to generalize quantum computation paradigm so that quantum parallel classical computations become possible.

5.1.4 Self and Binding

The quantum notion of self solved some long standing problems of TGD inspired theory of consciousness and led to a breakthrough in quantum theory of consciousness. Self is identified as a sub-system able to not generate bound state entanglement during quantum jumps. Generation of bound state entanglement leads to a loss of consciousness.

Subjective memory is assumed to correspond to an average of conscious experiences of quantum jumps occurred after the last wake-up of self. This leads to the identification of qualia as averages of the increments of quantum numbers

and zero modes in the ensemble of quantum jumps defining self. Summation hypothesis states that self X experiences the experiences of its subselves as abstracted experiences, averages X_{ij} about sub-subselves X_{ij} . Subselves of un-entangled selves can entangle (this is due to the many-sheeted sub-system concept) and this allows fusion and sharing of mental images.

Selves are called irreducible if they possess no subselves, otherwise reducible. Subselves correspond to mental images so that irreducible subselves possess no mental images and are in a state of pure self-awareness: it is not clear whether this kind of states are possible in practice. When the subselves of self fuse to single subself, a state of "one-ness" results. This mode of consciousness can be identified as "whole-body" consciousness and differs from ordinary consciousness during which self has large number of mental images. These modes could naturally explain emotional/holistic and rational modes of mind. These two modes could make it possible to understand various dichotomies like brain/left brain, emotional/analytic, religious/rational, Eastern/Western,...

One could understand linear cognitive processes like thinking and language as self cascades in which self decomposes into subselves, which in turn decompose into subselves, which ... and self hierarchy implies connection with computationalism. Quantum entanglement provides a mechanism leading also to formation of irreducible wholes at the level of mental images.

In TGD framework it is not at all obvious that the highest levels of our personal self hierarchy should correspond to the size of the physical body. Various empirical facts, in particular the observations related to the special effects of excitations of geomagnetic fields and ELF em fields in EEG frequency range on brain, inspire the hypothesis that our selves correspond to topological field quanta of em fields associated with EEG frequencies and thus by Uncertainty Principle have size scale of Earth. This leads to a rather radical modification of the brain centered views about consciousness, and one can quite seriously consider the questions like what physical death means from the point of view of consciousness: it could be that electromagnetic part of self hierarchy could survive after the physical death as a 'soul'.

5.1.5 Quantum model for sensory representations

One of the toughest challenges of quantum theories of consciousness is to understand how sensory representations are constructed at quantum level. It became as a surprise that the vision about sensory representation which resulted from a long lasting thought experimentation is actually very much what the original, fifteen year old, experience about myself as a computer sitting at its own terminal, when taken very literally in some aspects, actually suggests. This vision adds to the standard view about brain an additional layer responsible for the sensory representations and brings in the quantum level of control so that nerve pulse patterns are only part of the control loop. In fact, it has turned out that the same basic theory applies to both geometric memories, precognition, sensory perception, and motor actions.

1. As far as our consciousness is considered, primary sensory organs are the seats of sensory qualia and brain only constructs cognitive and symbolic representations. Various objections against this hypothesis can be circumvented by assuming that sensory organs entangle with the brain and by the mirror mechanism of the long term memory. The question how imagination differs from the sensory experience becomes trivial, and dreams and hallucinations can be understood as resulting via the back-projection of the imagined mental images to the primary sensory organs.
2. Libet's findings about passive aspects of consciousness lead to the view that sensory percept can be regarded as a geometric memory in time scale of .5 seconds involving entanglement with the geometric past mediated by negative energy MEs. Libet's experiments about the active aspects of consciousness in turn lead to realization that motor actions and sensory perceptions are in a well-defined sense time-reversals of each other: precognition is a definite aspect of motor action. One can say that motor action at the level of negative energy MEs is initiated from the level of muscles rather than brain and motor imagination is just a motor action starting from some level higher than muscles. The transformation of a p-adic ME to negative energy ME realizes the transformation of intention to action in a precisely targeted manner and the emission of negative energy makes possible extreme flexibility by buy now-let others pay mechanism of remote metabolism. This process is the basic step initiating motor action, neural activity leading to imagery, and active memory recall. This picture also explains why geometric memories occur more or less spontaneously whereas precognition is a rare phenomenon (pre-cognizer must *receive* negative energy MEs).
3. In TGD framework one can assign to any material structure a magnetic body having much large size. The closed flux loops composing magnetic bodies allow an elegant realization of the long term memories in terms of negative and positive energy MEs. A stronger hypothesis is that various magnetic bodies define sensory canvases at which various sensory representations are realized. Motor action can be seen as a geometric time reversal of sensory perception. Cortex can be seen as a collection of pre-existing symbolic and cognitive features possibly entangled with sensory mental images at sensory organs, and activated when they appear in the perceptive field or form a part of motor action. The basic task of the central nervous system is to identify these features from the sensory input. The mental images associated with various parts of the physical body are entangled with the points of the corresponding magnetic bodies representing objects of the perceptive field by sharing of mental images and in this manner define attributes of these objects. There is an entire hierarchy of representations corresponding to the hierarchy of magnetic bodies, and also sensory perception involves active selections by entangling a sequences of mental images defining paths along the tree-like structure defined by the hierarchy of magnetic bodies beginning from the personal magnetic body

and ending at the roots defined by magnetic bodies of sensory organs. This explains phenomena like sensory rivalry.

4. The decomposition of the perceptive field to objects is one of the basic aspects of sensory experiencing and TGD provides a mechanism generating these objects as mindlike space-time sheets: the boundaries of these objects correspond to regions of strong Kähler electric field whose strength is assumed to correlate with the intensity of the neural input. It might be that even the objects of perceptive field or thoughts could be regarded as features.
5. The computational activities associated with the construction of the sensory representations (say estimating distances and directions of the objects of perceptive field) and virtual sensory representations representing the goals of motor action are presumably realized as iterated processes in which virtual sensory inputs characterizing the expected experiences are compared with the real world sensory input. In a similar manner the goal of the motor action is compared with the sensory representation resulting from effect of a virtual motor action on the representation of the recent state of world and body. This comparison does not necessarily require sensory representation at any level of the self hierarchy and could be based on comparison circuits defined by parallel supra currents in which the inputs which are sufficiently near to each other generate constructive interference giving rise to a large Josephson current.

5.1.6 New Developments in TGD and Their Implications for TGD Inspired Theory of Consciousness

The conflict between the non-determinism of state function reduction and determinism of time evolution of Schrödinger equation is serious enough a problem to motivate the attempt to extend physics to a theory of consciousness by raising the observer from an outsider to a key notion also at the level of physical theory. Further motivations come from the failure of the materialistic and reductionistic dogmas in attempts to understand consciousness in neuroscience context.

There are reasons to doubt that standard quantum physics could be enough to achieve this goal and the new physics predicted by TGD is indeed central in the proposed theory. The developments in quantum TGD during last years have led to a fusion of real and p-adic physics by using generalization of number concept, to the realization of the crucial role of hyper-finite factors of type II_1 for quantum TGD, to the generalization of the imbedding space implying hierarchy of quantized values of Planck constant, to so called zero energy ontology, and to the reduction of quantum TGD to parton level with parton understood as 2-D surface whose orbit is light-like 3-surface, and to the realization that quantum TGD can be formulated as almost topological quantum field theory using category theoretical framework.

These developments have considerably simplified the conceptual framework behind both TGD and TGD inspired theory of consciousness and provided justi-

fication for various concepts of consciousness theory deduced earlier from quantum classical correspondence and properties of many-sheeted space-time.

The notions of quantum jump and self can be unified in the recent formulation of TGD relying on dark matter hierarchy characterized by increasing values of Planck constant. Negentropy Maximization Principle serves as a basic variational principle for the dynamics of quantum jump and must be modified to the case of hyper-finite factors of type II_1 . The new view about the relation of geometric and subjective time together with zero energy ontology leads to a new view about memory and intentional action. The quantum measurement theory based on finite measurement resolution and realized in terms of hyper-finite factors of type II_1 justifies the notions of sharing of mental images and stereo-consciousness deduced earlier on basis of quantum classical correspondence. A new element is finite resolution of quantum measurement and cognitive and sensory experience. Qualia reduce to quantum number increments associated with quantum jump. Self-referentiality of consciousness can be understood from quantum classical correspondence implying a symbolic representation of contents of consciousness at space-time level updated in each quantum jump. p-Adic physics provides space-time correlates for cognition and intentionality.

5.2 Part II: Time and Consciousness

5.2.1 Time and consciousness

In moments of consciousness as quantum jumps between quantum histories picture the basic challenge is to explain how psychological time arises: why the contents of at least sensory experiences are concentrated around definite value of geometric time and what is the origin of the arrow of psychological time. It has become gradually clear that TGD cannot reproduce the common sense conception of time and that one can only require that the generalized view is consistent with our restricted conscious experiences and shows our position in the hierarchy of consciousness.

The long sought-for solution to the puzzle of psychological time and its arrow was surprisingly simple. Psychological time corresponds to center of mass coordinate for mindlike space-time sheet and is zero mode so that its value is precisely defined for each state of quantum jump by the localization in zero modes associated with quantum jump. The geometry of future lightcone in turn implies the gradual drift of the mindlike space-time sheet to the direction of the future.

Much later came the realization that this picture leads to several paradoxes unless one assumes that psychological time labels the zone of volition corresponding to a p-adic-to-real phase transition proceeding towards the geometric future. Furthermore, the value of the psychological time must be assumed to be common for the selves at the same level of the self hierarchy, perhaps for the entire bio-sphere. This gives very strong first principle support for the view that entire bio-sphere is conscious being and gives justification for very speculative ideas such as sensory representations realized on the magnetic sensory canvas

having size much larger than the physical body. Rather concrete vision about the character of consciousness after the physical death emerges and throws light to various religious concepts (saints and sinners, heaven and hell).

The concept of self led to the understanding of the subjective memory as an average over experiences of self experienced after its "wake-up". Subjective memories are always about past. Geometric memories are predictions for the future/past assuming that no quantum jumps would occur after/had occurred before the one giving rise to the geometric memory. Pre-cognitions can be seen as geometric memories about future. Intentions are p-adic variants of precognitions. It seems that long term memories must correspond to geometric memories: this hypothesis, when combined with the spin glass model of brain, the notion of quantum self-organization, and some key aspects of many-sheeted physics, allows to understand the basic aspects of the long term memory and avoids the basic difficulties of the neural net models.

"Ontogeny recapitulates phylogeny" principle suggests that the structure of the many-sheeted space-time represents the structure of the cosmology of consciousness. This heuristic principle together with the concept of self, the hypothesis that also infinite primes are present in the topological condensate and association sequence concept, leads to a Grand Scenario for the cosmology of consciousness. There is no need to assume that different irreducible sub-experiences associated with given moment of consciousness correspond to a common value of the psychological time. Most naturally, the values of psychological time extending from zero to strictly infinite values of time and beyond(!) are present. This means that cosmology of consciousness has fractal like structure: there are subcosmologies which know nothing about each other's existence except in quantum jumps involving entanglement with larger space-time sheets: in this case the conscious experience could be regarded as a religious or mystic experience. Both future and past civilizations participate in each quantum jump. The allowance of infinite primes suggested strongly by various arguments, means that conscious intelligences which are God like as compared to us, participate in each quantum jump.

An especially important general consequence is the paradigm of 4-dimensional brain.

1. This paradigm trivializes the problem of long term memory. The desire to remember would be quantum communicated from the geometric now to the geometric past by sharing of mental images made possible by time-like quantum entanglement of sub-selves. In the case of episodal memories the sharing of mental images gives already rise to the memory. For non-episodal memories the memory is communicated classically to the geometric future. An essential element of the mechanism are negative energy MEs ("massless extremals") which are ideal for generating time-like quantum entanglement with the geometric past. Positive energy MEs are in turn involved with classical communications.
2. Second consequence is a model of cognition relying on the concept of cognitive neutrino pair: cognitive neutrino pair has almost vanishing to-

tal energy and consists of neutrino and antineutrino residing at different space-time sheets. The cornerstone of the model is the negative energy of the condensed matter neutrinos deriving from the classical Z^0 interaction with nuclear Z^0 charges. Thus one can say that TGD predicts that $k = 169$ space-time sheet ($L(169) \simeq 5$ microns) is the length scale in which cognitive consciousness emerges.

Quantum jumps between quantum histories concept explains the peculiar time delays of consciousness revealed in the experiments relating to active and passive roles of consciousness and the causal anomalies revealed by the experiments of Radin and Bierman. TGD predicts "tribar effect" as a general signature for the quantum jump between quantum histories concept.

5.2.2 Quantum model for memory

The neural realization of long term memories has remained to a high extent a mystery in the framework of the standard brain science. The TGD based quantum model for memory have developed gradually from the basic realization that in TGD framework the identification of quantum states as quantum histories makes it un-necessary to store information about the geometric past to the geometric now. This has deep implications.

1. It is possible to separate genuine geometric memory recall from apparent memory recalls such as feature recognition, associations, and implicit and procedural memories. There are no memory storages in brain and only memory representations abstracting the essential aspects of experience are needed.
2. The models of long term memory based on the assumption that information about the geometric past is stored in the recent state of the system predict that the new memories should mask the old ones. It is however known that childhood memories are the stablest ones. In TGD framework this ceases to be a problem.

Mirror mechanism provides a very general mechanism of long term memory. To remember something at a temporal distance T in the geometric past is to look at a mirror at a distance $cT/2$. If the mirror is quantum mirror only a timelike entanglement (allowed by the non-determinism of Kähler action) of the mental image of the geometric past with a mental image in brain now is needed. The un-necessity to communicate memories classically implies extreme generality of the mechanism: all kinds of memories: sensory, cognitive, verbal,... can be recalled in this manner. Even the mechanism of memory recall by cue can be generalized since the notion of tele association makes in principle sense.

The basic objections against this over-simplified picture is that there is no guarantee that the reflected ME returns to the brain and that there is no control over the time span of long term memories. The notion of magnetic body allows a more realistic formulation. Brain or the personal magnetic body generates

spontaneously negative energy MEs with all fundamental frequencies. These MEs can be also curved and are parallel to the closed flux tubes defining the personal magnetic body and connect geometric now with the brain of the geometric past: multiple reflections are probably required to achieve this. The length of the closed magnetic loop defines the time span of the corresponding long term memory. The sharing of mental images by timelike entanglement allows to communicate the desire to remember to the geometric past, and gives rise to the memory recall in the case of episodal memories. In the case of non-episodal/declarative memories the memory is communicated from the brain of the geometric past by classical communications using positive positive energy MEs which propagate with an effective phase velocity much lower than light velocity along closed magnetic flux tubes and generate in the receiving end symbolic representation of the memory.

Macrotemporal quantum coherence is further important piece of the model. The understanding of how macrotemporal quantum coherence is made possible by the spin glass degeneracy led to a concrete realization of the mirror model and also provided a connection with the ideas of Hameroff and Penrose. When a bound state is formed the zero modes of the bound state entangled subsystems become quantum fluctuating degrees of freedom. This means that state function reduction and state preparation cease to occur in these degrees of freedom. The bound state is in a kind of long-lasting multiverse state, or state of 'oneness' experientially, and the sequence of quantum jumps defined by the duration of the bound state behaves effectively as a single quantum jump. Macrotemporal quantum coherence making possible supercomputer like activities becomes possible.

The spin glass degeneracy associated with the join along boundaries bonds (the space-time correlates for the bound state formation) lengthens the lifetimes of the bound states dramatically and solves thus the basic objections against quantum consciousness. The spin glass degeneracy is due to classical gravitational energy of the system. The quantum jumps between different classical gravitational configurations involve the emission of gravitational (equivalently Z^0) MEs and the intention to remember is realized as a transformation of p-adic ME to negative energy gravitational ME. The fact that classical gravitational fields couple to classical gauge fields with a coupling which is about 10^8 stronger than the ordinary gravitational coupling, could play an important role too. Water clusters and macromolecules with sizes in the range of cell membrane thickness and cell size are good candidates for generating gravitonic MEs responsible for all geometric memories. Also classical Z^0 interaction might be involved since gravitonic MEs can be regarded also as Z^0 MEs.

A rather detailed neuro level model of long term memory is developed and the model conforms nicely with the basic facts known about the relationship of hippocampus and long term memory.

5.3 Part III: Intelligence, information, and consciousness

5.3.1 Conscious information and intelligence

In this chapter the notions of information and intelligence are discussed in TGD framework. The discussion reflects the chronological development of ideas towards increasing realism. Definitions for the information measures of the configuration space spinor field and information gain of conscious experience as well as the information theoretic interpretation of Kähler action are discussed in detail the first sections of the chapter.

1. Information content of conscious experience associated with single quantum jump can be defined as the difference of the informations associated with initial and final quantum histories, which are well defined geometric objects and to which classical information theory applies. One can assign separate information measures to both the state function reduction stage (localization in zero modes) and state preparation stage (cascade of self measurement leading to unentangled state) of the quantum jump. The requirement that information gain of conscious experience reduces to information gains associated with irreducible sub-experiences implies that information measures are local in zero modes.
2. The information content of the conscious experience associated with self is more interesting practically. Since self defines a statistical ensemble, it is straightforward to define entropies associated with the increments of quantum numbers and zero modes defining non-geometric and geometric qualia. These entropies characterize the fuzziness of the quale and are 'negative' information measures. Genuine information measures can be defined as differences of the entropies associated with the asymptotic thermal self (if indeed defined) and self. Also information measures for single quantum jump generalize to the case of self.
3. Information theoretic interpretation of the Kähler function is discussed in detail. With certain hypothesis about the degeneracy of the absolute minima as function of Kähler action, the negative of the Kähler function can be interpreted as an entropy type measure for the information content of the space-time surface. Absolute minimization of the Kähler action can be interpreted as a maximization of the information content of the space-time surface and quantum criticality makes TGD universe maximally interesting and maximizes its intelligence. A concrete prediction is that generation of Kähler electric fields generates cognitive resources: indeed, the presence of strong electric fields is the characteristic feature of living systems.
4. Quantum entanglement between real and p-adic degrees of freedom makes sense if entanglement coefficients are algebraic numbers. In this case one can define entanglement entropy using the p-adic variant of the logarithm.

p-Adic entropy can be also negative, and the states for which the entropy is negative are stable against self measurements (NMP) and define macrotemporally quantum coherent states. The number-theoretic entropy serves as an information measure for cognitive entanglement, and positive entanglement negentropy can be interpreted as a correlate for the experience of understanding. An open question is whether bound states with algebraic entanglement coefficients are sufficiently generic also in the real context to justify the use of the p-adic entanglement negentropy with the value of p fixed uniquely by the requirement that the negentropy is maximal. The number-theoretic definition of information could clearly pave the way towards the understanding of conscious information in the living systems.

Concerning the modelling of conscious intelligence the following aspects are important.

1. Association sequences represent geometric memories, simulations for time development whereas selves represent subjective memories and conscious experience involves always the comparison of geometric and subjective memories telling whether expectations were realized. Quantum theory of self-organization applies also to the evolution of consciousness understood as self-organization in the ensemble of association sequences/selves and implies Darwinian selection also at the level of selves and conscious experiences.
2. TGD Universe is quantum computer in a very general sense and one can understand intelligent system as a quantum computer like system performing one quantum computation per CP_2 time about 10^4 Planck times. Quantum computationalism is shown to reproduce the relevant aspects of computationalism and connectionism without reducing conscious brain to a deterministic machine. Holographic brain is also one of the dominating ideas of neuroscience. TGD based realization of memory allows to reduce hologram idea to its essentials: what matters is that piece of hologram is like a small window giving same information as larger window but in less accurate form. This inspires the concept of neuronal window: each neuron has small window to the perceptive landscape and is typically specialized to detect particular feature in the landscape. Coherent photons emitted by mindlike space-time sheets and propagating along axonal microtubules serving as wave guides, realize neuronal windows quantum physically. Massless extremals allow rather precise definition for the notion of quantum hologram.

A more refined formulation of these ideas is based on the notion of conscious hologram. Many-sheeted space-time is essentially a fractal Feynmann diagram with lines thickened to 4-surfaces. The lines are like wave guides carrying laser beams and vertices are like nodes where these laser beams interfere and generate the points of the hologram. The 3-

dimensionality of the ordinary hologram generalizes to stereo consciousness resulting in the fusion of mental images associated with various nodes of the conscious hologram. An essential element is the possibility of negative energy space-time sheets analogous to the past directed lines of the Feynmann diagram: negative energy MEs are the crucial element of sensory perception, motor action, and memory.

3. An important element is effective four-dimensionality of brain making possible to understand long term memories, planning and motor activities in a completely new manner. Further important ideas are music metaphor already described and the vision about brain as an associative net. The memetic code, with codewords consisting 126 bit sequences and represented in terms of nerve pulse sequences or membrane oscillations and time varying antineutrino magnetization, is the key essential element of brain as cognitive system. Codewords can be interpreted either as elements of a Boolean algebra or as bits in the binary expansion of an integer in the range $(0, 2^{126})$ so that memetic code makes brain able to assign numbers with qualia. An attractive and testable identification for the memetic codewords is as phonemes of language.

5.3.2 p-Adic physics as physics of cognition and intention

TGD as a generalized number theory vision forces the interpretation of the p-adic physics as a physics of cognitive representations so that matter-mind dichotomy corresponds to real-p-adic dichotomy at the level of the geometric correlates of mind. This interpretation has far reaching implications for both TGD inspired theory of consciousness and for the general world view provided by TGD. Cognition is predicted to be present in all length scales and the success of the p-adic physics in elementary particle length scales forces to conclude that cognition and intention are present even at this level. In this chapter these implications are studied from the point of view of cognitive consciousness.

p-Adic space-time sheets are identified as the counterparts of cognitive representations: one could also assign them with memes, morphic fields, or analogous notions used by parapsychologists. The possibility to identify the inherent non-determinism of the p-adic field equations as the non-determinism of imagination makes this identification so attractive. The 'phase transition' of a p-adic space-time sheet to a real space-time sheet taking place in quantum jump between quantum histories corresponds to the transformation of a thought into action or sensory experience (during dreams and hallucinations) whereas the reverse transformation corresponds to the transformation of the sensory input into cognition. One possible view is that p-adic memes are everywhere waiting for their materialization by p-adic-to-real phase transition and that biological systems are only a special class of cognitive systems. The identification of the psychological time as the value of the geometric time associated with the front of volition (identified as p-adic-to-real phase transition) proceeding towards geometric future has very strong implications and allows to consider even questions

like 'What after physical death?'

p-Adic teleportation for the massless extremals (MEs) is a basic mechanism making in principle possible the replication and transmission of memes with an effective velocity which can be superluminal. Time reversed cognition is a basic implication of the teleportation mechanism. Basic cognitive functions are discussed in this conceptual framework. Time reverse reference waves generate time reversed holograms, which suggests an extremely general and simple model of healing using the phase conjugate of the reference wave inducing the 'disease program' hologram and thus forcing the program to run backwards. DNA strand and its conjugate strand have interpretation as representations of a command and its time reversal coded to holograms by MEs scanning DNA like reading head and coding nucleotide sequence to a lightlike vacuum current.

The realization of p-adic-real phase transitions at brain level is suggested: the appearance of the millisecond rhythm behind neuronal synchronization would correspond to p-adic-to-real transition for MEs carrying classical Z^0 fields.

The obvious question is how to test p-adic physics empirically. First of all, thinking is p-adic sensory experiencing. Hence the reduction of theories-experimental science dichotomy to p-adic-real dichotomy seems natural: just like experimental science is an extension of everyday real sensory experience, theories represent an extension of everyday p-adic sensory experience (common sense thinking). Thus the basic test is how well p-adic physics based theories describe cognition. Secondly, the p-adic models for physical systems are strictly speaking models for cognitive models for real physics. The successes of these highly predictive models (consider only p-adic elementary particle mass calculations involving only very few integer valued parameters) supports the vision about p-adic physics as physics of cognition. p-Adic-real phase transitions as models for how thought is transformed to action and sensory input to thought provide a further testing ground for the new paradigm.

p-Adic-real phase transitions as models for how thought is transformed to action and sensory input to thought provide a further testing ground for the new paradigm. This forces the allowance of finite-dimensional extensions of p-adic numbers involving real transcendentals like π and e . The outcome is a series of number theoretical conjectures and a considerable generalization of the previously developed insights about how to understand and prove Riemann hypothesis. The zeros of Riemann Zeta can be identified as a universal number theoretically quantized spectrum of scaling momenta characterizing various conformally invariant critical systems.

5.4 Part IV: Paranormal Phenomena

5.4.1 Quantum model for paranormal phenomena

The general quantum model for bio-systems leads to a general model for electromagnetic bio-control which applies to a very wide variety of hard-to-understand bio-chemical phenomena such as molecular recognition mechanisms, water memory, and homeopathy and leads to a generalization of genetic code explaining

the mystery of introns. The same model generalizes to a model of paranormal phenomena such as psychokinesis, remote sensing, remote healing, telepathy, communications with deceased, and instrumental transcommunications.

1. Magnetic mirrors (ME-magnetic flux tube pairs) connecting the sender and receiver make possible a universal mechanism for the transfer of intent and action. p-Adic MEs represent the transfer of a mere intent and real MEs represent a transfer of action. p-Adic ME can be transformed to real ME either by receiver or some higher level magnetic self.
2. The transfer of intent gives rise to mechanism of remote interaction which can act both endo- and exogenously. Magnetic mirrors characterized by their fundamental frequencies make possible bridges between sender and receiver (say healer and healee) and allow a resonant interaction in which healer can initiate various control commands acting as 4-dimensional templates represented as holograms. Also smaller MEs can be send along the MEs serving as bridges (this is like throwing balls with light velocity!).
3. The ME-magnetic flux tube pair connecting sender and receiver acts as a reference wave which can initiate an arbitrarily complex hologram representing biological program. Sender has the ability to generate and amplify the frequencies which induce holograms representing the control commands. In particular, sender can initiate complex biological programs without knowing anything about their functioning.
4. Magnetic mirrors make possible also feedback and this feedback could make possible learning. For instance, in psychokinesis (especially so in micro PK), this learning would be crucial and analogous to that what occurs when we learn to drive a car. In healing this kind of feedback might help to find the healing frequency by trial and error.
5. It is quite possible that also multibrained and -bodied higher level magnetic selves actively participate in the process. This makes possible coherent amplification effects (TEM, prayer groups) and also makes available information resources of all brains involved with the group. This could for instance explain the ability of a remote viewer to see an object on basis of data which need not have any meaning for her. Fast amplitude modulation of alpha waves introducing higher harmonics to the carrier wave is a good candidate for mediating communication between brains and higher level multibrained selves. Mesoscopic 'features' in brain involve precisely this kind of amplitude modulation and might represent just this kind of messages. Interestingly, also speech is produced by fast amplitude modulation of 10 Hz basic vibration frequency of speech organs.

5.4.2 Model for OBEs

Out-of-body experiences (OBEs) are often understood as experience of seeing oneself from a position outside of the body. OBEs are poorly understood in the

framework of neuro science and pose a challenge for the reductionistic world view.

In TGD framework the notion of magnetic body provides an attractive starting point in attempts to understand what OBEs and related experiences are. The basic idea is that magnetic body serves effectively as a mirror defining a third person view as a cognitive representation also in ordinary wake-up state and that during OBEs this representation becomes sensory representation. Magnetic body need not always be a personal magnetic body but could correspond to a magnetic body receiving information from several brains (collective consciousness), magnetic body of another person, or be even associated with "dead" matter.

The progress in identifying dark matter as a phase of matter with large value of Planck constant making possible macroscopic quantum coherence has led to the vision about dark matter at magnetic flux quanta as quantum controller of ordinary matter in living systems. The Bose-Einstein condensates of dark photons decaying via decoherence to ordinary photons mediate interactions between ordinary and dark matter and the hypothesis is that dark photon "laser" beams from body and brain reflected at magnetic flux quanta give rise to third person aspect of consciousness which in OBEs and related experiences are realized as sensory representations. The identification of bio-photons as end products of the de-coherence of dark photon beams is natural.

The model leads also to a model for dreams, hallucinations, sensory feedback from brain to sensory organs, and directed attention. Concrete models for how dark photons can give rise to experiences in various sensory modalities such as vision, hearing, olfaction, and tactile senses, are proposed.

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