Introduction

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Contents

1 Background

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

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

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

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

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

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 puzzless and led to a number of arguments with a common gist: evolution is present already at the elementary particle level and the primes allowed by the p-adic length scale hypothesis are the fittest ones.

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

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

Despite these frustrating uncertainties, the number of the applications of the poorly defined p-adic physics growed steadily and the applications turned out to be relatively stable so that it

was clear that the solution to these problems must exist. It became only gradually clear that the solution of the problems might require going down to a deeper level than that represented by reals and p-adics.

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

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

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

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

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

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

3.4   TGD as a generalized number theory

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

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

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

What is especially satisfying is that p-adic and real regions of the space-time surface could emerge automatically as solutions of the field equations. In the space-time regions where the solutions of field equations give rise to in-admissible complex values of the imbedding space coordinates, p-adic solution can exist for some values of the p-adic prime. The characteristic non-determinism of the p-adic differential equations suggests strongly that p-adic regions correspond to 'mind stuff', the regions of space-time where cognitive representations reside. This interpretation implies that

p-adic physics is physics of cognition. Since Nature is probably extremely brilliant simulator of Nature, the natural idea is to study the p-adic physics of the cognitive representations to derive information about the real physics. This view encouraged by TGD inspired theory of consciousness clarifies difficult interpretational issues and provides a clear interpretation for the predictions of p-adic physics.

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 $p = 2^{127-1}$, $k = 0, 1, 2, ...$ [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 $B_n = 4cos^2(\pi/n)$, $n \geq 3$, varying by a factor in the range $n > 3$ [C6]. It must be however emphasized that the relation of this picture to the model of quantized gravitational Planck constant h_{gr} appearing in Nottale's model is not yet completely understood.

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

1. Living matter and dark matter

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

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally.

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

2. Dark matter hierarchy and the notion of self

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

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

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

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

The simplest dimensional estimate gives for the average increment 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

Brain as a hologram is an old idea and it emerges naturally also in TGD framework both at quantum and classical level, which by quantum classical correspondence is expected to reflect what happens at the deeper quantum level.

4.1   What "hologram" means in TGD Universe?

Concerning the notion of hologram there are several new elements involved.

1. Classical and quantum coherence regions can be identified as space-time sheets so that a concrete topological view about what happens in de-coherence and interference results. Interference occurs in the junctions of space-time sheets, say at regions where magnetic flux tubes meet each other or some other kinds of space-time sheets, say electric flux quanta. De-coherence could mean simply the decay of space-time sheet to separate geometrically parallel space-time sheets.

2. An entire hierarchy of fractal copies of the standard model is predicted labelled by the primes $p \simeq 2^k$ labelling preferred p-adic length scales and integers $k_d \geq 0$ labelling the levels of dark matter hierarchy with Planck constant given by $\hbar = \lambda^{k_d} \hbar_0$. λ is predicted to depend on p-adic length scale logarithmically and $\lambda \simeq 2^{11}$ seems to be a preferred value of λ in living matter and assignable to $k = 137$ defining atomic length scale. Dark photons are predicted as also gluons massless below the confinement scale and electro-weak bosons massless below the appropriate weak length scale. This hierarchy plays a key role in the modelling of living matter and leads to a highly successful model of EEG predicting correctly the band structure and narrow resonance bands as well as providing an interpretation of EEG as responsible for the communications between biological body and corresponding magnetic body. A further important prediction is a fractal hierarchy of EEGs implying a prediction for a hierarchy of biorhythms [M3].

3. Topological light rays (massless extremals, MEs) are natural space-time correlates for the structures representing Bose-Einstein condensates of massless particles. MEs can carry also

light-like vacuum currents so that they can serve as sources of coherent photons. MEs carry also classical electro-weak fields with Abelian holonomy and gluon fields for which holonomy is always Abelian [J4]. In particular, W MEs make possible charge entanglement over arbitrarily long length scales inducing what might be called exotic ionization [M3]. The resulting charge polarization is an ideal mechanism for the control of biological body by the corresponding magnetic body.

4. The fusion of real physics and various p-adic physics serving as correlates for cognition and intentionality to single coherent structure leads to the generalization of number concept obtained by gluing p-adic numbers and reals along common rationals. Also algebraic extensions of rationals glued to reals along common algebraics can be allowed. This implies that most points of p-adic space-time sheets are at infinity and the projection to the real imbedding space consists of a discrete set of points with real distances above some cutoff. One implication is that p-adic local physics determined basically by p-adic continuity and smoothness dictates long length scale real physics for real space-time sheets having common points with the p-adic space-time sheets. This means p-adic fractality with characteristic long range correlations identifiable as being basically due to intentional actions. p-Adic fractality would be the counterpart for the fractality of holograms and imply a holistic coding of information as fractally scaled up variants.

5. The new view about energy and time add a further new element to the picture. The sign of the conserved inertial energy can be also negative and correlates with the time orientation of space-time sheet. In cosmological length scales the density of inertial energy vanishes whereas that of gravitational energy is non-vanishing. The simplest hypothesis consistent with this is that gravitational energy is the magnitude of inertial energy. Negative energy photons identifiable as phase conjugate photons make possible signals propagating to the geometric past. This allows to realize memory recall as communications with geometric past using time mirror mechanism. Also remote metabolism in which the system needing energy sends negative energy photons to a system in the geometric past becomes possible. This means also a universal mechanism of intentional action in which p-adic space-time sheet representing intention is transformed in quantum jump to a real negative energy W ME representing desire and inducing the desired action in the geometric past.

4.2   What "conscious hologram" means in TGD Universe?

The notion of conscious hologram implies further new elements.

1. The basic concepts quantum jump and self hierarchy. The dynamics of quantum jumps implies that conscious hologram corresponds to quantum dynamical structure evolving quantum jump by quantum jump. Negentropy Maximization Principle poses the basic constraint on this dynamics. Dark matter hierarchy predicts infinite hierarchy of selves with the duration of moment of consciousness with respect to geometric time defining the duration of experienced period of consciousness. Even life cycle can be regarded as single moment of consciousness at the highest level of self involved.

2. Quantum parallel dissipation represents a further new notion: the sub-selves of self can dissipate although self behaves as a quantum coherent system. The description of quarks inside hadrons as a dissipating system while hadrons themselves are regarded as quantum systems would thus not be a mere convenient but self-contradictory approximation. If self corresponds to single quantum jump at highest level involved, there should be no experience about the flow of time. The notion of quantum parallel dissipation however implies that self experiences the sequences of the quantum jumps of its sub-selves as mental images whose

contents are averages over individual quantum jumps. Self would experience these mental images as time ordered sequences and this would give rise to the experience of flow of time. Only during experiences in which mental images are absent, such as during deep meditation, the experience about flow of time would be absent.

3. TGD inspired theory of consciousness leads to a concrete proposal about how qualia can be assigned to various macroscopic quantum phase transitions. For instance, cognitive and emotional qualia could correspond to cyclotron phase transitions for dark BE condensate of ions at magnetic body and thus to somatosensory experiences at the level of magnetic body. The formation of hologram would give rise to a conscious experience which justifies the attribute "conscious".

4. Quantum classical correspondence and many-sheeted space-time encourages a generalization of the notion of sub-system. The basic observation is that two disjoint space-time sheets can contains topologically condensed smaller space-time sheets connected by a join along boundaries bond. This suggest that the sub-systems of two unentangled systems can entangle and this process corresponds to sharing and fusion of mental images at the level of conscious experience.

   This idea is very natural in renormalization group inspired thinking. Dark matter hierarchy and the ensuing generalization of the notion of state space to a hierarchy of state spaces justifies this idea. Configuration space, "the world of classical worlds" identifiable as space-time surfaces is the arena of quantum dynamics in TGD. Configuration space Clifford algebras are expressible as direct integrals of von Neuman algebras known as hyperfinite factors of type II_1 and the inclusions of these algebras known as Jones inclusions would be a concrete realization for the hierarchy of the state spaces associated with the hierarchy of space-time sheets.

Many items in the list have emerged during the last two years and the chapters of this book are therefore somewhat out of date. The implications of the coding of long length scale real physics by the local p-adic physics is not discussed systematically (for a general discussion see [E1]). A systematic discussion of the role of dark matter hierarchy and how charged W bosons and gluons contribute to the dynamics of the conscious hologram is lacking from the key chapter "Biosystems as Conscious Holograms". Same can be said about the connection between configuration space spinors and hyper-finite factors of type II_1.

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 Biosystems as Conscious Holograms

5.1.1 Time, space-time, and consciousness

This chapter is devoted to the TGD based view about time, space-time, and consciousness. The chapter begins with an updated view about the notions of many-sheeted space-time and topological field quantization taking remote metabolism as an example about the new bio-physics made possible by negative energy MEs and many-sheeted space-time.

The understanding of the notion of psychological time and its arrow - or equivalently, the relationship between subjective and geometric time - turned out to be quite difficult challenge and led to a handful of proposals based on the identification of space-time sheet as a correlate

of self and the idea that the experienced flow of geometric correspond to some kind of motion in space-time or in imbedding space. These identifications did not lead to anything practical and generated paradoxes.

The most recent proposal involves no ad hoc assumptions and relies on the recent formulation of quantum TGD using zero energy ontology. The correlate of self is now so called causal diamond (pair of future and past directed light-cones) which is 8-D sub-manifold of the imbedding space rather than space-time sheet. The flow of geometric time is apparent and due the change of quantum state in quantum jump which in the first approximation means a shift of the quantum superposition of space-time surfaces to the direction of the geometric past of the imbedding space. This proposal allows to understand the asymmetry between geometric future and past at the level of conscious experience and makes also precise quantitative predictions. Also a unification of the definition of self identifying it as a sequence of quantum jumps and of the definition based on the reduction of self hierarchy to a fractal hierarchy of quantum jumps within quantum jumps becomes possible.

The TGD based view about the relationship between time and intentionality is analyzed. The basic new result is the characterization of intentionality as a local randomness combined with long range temporal correlations realized in terms of p-adic fractal statistics involving the breakdown of the ordinary real statistics. The elegance of the model is that long range correlations reflecting intentionality reduce to p-adic continuity: very distant space-time points can be very close p-adically. This characterization allows to experimentally differentiate between intentionality and genuine randomness and determine the p-adic prime characterizing the intentional system without any model dependent assumptions. The astrophysical real size for the p-adically small space-time sheets representing intentions justifies the assumption about astrophysical sizes of the personal magnetic body and MEs meaning the most dramatic deviation between TGD based and standard view about living matter.

The TGD inspired view about time and brain is compared with the neuroscience based vision. The time delays related to passive and active aspects of consciousness discovered by Libet are shown to support the notion of magnetic body having astrophysical size. The general model for the intentional action allows to understand sensory perception, motor action, and memory as special cases of the mechanism for which the personal magnetic body is the intentional agent and motor action proceeds from long to short length and time scales.

The intention represented by a p-adic ME is transformed to a negative energy ME representing the desire about the action and entangling the magnetic body with some lower level in the hierarchy. The cascade of intentions transformed to desires eventually reaches the material body and induces the desired action as a reaction in the geometric past communicated classically to the geometric future. Brain only reacts to the desires quantum communicated from the geometric future, which explains the coherence of motor action difficult to understand if brain genuinely plans and initiates the action. Also remote mental interactions are based on the same mechanism and precognition and long term memory as well as PK and retro PK can be seen as different aspects of the same phenomenon. The model predicts four types of memories corresponding to cyclotron transitions of protons and electrons and Z^0 cyclotron transitions of neutrons and neutrinos identifiable as long term sensory and motor memories (p,n) , short term sensory memories (e), and cognitive working memories (ν). Some models for long term memories are discussed and only the so called time-mirror mechanism is found to be consistent with the identification of the magnetic body as experiencer. A precise realization of the time-mirror mechanism based on spin glass degeneracy is identified.

5.1.2   Macro-temporal quantum coherence and spin glass degeneracy

In this chapter two central questions of quantum consciousness theories are discussed. What is the the mechanism guaranteing macroscopic quantum coherence in macro-temporal time scales?

In which sense living matter can be regarded as a hologram?

TGD inspired theory of consciousness leads to a first principle theory of state function reduction free of the logical paradoxes, allows precise definitions for the notions of quantum coherence and de-coherence, and predicts a mechanism making the lifetimes of macroscopic bound states much longer than predicted by the standard physics.

There are three arguments supporting macrotemporal quantum coherence.

1. Quantum classical correspondence allows to identify space-time sheets as quantum coherence regions and since they can have arbitrarily large sizes, macroscopic and macro-temporal quantum coherence follow as consequences.

2. The basic distinction between TGD and standard physics is quantum spin glass degeneracy, which among other things implies that quantum bound states of, say, two molecules have enormous spin glass degeneracy absent in the free state. This in turn means that the system spends much longer time in bound states than in free states and this implies much longer de-coherence time than expected otherwise. The almost degenerate spin glass states differ only by their classical gravitational energy so that gravitation is indeed important.

3. TGD supports the hypothesis that Planck constant is dynamical, quantized, and can have arbitrarily large values. Dark matter can be identified as a phase with large Planck constant and an entire hierarchy of dark matters is predicted. Large $\hbar$ phases have long de-coherence lengths and times so that dark matter can be quantum coherent. Since arguments 1) and 2) do not involve Planck constant, all three arguments can be consistent with each other.

In the p-adic context one must modify Shannon's definition of entropy by replacing the ordinary logarithm based on p-adic norm. This definition gives rise to a real valued entropy in both real and p-adic contexts if entanglement coefficients are rational/algebraic numbers. For irrational/non-algebraic entanglement standard Shannon formula and its p-adic variant must be used and gives rise to non-negative entropy. Unlike Shannon entropy, the p-adic entropies (one for each p) can be also negative so that the entanglement entropy defines a genuine information measure whose sign tells whether the system contains information or dis-information. For the p-adic entropies Negentropy Maximization Principle tends to preserve the quantum coherence if p divides the common denominator of the entanglement probabilities. Thus the states with rational/algebraic entanglement can be regarded as bound states, which are not at all fragile like the states with irrational/non-algebraic entanglement are. This leads to a purely number-theoretic characterization of life: life corresponds to islands of rational/algebraic numbers in the seas of real and p-adic continua. The new views about quantum coherence and information have testable implications at the level of fundamental physics, quantum computation, biology, and consciousness.

5.1.3   Bio-systems as conscious holograms

The notion of conscious hologram is TGD based generalization of the idea about brain as a hologram. In nutshell, the notion of conscious hologram follows from the topological field quantization. Classical fields and matter form a Feynmann diagram like structure consisting of lines representing matter (say charged particles) and bosons (say photons). The matter lines are replaced by space-time sheets representing matter (elementary particles, atoms, molecules,...), and virtual bosons are replaced by topological light rays ("mass-less extremals", MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

The internal lines of the Feynmann diagram are analogous to wave guides and the classical fields and coherent light propagating along these wave guides interfere at the space-time sheets representing the vertices of the Feynmann diagram and the "points" of the conscious hologram. The formation of the hologram corresponds to the self-organization induced by the leakage of supra

currents to smaller (say atomic) space-time sheets. This leakage is induced by the high frequency MEs propagating along low frequency MEs serving as correlates for quantum entanglement. The 3-D stereovision associated with ordinary hologram is generalized to stereo consciousness resulting, when the mental images associated with different 'points' of conscious hologram fuse to single mental image. Central nervous system can be regarded as a conscious hologram of this kind.

Time mirror mechanism is a key element of intentional action. The notion of four-wave interaction generalizes: the interference pattern of oppositely moving reference waves forming an archetypal standing wave (possibly moving as in case of nerve pulse) can be replaced by any synchronously oscillating periodic spatial pattern. Plasma waves for which the frequency does not depend on wave vector are ideal candidates for holograms in the generalized sense. Living matter is full of this kid of holograms: besides plasma oscillations associated with biologically important ions, also Z^0 plasma oscillations associated with atoms and molecules can define holograms. p-Adic length scale hypothesis predicts a hierarchy of plasma frequencies related by powers $2^{3k/4}$ so that even so called "non-living matter" could build this kind of sensory representations based on plasma oscillations.

p-Adic length scale hypothesis and dark matter hierarchy allow to quantify the notion of conscious hologram. The hierarchy of generalized EEGs associated with the dark matter hierarchy allows to propose concrete mechanism of remote mental interactions playing a key role also in the interaction of magnetic bodies with the biological body. Experimental findings related to anomalous pre-cognition support the view that even galactic magnetosphere acts as a conscious entity receiving sensory input from bio-sphere and controlling it.

Bio-photons provide an application of the general theory. Simple mathematical facts about the delayed luminescence induced by an external perturbation combined with the model for a hierarchy of dark EEGs assignable to that of Josephson junctions, lead to a model in which positive and negative energy MEs transversal to DNA strand and representing dark photons generate coherent bio-photons via de-coherence. Rather detailed quantitative models for how MEs and supra current circuits interact and how bio-photons are generated during the gene expression emerge.

Peter Gariaev and his group have discovered a radio wave emission from DNA induced by laser light. The model explaining delayed luminescence covers also this phenomenon: now the decay of dark photons with energies above thermal threshold to radio-wave photons rather than de-coherence would be the mechanism. The findings allow an explanation in terms of a many-sheeted laser action, and a rather detailed view about how bio–system acts as a many-sheeted laser at a wide wave-length range emerges.

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus. The analysis of the work of Tiller in the conceptual framework of TGD leads to the conclusion that four-wave interaction, which is a basic mechanism to produce phase conjugate waves (negative energy topological light rays), serves also as a basic mechanism of intentional action. This leads to a unified view allowing to see EEG and nerve pulse as a particular realization of four-wave interaction.

5.1.4 General theory of qualia

The connection between the general theory of qualia and quantum measurement theory and thermodynamics turned out to be a breakthrough in the development of the ideas related to qualia. In TGD framework the contents of consciousness is determined as some kind of average over the sequence of very large number of quantum jump and this suggests strongly that non-geometric qualia allow a statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps after the last 'wake-up' of self.

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

2. The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics is basically part of theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM...$ generalizes to TGD context: note however that in case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light cone boundary of ME. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is a gradient (flow) of the extensive variable in the direction of the subjective time. Super-canonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

3. Since subjective existence corresponds to quantum jumps, it is natural to assume that only the increments of zero modes and quantum numbers are experienced consciously. Statistical interpretation also suggests that an averaging over the increments occurs. The possibility of sub-selves makes possible to have sequences of sub-selves (mental images) of finite subjective time duration and this makes possible structured subjective memories (for instance, it becomes possible to remember the digits of a phone number). A further working hypothesis analogous to functionalism is universality: kinesthetic qualia depending on the quantum number increments are universal. Thus the increments of Poincare and color and electro-weak quantum numbers define what might be called universal kinesthetic qualia.

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

1. Emotions as order-disorder qualia $T - S$ pair correspond subjective existence and generalizes

to disorder-order type, information theoretic qualia qualia about the state of self. The fact that emotions correlate strongly with peptides which are also informational molecules, supports the identification of the qualia associated with various entropy growth rates as emotions. The entropy of sub-self in turn characterizes the sharpness of the mental image.

2. Kinesthetic qualia defined by generalized forces p-V pair corresponds to the geometric ex-

istence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. Quite generally, the rates for the increase for a maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define what might be called kinesthetic qualia. Senses of force and torque, hearing, and intensity of color sensation can be regarded as examples of generalized kinesthetic qualia.

3. Generalized chemical qualia vm $\mu - N$ pair corresponds to 'objective existence' defined by quantum histories and N is generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. Quite generally, super-canonical and quaternion conformal super algebras should define these kind of qualia and the number of these qualia is very large. The particle numbers in question can be numbers of ions of Cooper pairs in various magnetic states, numbers of colored configuration space photons in various states of super-canonical representation, numbers of join along boundaries bonds, etc.. and one can understand chemical qualia, color vision, and sensations of pain and pleasure as generalized chemical qualia.

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

There are two basic mechanisms generating sensory qualia.

1. Quantum phase transition in which single particle transition occurs coherently for some macroscopic quantum phase produces qualia defined by the increments of quantum numbers in the transition. Quantum phase transition could be induced by the transition frequency: quantum phase transition leading to the generation of new kind of macroscopic quantum phase is in question. The magnetic quantum phase transitions at super-conducting magnetic flux tubes provide a basic example of this mechanism, and the quantum model of hearing relies on Z^0 magnetic quantum phase transitions.

2. The flow of particles with fixed quantum numbers between "electrodes" of what might be called a quantum capacitor induces qualia defined by the quantum numbers of the particles involved. The "electrodes" carry opposite net quantum numbers. Second electrode corresponds to the sub-self defining the quale mental image. Obviously cell interior and exterior are excellent candidates for the electrodes of the quantum capacitor. Also neuron and post-synaptic neuron. In fact, living matter is full of electrets defining capacitor like structures. The capacitor model applies to various chemical qualia and also to color vision and predicts that also cells should have senses.

5.2 PART II: Homeopathy and Metabolism

5.2.1 Homeopathy in many-sheeted space-time

The claimed mechanisms of homeopathic healing and the method of manufacturing homeopathic potencies are not the only paradoxical aspects of homeopathy. Also the reported frequency imprinting and entrainment, codes based on field patterns, and associative learning of water look mysterious in the framework of standard physics.

1. Frequency imprinting and entrainment

Frequency imprinting and entrainment at preferred frequencies are believed to be fundamental for homeopathy and acupuncture. The data suggest that water builds representations for the chemicals it contains as space-time sheets containing water in liquid crystal form. These space-time sheets reproduce relevant part for the spectrum of rotational frequencies of the molecule in rigid rotor approximation. Also the mimicry of vibrational spectrum using sound waves can be considered possible. Besides LC water blobs also magnetic mirrors consisting of magnetic flux tube plus parallel MEs pop up naturally in the original model of frequency imprinting and entrainment.

The basic objection is that if the space-time sheets are in thermal equilibrium, the scenario partially fails in the case of fundamentally important rotational and conformational spectra which are in microwave region. TGD however suggests that also inherently dark atoms identifiable as anyonic counterparts of ordinary atoms are possible and have the same energy spectrum as ordinary atoms, and that the notion of atom and molecule generalizes to what might be called N-atom/molecule having energy spectrum scaled up by a factor $1 \leq N \leq \lambda^k$, $\hbar(k) = \lambda^k \hbar_0$. In this case various vibrational and rotational frequencies would define a hierarchy of dark energies which can be above thermal threshold. In particular, rotational and conformational microwave spectra of bio-molecules have dark counterparts with energies above the thermal threshold. Otherwise only cyclotron energies and plasma oscillation energies can be above thermal threshold at sufficiently high levels of dark matter hierarchy.

2. Scaling laws

Homeopathy seems to involve two kinds of scaling laws which seem to be closely related. What I call scaling law of homeopathy states that homeopathic frequencies appear in pairs (f_h, f_l) of high and low frequencies such that their ratio is given by $f_h/f_l \simeq 2 \times 10^{11}$. TGD approach explains this ratio predicts a generalization of the law. $v = Lf_l$ scaling law tells in TGD framework how the frequencies associated with generalized EEG code for the velocities of physiological waves and their frequencies $f_h = cf_l/v$. The general model for motor control by magnetic body predicts this scaling law.

3. Model for the homeopathy

The model of homeopathy must explain the effectiveness of homeopathic remedies manufactured by a repeated dilution and succussion. This can be understood if part of chemical involved is transformed to dark matter and is also represented by water clusters or dark super-nuclei formed from protons. This minimal representation involves thermally stable dark cyclotron frequencies. If inherently dark atoms and molecules with essentially same energy spectrum as ordinary ones are possible, also the mimicry of vibrational and rotational spectrum is possible by clusters of dark water molecules.

One must also understand why homeopathic remedies are manufactured from molecules which basically cause the symptoms to be cured. The explanation is that the presence of molecules mimicking the poisonous molecule makes it possible to sweep the poisonous molecules "under the rug" if they enter the organism. In the presence of Bose-Einstein condensates of dark photons generated by the mimicking particles, the poisonous molecules drop to dark space-time sheets where they are harmless: the mechanism is generalization of induced emission.

The model should also explain the associative learning and field codes. The presence of a hierarchy of dark matter levels leads to a model for how magnetic body performs motor control in terms of dark plasmoids and their quantal plasma oscillation patterns and receives sensory input from the biological body and experiences it as a kind of somatosensory representation along entire magnetic body. It would be the magnetic bodies at higher levels of dark matter hierarchy which learn rather than mere water. Context sensitive field codes emerge naturally as codes involved with all bio-control, in particular that of gene expression.

The charge entanglement by W MEs is the essentially new element in the model for generalized motor actions by magnetic body. Also the telepathic sharing of mental images could rely on charge entanglement. The reduction of charge entanglement can induce a quantum jump to a state in which local Bose-Einstein condensates become exotically ionized with certain probability depending on the intensity of W field. These Bose-Einstein condensates define pixels of generalized motor maps. Plasma oscillations in turn induce various physiological responses such as Ca^{++} and Mg^{++} waves and nerve pulses in turn giving rise to the generalized motor action. Field code is the correspondence between the spatio-temporal pattern of plasma oscillations and generalized motor action.

4. Dark nuclear strings as analogs of as analogs of DNA-, RNA- and amino-acid sequences and baryonic realization of genetic code

A speculative picture proposing a connection between homeopathy, water memory, and phantom DNA effect is discussed and on basis of this connection a vision about how the tqc hardware represented by the genome is actively developed by subjecting it to evolutionary pressures represented by a virtual world representation of the physical environment. The speculation inspired by this vision is that genetic code as well as DNA-, RNA- and amino-acid sequences should have representation in terms of nuclear strings. The model for dark baryons indeed leads to an identification of these analogs and the basic numbers of genetic code including also the numbers of aminoacids coded by a given number of codons are predicted correctly. Hence it seems that genetic

code is universal rather than being an accidental outcome of the biological evolution.

5. Some applications

The model of the magnetic body and the mechanism of motor control based on plasma oscillations of plasmoids can be tested by finding whether it allows to understand various enigmatic findings. Priore's machine which is a device demonstrated to induce a cure of cancer by somehow stimulating the immune system defines one such application. The findings of Sue Benford about intentionally produced tracks and dots in nuclear emulsions and microwave hearing and closely related taos hum define further applications. There is experimental evidence that electromagnetic stimulation can be used to transfer genetic information imprinted in field patterns between organisms belonging to different species. The idea about genes responsible for genetic self engineering and responding to field patterns representing foreign genes pops up naturally in dark matter inspired vision.

The general model for the magnetic body allows also to sharpen the model of remote mental interactions. In fact, these effects would be only a scaled-up exogenous versions of the effects appearing endogenously in cellular length scales and also in astrophysical length scales in communications between magnetic bodies and corresponding biological bodies.

5.2.2 Macroscopic quantum coherence and quantum metabolism as different sides of the same coin

The quantum view about metabolism has developed in two stages. First came the somewhat unbalanced vision about the connection of quantum metabolism and bound state formation. The second breakthrough was the discovery of dark matter hierarchy and associated hierarchy of generalized EEGs.

1. Quantum metabolism and bound state formation

Topological self-referentiality states that the topological field quanta of the classical fields associated with a material system provide a concrete representation for a theory about the material system. Actually this principle generalizes and implies an entire hierarchy of representations. An important outcome of the topological self-referentiality is that the 'buy-now' part of the buy now-pay later mechanism for energy production can be understood as a generation of bound states with binding energy liberated as a usable energy. 'Pay later' means that sooner or later thermal noise destroys the bound state.

This observation led to a quantum vision about energy economy in living matter: generation of the macroscopic coherence involving also binding of mental images to larger ones and liberation of a usable energy are different sides of the same coin. Besides, or perhaps even instead, the ordinary metabolism, quantum metabolism should be key element of living matter. Indeed, also ordinary metabolism might be accompanied by the effective over-unity energy production implied by the generation of quantum bound state entanglement: this implies a connection with the claimed over unity phenomena. This should reflect experimentally as apparently miraculous ability of the organism to cope without the use of the metabolic energy. Anomalies of this kind have been indeed observed at the level of neuronal metabolism and nano-biology is just challenging the basic assumptions of the Newtonian biology.

This vision can be criticized for over-emphasizing the formation of bound states: also the transitions to bound states with lower energy, say transitions between cyclotron states, can generate metabolic energy.

2. Dark matter hierarchy and quantum metabolism

The vision about a hierarchy of generalized EEGs associated with dark matter hierarchy a second decisive boost for new views about quantum metabolism. The crucial new element is that

at higher levels of dark matter hierarchy photons with arbitrarily low frequencies can correspond to energies above the thermal threshold. This explains the observed mysterious effects of ELF radiation on living matter and implies that magnetic bodies are key participants in the metabolism. The equally mysterious findings about the ionic membrane currents can be understood if these currents are essentially non-dissipative and that ionic channels and pumps are actually ionic receptors. Hence it seems that generalized EEGs could take a lion share of the metabolic energy rather than ionic currents as thought usually. This picture allows to understand various strange findings about neuronal metabolism.

3. Holy trinity of red blood cells, neurons, and astrocytes

These ingredients allow to develop a general view about how the sensory representations and motor control are realized in terms of MEs. Time mirror mechanism and charge entanglement induced by W MEs are the basic elements in the general model for how magnetic body controls biological body and receives sensory information from it.

A model for motor control and sensory representations based on the trinity of red blood cells, astrocytes, and neurons emerges and raises astrocytes from a status of passive energy storage to an active link in the quantum control of brain by magnetic body. One can also identify mechanisms for the generation of coherent locomotion construct a quantum view about how ATP serves as a universal energy currency.

This view also allows a deeper interpretation of chemical communications and biological information molecules. There are full reasons to believe that substructures of these molecules can have bound state entanglement with the surrounding world. This entanglement can be interpreted in terms of 'telepathic' quantum communications. In fact, I introduced already few years ago the notion semitrance as entanglement with higher level selves but at this time I had not yet understood that quantum jump involves also state function preparation process realized as a cascade of self measurements against which only bound state entanglement is stable.

4. Molecular motors

During last years molecular motors have become the hot topics of biology. The so called Brownian motors are the dominating theoretical paradigm but there are some empirical findings challenging the concept. TGD suggests an alternative approach based on the notion of quantum motor. The basic idea is that all moving parts of the quantum motor move on the non-atomic space-time sheets so that momentum dissipation is minimal. It turns out that this picture might work but that TGD allows both quantum and classical modes for the molecular motors and it is quite possible that both modes are present. The model allows a new view about the real function of ATP leading to precisely correct quantitative predictions. Also the real function of membrane potential can be understood and quantum model for nerve pulse and EEG constructed.

The fascinating ability of molecular motors to co-operate finds an explanation in terms of the notion of super-genome: super-genome consists of sequences of nuclei analogous to text lines at the pages of book represented by magnetic flux sheets. Also the magnetic bodies of molecular motors can integrate in a similar manner to larger structures so that the population of molecular motors becomes a society.

5. Remote metabolism and effective super-luminal velocities

After the pioneering experiments of Nimtz and his collaborators 1992 a lot of evidence for effective super-luminal signal velocities has been accumulating. The simplest model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. Thus these experiments would give a firm grasp on phenomena at the border of dead and living matter.

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