

# Introduction to "Universe as a Conscious Hologram"

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## Contents

<b>1</b>	<b>Basic Ideas of Topological Geometrodynamics (TGD)</b>	<b>3</b>
1.1	Geometric Vision Very Briefly . . . . .	3
1.2	Two Visions About TGD as Geometrization of Physics and Their Fusion . . . . .	6
1.2.1	TGD as a Poincare Invariant Theory of Gravitation . . . . .	6
1.2.2	TGD as a Generalization of the Hadronic String Model . . . . .	7
1.2.3	Fusion of the Two Approaches via a Generalization of the Space-Time Concept . . . . .	7
1.3	Basic Objections . . . . .	8
1.3.1	Topological Field Quantization . . . . .	9
1.4	Quantum TGD as Spinor Geometry of World of Classical Worlds . . . . .	9
1.4.1	World of Classical Worlds . . . . .	9
1.4.2	Identification of Kähler function . . . . .	10
1.4.3	WCW spinor fields . . . . .	10
1.4.4	The role of modified Dirac action . . . . .	11
1.5	Construction of scattering amplitudes . . . . .	11
1.5.1	Reduction of particle reactions to space-time topology . . . . .	11
1.5.2	Construction of the counterparts of S-matrices . . . . .	12
1.5.3	The notion of M-matrix . . . . .	12
1.6	TGD as a generalized number theory . . . . .	13
1.6.1	The Threads in the Development of Quantum TGD . . . . .	13
1.6.2	Number theoretic vision very briefly . . . . .	14
1.6.3	p-Adic TGD and fusion of real and p-adic physics to single coherent whole . . . . .	15
1.6.4	Infinite primes . . . . .	17
1.7	An explicit formula for $M^8 - H$ duality . . . . .	17
1.7.1	Holography in $H$ . . . . .	17
1.7.2	Number theoretic holography in $M_c^8$ . . . . .	17
1.7.3	Can one find an explicit formula for $M^8 - H$ duality? . . . . .	18

1.7.4	What could the number theoretic holography mean physically? . . . . .	19
1.7.5	Twistor lift of the holography . . . . .	19
1.8	Hierarchy of Planck Constants and Dark Matter Hierarchy . . . . .	20
1.8.1	Dark Matter as Large $\hbar$ Phases . . . . .	20
1.8.2	Hierarchy of Planck Constants from the Anomalies of Neuroscience and Biology . . . . .	21
1.8.3	Dark Matter as a Source of Long Ranged Weak and Color Fields . . . . .	22
1.9	Twistors in TGD and connection with Veneziano duality . . . . .	22
1.9.1	Twistor lift at space-time level . . . . .	22
1.9.2	Twistor lift at the level of scattering amplitudes and connection with Veneziano duality . . . . .	23
<b>2</b>	<b>Bird's Eye of View about the Topics of "Bio-Systems as Conscious Holograms"</b>	<b>26</b>
2.1	Organization of "Bio-Systems as Conscious Holograms" . . . . .	26
2.2	Organization of "Bio-Systems as Conscious Holograms" . . . . .	27
<b>3</b>	<b>Sources</b>	<b>27</b>
3.1	PART I: BIO-SYSTEMS AS CONSCIOUS HOLOGRAMS . . . . .	27
3.1.1	Bio-Systems as Conscious Holograms . . . . .	27
3.1.2	Macro-Temporal Quantum Coherence and Spin Glass Degeneracy . . . . .	28
3.1.3	Spin Glasses, Complexity, and TGD . . . . .	30
3.2	PART II: WATER MEMORY . . . . .	30
3.2.1	Homeopathy in Many-Sheeted Space-time . . . . .	30
3.2.2	TGD view about water memory and the notion of morphogenetic field . . . . .	32
3.2.3	Could cancer be a disease of magnetic body? . . . . .	32
3.3	PART III: METABOLISM . . . . .	33
3.3.1	Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I . . . . .	33
3.3.2	Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II . . . . .	34
3.3.3	About Concrete Realization of Remote Metabolism . . . . .	35
3.3.4	Quantum gravitation and quantum biology in TGD Universe . . . . .	36

# 1 Basic Ideas of Topological Geometrodynamics (TGD)

Standard model describes rather successfully both electroweak and strong interactions but sees them as totally separate and contains a large number of parameters which it is not able to predict. For about four decades ago unified theories known as Grand Unified Theories (GUTs) trying to understand electroweak interactions and strong interactions as aspects of the same fundamental gauge interaction assignable to a larger symmetry group emerged. Later superstring models trying to unify even gravitation and strong and weak interactions emerged. The shortcomings of both GUTs and superstring models are now well-known. If TGD - whose basic idea emerged towards the end of 1977 - would emerge now it would be seen as an attempt to solve the difficulties of these approaches to unification.

The basic physical picture behind the geometric vision of TGD corresponds to a fusion of two rather disparate approaches: namely TGD as a Poincare invariant theory of gravitation and TGD as a generalization of the old-fashioned string model. After 1995 number theoretic vision started to develop and was initiated by the success of mass calculations based on p-adic thermodynamics. Number theoretic vision involves all number fields and is complementary to the geometric vision: one can say that this duality is analogous to momentum-position duality of wave mechanics. TGD can be also regarded as topological quantum theory in a very general sense as already the attribute "Topological" in "TGD" makes clear. Space-time surfaces as minimal surfaces can be regarded as representatives of homology equivalence classes and p-adic topologies generalize the notion of local topology and apply to the description of correlates of cognition.

## 1.1 Geometric Vision Very Briefly

*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 [K1].

The basic vision and its relationship to existing theories is now rather well understood.

1. Space-times are representable as 4-surfaces in the 8-dimensional embedding space  $H = M^4 \times CP_2$ , where  $M^4$  is 4-dimensional (4-D) Minkowski space and  $CP_2$  is 4-D complex projective space (see Appendix).
2. Induction procedure (a standard procedure in fiber bundle theory, see Appendix) allows to geometrize various fields. Space-time metric characterizing gravitational fields corresponds to the induced metric obtained by projecting the metric tensor of  $H$  to the space-time surface. Electroweak gauge potentials are identified as projections of the components of  $CP_2$  spinor connection to the space-time surface, and color gauge potentials as projections of  $CP_2$  Killing vector fields representing color symmetries. Also spinor structure can be induced: induced spinor gamma matrices are projections of gamma matrices of  $H$  and induced spinor fields just  $H$  spinor fields restricted to space-time surface. Spinor connection is also projected. The interpretation is that distances are measured in embedding space metric and parallel translation using spinor connection of embedding space.

Twistor lift of TGD means that one can lift space-time surfaces in  $H$  to 6-D surfaces a analogs of twistor space of space-time surface in the Cartesian product of the twistor spaces of  $M^4$  and  $CP_2$ , which are the only 4-manifolds allowing twistor space with Kähler structure [A7]. The twistor structure would be induced in some sense, and should coincide with that associated with the induced metric. Clearly, the 2-spheres defining the fibers of twistor spaces of  $M^4$  and  $CP_2$  must allow identification: this 2-sphere defines the  $S^2$  fiber of the twistor space of the space-time surface. This poses a constraint on the embedding of the twistor space of space-time surfaces as sub-manifold in the Cartesian product of twistor spaces. The existence of Kähler structure allows to lift 4-D Kähler action to its 6-D counterparts and the 6-D counterpart of twistor space is obtained by its dimensional reduction so that one obtains a sphere bundle. This makes possible twistorialization for all space-time surfaces: in general relativity the general metric does not allow this.

3. A geometrization of quantum numbers is achieved. The isometry group of the geometry of  $CP_2$  codes for the color gauge symmetries of strong interactions. Vierbein group codes

for electroweak symmetries, and explains their breaking in terms of  $CP_2$  geometry so that standard model gauge group results. There are also important deviations from the standard model: color quantum numbers are not spin-like but analogous to orbital angular momentum: this difference is expected to be seen only in  $CP_2$  scale. In contrast to GUTs, quark and lepton numbers are separately conserved and family replication has a topological explanation in terms of topology of the partonic 2-surface carrying fermionic quantum numbers.

$M^4$  and  $CP_2$  are unique choices for many other reasons. For instance, they are the unique 4-D space-times allowing twistor space with Kähler structure.  $M^4$  light-cone boundary allows a huge extension of 2-D conformal symmetries.  $M^4$  and  $CP_2$  allow quaternionic structures. Therefore standard model symmetries have number theoretic meaning.

4. Induced gauge potentials are expressible in terms of embedding space coordinates and their gradients and general coordinate invariance implies that there are only 4 field-like variables locally. Situation is thus extremely simple mathematically. The objection is that one loses linear superposition of fields. The resolution of the problem comes from the generalization of the concepts of particle and space-time.

Space-time surfaces can be also particle like having thus finite size. In particular, space-time regions with Euclidian signature of the induced metric (temporal and spatial dimensions in the same role) emerge and have interpretation as lines of generalized Feynman diagrams. Particles in space-time can be identified as a topological inhomogeneities in background space-time surface which looks like the space-time of general relativity in long length scales.

One ends up with a generalization of space-time surface to many-sheeted space-time with space-time sheets having extremely small distances of about  $10^4$  Planck lengths ( $CP_2$  size). As one adds a particle to this kind of structure, it touches various space-time sheets and thus interacts with the associated classical fields. Their effects superpose linearly in good approximation and linear superposition of fields is replaced with that for their effects.

This resolves the basic objection. It also leads to the understanding of how the space-time of general relativity and quantum field theories emerges from TGD space-time as effective space-time when the sheets of many-sheeted space-time are lumped together to form a region of Minkowski space with metric replaced with a metric identified as the sum of empty Minkowski metric and deviations of the metrics of sheets from empty Minkowski metric. Gauge potentials are identified as sums of the induced gauge potentials. TGD is therefore a microscopic theory from which the standard model and general relativity follow as a topological simplification, however forcing a dramatic increase of the number of fundamental field variables.

5. A further objection is that classical weak fields identified as induced gauge fields are long ranged and should cause large parity breaking effects due to weak interactions. These effects are indeed observed but only in living matter. The basic problem is that one has long ranged classical electroweak gauge fields. The resolution of the problem is that the quantum averages of induced weak and color gauge fields vanish due to the fact that color rotations affect both space-time surfaces and induced weak and color fields. Only the averages of electromagnetic fields are nonvanishing. The correlations functions for weak fields are nonvanishing below Compton lengths of weak bosons. In living matter large values of effective Planck constant labelling phases of ordinary matter identified as dark matter make possible long ranged weak fields and color fields.
6. General coordinate invariance requires holography so that space-time surfaces are analogous to Bohr orbits for particles identified as 3-surfaces. Bohr orbit property would be naturally realized by a 4-D generalization of holomorphy of string world sheets and implies that the space-time surfaces are minimal surfaces apart from singularities. This holds true for any action as long as it is general coordinate invariant and constructible in terms of the induced geometry. String world sheets and light-like orbits of partonic 2-surfaces correspond to singularities at which the minimal surface property of the space-time surfaces realizing the preferred extremal property fails. Preferred extremals are not completely deterministic, which implies what I call zero energy ontology (ZEO) meaning that the Bohr orbits are the fundamental objects. This leads to a solution of the basic paradox of quantum measurement

theory. Also the mathematically ill-defined path integral disappears and leaves only the well-defined functional integral over the Bohr orbits.

7. A string model-like picture emerges from TGD and one ends up with a rather concrete view about the topological counterpart of Feynman diagrammatics. The natural stringy action would be given by the string world sheet area, which is present only in the space-time regions with Minkowskian signature. Gravitational constant could be present as a fundamental constant in string action and the ratio  $\hbar/G/R^2$  would be determined by quantum criticality conditions. The hierarchy of Planck constants  $\hbar_{eff}/\hbar = n$  assigned to dark matter in TGD framework would allow to circumvent the objection that only objects of length of order Planck length are possible since string tension given by  $T = 1/\hbar_{eff}G$  apart from numerical factor could be arbitrary small. This would make possible gravitational bound states as partonic 2-surfaces as structures connected by strings and solve the basic problem of superstring theories. This option allows the natural interpretation of  $M^4$  type vacuum extremals with  $CP_2$  projection, which is Lagrange manifold as good approximations for space-time sheets at macroscopic length scales. String area does not contribute to the Kähler function at all.

Whether induced spinor fields associated with Kähler-Dirac action and de-localized inside the entire space-time surface should be allowed remains an open question: super-conformal symmetry strongly suggests their presence. A possible interpretation for the corresponding spinor modes could be in terms of dark matter, sparticles, and hierarchy of Planck constants.

It is perhaps useful to make clear what TGD is not and also what new TGD can give to physics.

1. TGD is *not* just General Relativity made concrete by using embeddings: the 4-surface property is absolutely essential for unifying standard model physics with gravitation and to circumvent the incurable conceptual problems of General Relativity. The many-sheeted space-time of TGD gives rise only at the macroscopic limit to GRT space-time as a slightly curved Minkowski space. TGD is *not* a Kaluza-Klein theory although color gauge potentials are analogous to gauge potentials in these theories.

TGD space-time is 4-D and its dimension is due to completely unique conformal properties of light-cone boundary and 3-D light-like surfaces implying enormous extension of the ordinary conformal symmetries. Light-like 3-surfaces represent orbits of partonic 2-surfaces and carry fundamental fermions at 1-D boundaries of string world sheets. TGD is *not* obtained by performing Poincare gauging of space-time to introduce gravitation and is plagued by profound conceptual problems.

2. TGD is *not* a particular string model although string world sheets emerge in TGD very naturally as loci for spinor modes: their 2-dimensionality makes among other things possible quantum deformation of quantization known to be physically realized in condensed matter, and conjectured in TGD framework to be crucial for understanding the notion of finite measurement resolution. Hierarchy of objects of dimension up to 4 emerge from TGD: this obviously means analogy with branes of super-string models.

TGD is *not* one more item in the collection of string models of quantum gravitation relying on Planck length mystics. Dark matter becomes an essential element of quantum gravitation and quantum coherence in astrophysical scales is predicted just from the assumption that strings connecting partonic 2-surfaces are responsible for gravitational bound states.

TGD is *not* a particular string model although AdS/CFT duality of super-string models generalizes due to the huge extension of conformal symmetries and by the identification of WCW gamma matrices as Noether super-charges of super-symplectic algebra having a natural conformal structure.

3. TGD is *not* a gauge theory. In TGD framework the counterparts of also ordinary gauge symmetries are assigned to super-symplectic algebra (and its Yangian [A1] [B4, B2, B3]), which is a generalization of Kac-Moody algebras rather than gauge algebra and suffers a fractal hierarchy of symmetry breakings defining hierarchy of criticalities. TGD is *not* one more quantum field theory like structure based on path integral formalism: path integral

is replaced with functional integral over 3-surfaces, and the notion of classical space-time becomes an exact part of the theory. Quantum theory becomes formally a purely classical theory of WCW spinor fields: only state function reduction is something genuinely quantal.

4. TGD view about spinor fields is *not* the standard one. Spinor fields appear at three levels. Spinor modes of the embedding space are analogs of spinor modes characterizing incoming and outgoing states in quantum field theories. Induced second quantized spinor fields at space-time level are analogs of stringy spinor fields. Their modes are localized by the well-definedness of electro-magnetic charge and by number theoretic arguments at string world sheets. Kähler-Dirac action is fixed by supersymmetry implying that ordinary gamma matrices are replaced by what I call Kähler-Dirac gamma matrices - this something new. WCW spinor fields, which are classical in the sense that they are not second quantized, serve as analogs of fields of string field theory and imply a geometrization of quantum theory.
5. TGD is in some sense an extremely conservative geometrization of entire quantum physics: *no* additional structures such as gauge fields as independent dynamical degrees of freedom are introduced: Kähler geometry and associated spinor structure are enough. "Topological" in TGD should not be understood as an attempt to reduce physics to torsion (see for instance [B1]) or something similar. Rather, TGD space-time is topologically non-trivial in all scales and even the visible structures of the everyday world represent non-trivial topology of space-time in the TGD Universe.
6. Twistor space - or rather, a generalization of twistor approach replacing masslessness in 4-D sense with masslessness in 8-D sense and thus allowing description of also massive particles - emerged originally as a technical tool, and its Kähler structure is possible only for  $H = M^4 \times CP_2$ . It however turned out that much more than a technical tool is in question. What is genuinely new is the infinite-dimensional character of the Kähler geometry making it highly unique, and its generalization to p-adic number fields to describe correlates of cognition. Also the hierarchy of Planck constants  $h_{eff} = n \times h$  reduces to the quantum criticality of the TGD Universe and p-adic length scales and Zero Energy Ontology represent something genuinely new.

The great challenge is to construct a mathematical theory around these physically very attractive ideas and I have devoted the last 45 years to the realization of this dream and this has resulted in 26 online books about TGD and nine online books about TGD inspired theory of consciousness and of quantum biology.

A collection of 30 online books is now (August 2023) under preparation. The goal is to minimize overlap between the topics of the books and make the focus of a given book sharper.

## 1.2 Two Visions About TGD as Geometrization of Physics and Their Fusion

As already mentioned, TGD as a geometrization of physics can be interpreted both as a modification of general relativity and generalization of string models.

### 1.2.1 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 Minkowski space and  $CP_2 = SU(3)/U(2)$  is the complex projective space of two complex dimensions [A3, A6, A2, A5].

The identification of the space-time as a sub-manifold [A4, A9] 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.

It soon however turned out that sub-manifold 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  $X^4$ .

The choice of  $H$  is unique from the condition that TGD has standard model symmetries. Also number theoretical vision selects  $H = M^4 \times CP_2$  uniquely.  $M^4$  and  $CP_2$  are also unique spaces allowing twistor space with Kähler structure.

### 1.2.2 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.

This decay vertex does not however correspond to a direct generalization of trouser vertex of string models. Indeed, the important difference between TGD and string models is that the analogs of string world sheet diagrams do not describe particle decays but the propagation of particles via different routes. Particle reactions are described by generalized Feynman diagrams for which 3-D light-like surface describing particle propagating join along their ends at vertices. As 4-manifolds the space-time surfaces are therefore singular like Feynman diagrams as 1-manifolds.

Quite recently, it has turned out that fermionic strings inside space-time surfaces define an exact part of quantum TGD and that this is essential for understanding gravitation in long length scales. Also the analog of AdS/CFT duality emerges in that the Kähler metric can be defined either in terms of Kähler function identifiable as Kähler action assignable to Euclidian space-time regions or Kähler action + string action assignable to Minkowskian regions.

The recent view about construction of scattering amplitudes is very “stringy”. By strong form of holography string world sheets and partonic 2-surfaces provide the data needed to construct scattering amplitudes. Space-time surfaces are however needed to realize quantum-classical correspondence necessary to understand the classical correlates of quantum measurement. There is a huge generalization of the duality symmetry of hadronic string models.

The proposal is that scattering amplitudes can be regarded as sequences of computational operations for the Yangian of super-symplectic algebra. Product and co-product define the basic vertices and realized geometrically as partonic 2-surfaces and algebraically as multiplication for the elements of Yangian identified as super-symplectic Noether charges assignable to strings. Any computational sequences connecting given collections of algebraic objects at the opposite boundaries of causal diamond (CD) produce identical scattering amplitudes.

### 1.2.3 Fusion of the Two Approaches via a Generalization of the Space-Time Concept

The problem is that the two approaches to TGD 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 could be “vapor phase” that is a “gas” of particle like 3-surfaces and string like objects (counterpart of the “baby universes” of GRT) and the non-conservation of energy in GRT corresponds to the transfer of energy between different sheets of the space-time and possible existence vapour phase.

. What one obtains is what I have christened as many-sheeted space-time (see **Fig.** <http://tgdtheory.fi/appfigures/manysheeted.jpg> or **Fig. ??** in the appendix of this book). One particular aspect is topological field quantization meaning that various classical fields assignable to a physical system correspond to space-time sheets representing the classical fields to that particular system. One can speak of the field body of a particular physical system. Field body consists of topological light rays, and electric and magnetic flux quanta. In Maxwell's theory the physical system does not possess this kind of field identity. The notion of the magnetic body is one of the key players in TGD inspired theory of consciousness and quantum biology. The existence of monopole flux tubes requiring no current as a source of the magnetic field makes it possible to understand the existence of magnetic fields in cosmological and astrophysical scales.

This picture became more detailed with the advent of zero energy ontology (ZEO). The basic notion of ZEO is causal diamond (CD) identified as the Cartesian product of  $CP_2$  and of the intersection of future and past directed light-cones and having scale coming as an integer multiple of  $CP_2$  size is fundamental. CDs form a fractal hierarchy and zero energy states decompose to products of positive and negative energy parts assignable to the opposite boundaries of CD defining the ends of the space-time surface. The counterpart of zero energy state in positive energy ontology is the pair of initial and final states of a physical event, say particle reaction.

At space-time level ZEO means that 3-surfaces are pairs of space-like 3-surfaces at the opposite light-like boundaries of CD. Since the extremals of Kähler action connect these, one can say that by holography the basic dynamical objects are the space-time surface connecting these 3-surfaces and identifiable as analogs of Bohr orbits. This changes totally the vision about notions like self-organization: self-organization by quantum jumps does not take for a 3-D system but for the entire 4-D field pattern associated with it.

General Coordinate Invariance (GCI) allows to identify the basic dynamical objects as space-like 3-surfaces at the ends of space-time surface at boundaries of CD: this means that space-time surface is analogous to Bohr orbit. An alternative identification of the lines of generalized Feynman diagrams is as light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. Also the Euclidian 4-D regions can have a similar interpretation. The requirement that the two interpretations are equivalent, leads to a strong form of General Coordinate Invariance. The outcome is effective 2-dimensionality stating that the partonic 2-surfaces identified as intersections of the space-like ends of space-time surface and light-like wormhole throats are the fundamental objects. That only effective 2-dimensionality is in question is due to the effects caused by the failure of strict determinism of Kähler action. In finite length scale resolution these effects can be neglected below UV cutoff and above IR cutoff. One can also speak about a strong form of holography.

The understanding of the super symplectic invariance leads to the proposal that super symplectic algebra and other Kac-Moody type algebras labelled by non-negative multiples of basic conformal weights allow a hierarchy of symmetry breakings in which the analog of gauge symmetry breaks down to a genuine dynamical symmetry. This gives rise to fractal hierarchies of algebras and symmetry breakings. This breaking can occur also for ordinary conformal algebras if one restricts the conformal weights to be non-negative integers.

### 1.3 Basic Objections

Objections are the most powerful tool in theory building. The strongest objection against TGD is the observation that all classical gauge fields are expressible in terms of four embedding space coordinates only- essentially  $CP_2$  coordinates. The linear superposition of classical gauge fields taking place independently for all gauge fields is lost. This would be a catastrophe without many-sheeted space-time. Instead of gauge fields, only the effects such as gauge forces are superposed. Particles topologically condense to several space-time sheets simultaneously and experience the sum of gauge forces. This transforms the weakness to extreme economy: in a typical unified theory the number of primary field variables is countered in hundreds if not thousands, now it is just four.

Second objection is that TGD space-time is quite too simple as compared to GRT space-time due to the embeddability to 8-D embedding space. One can also argue that Poincare invariant theory of gravitation cannot be consistent with General Relativity. The above interpretation makes it possible to understand the relationship to GRT space-time and how the Equivalence Principle



(EP) follows from Poincare invariance of TGD. The interpretation of GRT space-time is as effective space-time obtained by replacing many-sheeted space-time with Minkowski space with effective metric determined as a sum of Minkowski metric and sum over the deviations of the induced metrics of the space-time sheets from Minkowski metric. Poincare invariance strongly suggests classical EP for the GRT limit in long length scales at least. One can also consider other kinds of limits such as the analog of GRT limit for Euclidian space-time regions assignable to elementary particles. In this case deformations of  $CP_2$  metric define a natural starting point and  $CP_2$  indeed defines a gravitational instanton with a very large cosmological constant in Einstein-Maxwell theory. Also gauge potentials of the standard model correspond classically to superpositions of induced gauge potentials over space-time sheets.

### 1.3.1 Topological Field Quantization

Topological field quantization distinguishes between TGD based and more standard - say Maxwellian - notion of field. In Maxwell's fields created by separate systems superpose and one cannot tell which part of field comes from which system except theoretically. In TGD these fields correspond to different space-time sheets and only their effects on test particle superpose. Hence physical systems have well-defined field identifies - field bodies - in particular magnetic bodies.

The notion of magnetic body carrying dark matter with non-standard large value of Planck constant has become central concept in TGD inspired theory of consciousness and living matter, and by starting from various anomalies of biology one ends up to a rather detailed view about the role of magnetic body as intentional agent receiving sensory input from the biological body and controlling it using EEG and its various scaled up variants as a communication tool. Among other things this leads to models for cell membrane, nerve pulse, and EEG.

## 1.4 Quantum TGD as Spinor Geometry of World of Classical Worlds

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 have been the following ones.

### 1.4.1 World of Classical Worlds

The notion of WCW reduces the interacting quantum theory to a theory of free WCW spinor fields.

1. Quantum theory for extended particles is free(!), classical(!) field theory for a generalized Schrödinger amplitude identified as WCW spinor in the configuration space  $CH$  ("world of classical worlds", WCW) 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.
2. 4-D general coordinate invariance forces holography and replaces the ill-defined path integral over all space-time surfaces with a discrete sum over 4-D analogs of Bohr orbits for particles identified as 3-surfaces. Holography means that basic objects are these analogs of Bohr orbits. Since there is no quantization at the level of WCW, one has an analog of wave mechanics with point-like particles replaced with 4-D Bohr orbits.
3. One must geometrize WCW as the space of Bohr orbits. In an infinite-dimensional situation the existence of geometry requires maximal symmetries already in the case of loop spaces. Physics is unique from its mathematical existence.

WCW is endowed with metric and spinor structure so that one can define various metric related differential operators, say Dirac operators, appearing in the field equations of the theory <sup>1</sup>

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<sup>1</sup>There are four kinds of Dirac operators in TGD. The geometrization of quantum theory requires Kähler metric definable either in terms of Kähler function identified as a the bosonic action for Euclidian space-time regions

### 1.4.2 Identification of Kähler function

The evolution of these basic ideas has been rather slow but has gradually led to a rather beautiful vision. One of the key problems has been the definition of Kähler function. Kähler function is Kähler action for a preferred extremal assignable to a given 3-surface but what this preferred extremal is? The obvious first guess was as absolute minimum of Kähler action but could not be proven to be right or wrong. One big step in the progress was boosted by the idea that TGD should reduce to almost topological QFT in which braids would replace 3-surfaces in finite measurement resolution, which could be inherent property of the theory itself and imply discretization at partonic 2-surfaces with discrete points carrying fermion number.

It took long time to realize that there is no discretization in 4-D sense - this would lead to difficulties with basic symmetries. Rather, the discretization occurs for the parameters characterizing co-dimension 2 objects representing the information about space-time surface so that they belong to some algebraic extension of rationals. These 2-surfaces - string world sheets and partonic 2-surfaces - are genuine physical objects rather than a computational approximation. Physics itself approximates itself, one might say! This is of course nothing but strong form of holography.

1. TGD as almost topological QFT vision suggests that Kähler action for preferred extremals reduces to Chern-Simons term assigned with space-like 3-surfaces at the ends of space-time (recall the notion of causal diamond (CD)) and with the light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. Minkowskian and Euclidian regions would give at wormhole throats the same contribution apart from coefficients and in Minkowskian regions the  $\sqrt{g_4}$  factor coming from metric would be imaginary so that one would obtain sum of real term identifiable as Kähler function and imaginary term identifiable as the ordinary Minkowskian action giving rise to interference effects and stationary phase approximation central in both classical and quantum field theory.

Imaginary contribution - the presence of which I realized only after 33 years of TGD - could also have topological interpretation as a Morse function. On physical side the emergence of Euclidian space-time regions is something completely new and leads to a dramatic modification of the ideas about black hole interior.

2. The way to achieve the reduction to Chern-Simons terms is simple. The vanishing of Coulomb contribution to Kähler action is required and is true for all known extremals if one makes a general ansatz about the form of classical conserved currents. The so called weak form of electric-magnetic duality defines a boundary condition reducing the resulting 3-D terms to Chern-Simons terms. In this way almost topological QFT results. But only "almost" since the Lagrange multiplier term forcing electric-magnetic duality implies that Chern-Simons action for preferred extremals depends on metric.

### 1.4.3 WCW spinor fields

Classical WCW spinor fields are analogous to Schrödinger amplitudes and the construction of WCW Kähler geometry reduces to the second quantization of free spinor fields of  $H$ .

1. The WCW metric is given by anticommutators of WCW gamma matrices which also have interpretation as supercharges assignable to the generators of WCW isometries and allowing expression as non-conserved Noether charges. Holography implies zero energy ontology (ZEO) meaning that zero energy states are superpositions of Bohr orbits connecting boundaries of causal diamond (CD). CDs form a fractal hierarchy and their space forming the spine of WCW is finite-dimensional and can be geometrized. The alternative interpretation is as a superposition of pairs of ordinary 3-D fermionic states assignable to the ends of the space-time surfaces.
2. There are several Dirac operators. WCW Dirac operator  $D_{WCW}$  appears in Super-symplectic gauge conditions analogous to Super Virasoro conditions. The algebraic variant of the  $H$

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or as anti-commutators for WCW gamma matrices identified as conformal Noether super-charges associated with the second quantized modified Dirac action consisting of string world sheet term and possibly also modified Dirac action in Minkowskian space-time regions. These two possible definitions reflect a duality analogous to AdS/CFT duality.

Dirac operator  $D_H$  appears in fermionic correlation functions: this is due to the fact that free fermions appearing as building bricks of WCW gamma matrices are modes of  $D_H$ . The modes of  $D_H$  define the ground states of super-symplectic representations. There is also the modified Dirac operator  $D_{X^4}$  acting on the induced spinors at space-time surfaces and it is dictated by symmetry one the action fixing the space-time surfaces as Bohr orbits is fixed.  $D_H$  is needed since it determines the expressions of WCW gamma matrices as Noether charges assignable to 3-surfaces at the ends of WCW.

#### 1.4.4 The role of modified Dirac action

1. By quantum classical correspondence, the construction of WCW spinor structure in sectors assignable to CDs reduces to the second quantization of the induced spinor fields of  $H$ . The basic action is so called modified Dirac action in which gamma matrices are replaced with the modified gamma matrices defined as contractions of the canonical momentum currents of the bosonic action defining the space-time surfaces with the embedding space gamma matrices. In this way one achieves super-conformal symmetry and conservation of fermionic currents among other things and a consistent Dirac equation.

Modified Dirac action is needed to define WCW gamma matrices as super charges assignable to WCW isometry generators identified as generators of symplectic transformations and by holography are needed only at the 3-surface at the boundaries of WCW. It is important to notice that the modified Dirac equation does not determine propagators since induced spinor fields are obtained from free second quantized spinor fields of  $H$ . This means enormous simplification and makes the theory calculable.

2. An important interpretational problem relates to the notion of the induced spinor connection. The presence of classical W boson fields is in conflict with the classical conservation of em charge since the coupling to classical W fields changes em charge.

One way out of the problem is the fact that the quantum averages of weak and gluon fields vanish unlike the quantum average of the em field. This leads to a rather precise understanding of electroweak symmetry breaking as being due the fact that color symmetries rotate space-time surfaces and also affect the induced weak fields.

One can also consider a stronger condition. If one requires that the spinor modes have well-defined em charge, one must assume that the modes in the generic situation are localized at 2-D surfaces - string world sheets or perhaps also partonic 2-surfaces - at which classical W boson fields vanish. Covariantly constant right handed neutrinos generating super-symmetries forms an exception. The vanishing of the  $Z^0$  field is possible for Kähler-Dirac action and should hold true at least above weak length scales. This implies that the string model in 4-D space-time becomes part of TGD. Without these conditions classical weak fields can vanish above weak scale only for the GRT limit of TGD for which gauge potentials are sums over those for space-time sheets.

The localization would simplify the mathematics enormously and one can solve exactly the Kähler-Dirac equation for the modes of the induced spinor field just like in super string models.

At the light-like 3-surfaces the signature of the induced metric changes from Euclidian to Minkowskian so that  $\sqrt{g_4}$  vanishes. One can pose the condition that the algebraic analog of the massless Dirac equation is satisfied by the modes of the modified-Dirac action assignable to the Chern-Simons-Kähler action.

## 1.5 Construction of scattering amplitudes

### 1.5.1 Reduction of particle reactions to space-time topology

Particle reactions are identified as topology changes [A8, A10, A11]. 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 WCW 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.

During years this naïve and very rough vision has of course developed a lot and is not anymore quite equivalent with the original insight. In particular, the space-time correlates of Feynman graphs have emerged from theory as Euclidian space-time regions and the strong form of General Coordinate Invariance has led to a rather detailed and in many respects un-expected visions. This picture forces to give up the idea about smooth space-time surfaces and replace space-time surface with a generalization of Feynman diagram in which vertices represent the failure of manifold property. I have also introduced the word “world of classical worlds” (WCW) instead of rather formal “configuration space”. I hope that “WCW” does not induce despair in the reader having tendency to think about the technicalities involved!

### 1.5.2 Construction of the counterparts of S-matrices

What does one mean with the counterpart of S-matrix in the TGD framework has been a long standing problem. The development of ZEO based quantum measurement theory has led to a rough overall view of the situation.

1. There are two kinds of state function reductions (SFRs). ”Small” SFRs (SSFRs) following the TGD counterpart of a unitary time evolution defines a sequence of SFRs, which is analogous to a sequence of repeated quantum measurements associated with the Zeno effect. In wave mechanics nothing happens in these measurements. In quantum optics these measurements correspond to weak measurements. In TGD SSFR affects the zero energy state but leaves the 3-D state at the passive boundary of CD unaffected.
2. In TGD framework each SSFR is preceded by a counterpart of a unitary time evolution, which means dispersion in the space of CDs and unitary time evolution in fermionic degrees of freedom such that the passive boundary of CDs and 3-D states at it are unaffected but a superposition of CDs with varying active boundaries in the space of CDs is formed. In SSFR a localization in the space of CDs occurs such that the active is fixed. In a statistical sense the size of the CD increases and the increasing distance between the tips of the CD gives rise to the arrow of geometric time.
3. Also ”big” SFRs (BSFRs) can occur and they correspond to ordinary SFRs. In BSFR the roles of the active and passive boundary are changed and this means that the arrow of time is changed. Big SFR occurs when the SSFR corresponds to a quantum measurement, which does not commute with the operators, which define the states at the passive boundary of CD as their eigenstates. This means a radical deviation from standard quantum measurement theory and has predictions in all scales.
4. One can assign the counterpart of S-matrix to the unitary time evolution between two subsequent SSFRs and also to the counterpart of S-matrix associated with BSFR. At least in the latter case the dimension of the state space can increase since at least BSFRs lead to the increase of the dimension of algebraic extension of rationals assignable to the space-time surface by  $M^8 - H$  duality. Unitarity is therefore replaced with isometry.
5. I have also considered the possibility that unitary S-matrix could be replaced in the fermionic degrees of freedom with Kähler metric of the state space satisfying analogs of unitarity conditions but it seems that this is un-necessary and also too outlandish an idea.

### 1.5.3 The notion of M-matrix

1. The most ambitious dream is that zero energy states correspond to a complete solution basis for the Dirac operators associated with WCWs associated with the spaces of CDs with fixed passive boundary: this would define an S-matrix assignable to SFR. Also the analog of S-matrix for the localizations of the states to the active boundary assignable to the BSFR changing the state at the passive boundary of CD is needed.

2. If one allows entanglement between positive and energy parts of the zero energy state but assumes that the states at the passive boundary are fixed, one must introduce the counterpart of the density matrix, or rather its square root. This classical free field theory would dictate what I have called M-matrices defined between positive and negative energy parts of zero energy states which form orthonormal rows of what I call U-matrix as a matrix defined between zero energy states. A given M-matrix in turn would decompose to a product of a hermitian square root of density matrix and unitary S-matrix.
3. M-matrix would define time-like entanglement coefficients between positive and negative energy parts of zero energy states (all net quantum numbers vanish for them) and can be regarded as a hermitian square root of density matrix multiplied by a unitary S-matrix. Quantum theory would be in a well-defined sense a square root of thermodynamics. The orthogonality and hermiticity of the M-matrices commuting with S-matrix means that they span infinite-dimensional Lie algebras acting as symmetries of the S-matrix. Therefore quantum TGD would reduce to group theory in a well-defined sense.
4. In fact the Lie algebra of Hermitian M-matrices extends to Kac-Moody type algebra obtained by multiplying hermitian square roots of density matrices with powers of the S-matrix. Also the analog of Yangian algebra involving only non-negative powers of S-matrix is possible and would correspond to a hierarchy of CDs with the temporal distances between tips coming as integer multiples of the  $CP_2$  time.

The M-matrices associated with CDs are obtained by a discrete scaling from the minimal CD and characterized by integer  $n$  are naturally proportional to a representation matrix of scaling:  $S(n) = S^n$ , where  $S$  is unitary S-matrix associated with the minimal CD [K10]. This conforms with the idea about unitary time evolution as exponent of Hamiltonian discretized to integer power of  $S$  and represented as scaling with respect to the logarithm of the proper time distance between the tips of CD.

5. I have also considered the notion of U-matrix. U-matrix elements between M-matrices for various CDs are proportional to the inner products  $Tr[S^{-n_1} \circ H^i H^j \circ S^{n_2} \lambda]$ , where  $\lambda$  represents unitarily the discrete Lorentz boost relating the moduli of the active boundary of CD and  $H^i$  form an orthonormal basis of Hermitian square roots of density matrices.  $\circ$  tells that  $S$  acts at the active boundary of CD only. I have proposed a general representation for the U-matrix, reducing its construction to that of the S-matrix.

## 1.6 TGD as a generalized number theory

Quantum T(opological)D(ynamics) as a classical spinor geometry for infinite-dimensional configuration space (“world of classical worlds”, WCW), 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. The fourth thread deserves the name “TGD as a generalized number theory”. It involves three separate threads: the fusion of real and various p-adic physics to a single coherent whole by requiring number theoretic universality discussed already, the formulation of quantum TGD in terms of complexified counterparts of classical number fields, and the notion of infinite prime. Note that one can identify subrings such as hyper-quaternions and hyper-octonions as sub-spaces of complexified classical number fields with Minkowskian signature of the metric defined by the complexified inner product.

### 1.6.1 The Threads in the Development of Quantum TGD

The development of TGD has involved several strongly interacting threads: physics as infinite-dimensional geometry; TGD as a generalized number theory, the hierarchy of Planck constants interpreted in terms of dark matter hierarchy, and TGD inspired theory of consciousness. In the following these threads are briefly described.

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

2. The discussions with Tony Smith initiated a fourth thread which deserves the name “TGD as a generalized number theory”. The basic observation was that classical number fields might allow a deeper formulation of quantum TGD. 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 rather fruitful revision of the basic views about what the final form and physical content of quantum TGD might be. Together with the vision about the fusion of p-adic and real physics to a larger coherent structure these sub-threads fused to the “physics as generalized number theory” thread.
3. A further thread emerged from 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 strongly suggested by the failure of strict determinism for the fundamental variational principle. The identification of hierarchy of Planck constants labelling phases of dark matter 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.

The chronology based identification of the threads is quite natural but not logical and it is much more logical to see p-adic physics, the ideas related to classical number fields, and infinite primes as sub-threads of a thread which might be called “physics as a generalized number theory”. In the following I adopt this view. This reduces the number of threads to three corresponding to geometric, number theoretic and topological views of physics.

TGD forces the generalization of physics to a quantum theory of consciousness, and TGD as a generalized number theory vision leads naturally to the emergence of p-adic physics as physics of cognitive representations.

### 1.6.2 Number theoretic vision very briefly

Number theoretic vision about quantum TGD involves notions like adelic physics,  $M^8 - H$  duality and number theoretic universality. A short review of the basic ideas that have developed during years is in order.

1. The physical interpretation of  $M^8$  is as an analog of momentum space and  $M^8 - H$  duality is analogous to momentum-position duality of ordinary wave mechanics.
2. Adelic physics means that all classical number fields, all p-adic number fields and their extensions induced by extensions of rationals and defining adeles, and also finite number fields are basic mathematical building bricks of physics.

The complexification of  $M^8$ , identified as complexified octonions, would provide a realization of this picture and  $M^8 - H$  duality would map the algebraic physics in  $M^8$  to the ordinary physics in  $M^4 \times CP_2$  described in terms of partial differential equations.

3. Negentropy Maximization Principle (NMP) states that the conscious information assignable with cognition representable measured in terms of p-adic negentropy increases in statistical sense.

NMP is mathematically completely analogous to the second law of thermodynamics and number theoretic evolution as an unavoidable statistical increase of the dimension of the algebraic extension of rationals characterizing a given space-time region implies it. There is no paradox involved: the p-adic negentropy measures the conscious information assignable to the entanglement of two systems regarded as a conscious entity whereas ordinary entropy measures the lack of information about the quantum state of either entangled system.

4. Number theoretical universality requires that space-time surfaces or at least their  $M^8 - H$  duals in  $M_c^8$  are defined for both reals and various p-adic number fields. This is true if they are

defined by polynomials with integer coefficients as surfaces in  $M^8$  obeying number theoretic holography realized as associativity of the normal space of 4-D surface using as holographic data 3-surfaces at mass shells identified in terms of roots of a polynomial. A physically motivated additional condition is that the coefficients of the polynomials are smaller than their degrees.

5. Galois confinement is a key piece of the number theoretic vision. It states that the momenta of physical states are algebraic integers in the extensions of rationals assignable to the space-time region considered. These numbers are in general complex and are not consistent with particle in box quantization. The proposal is that physical states satisfy Galois confinement being thus Galois singlets and having therefore total momenta, whose components are ordinary integers, when momentum unit defined by the scale of causal diamond (CD) is used.
6. The notion of p-adic prime was introduced in p-adic mass calculations that started the developments around 1995. p-Adic length scale hypothesis states that p-adic primes near powers of 2 have a special physical role (as possibly also the powers of other small primes such as  $p = 3$ ).

The proposal is that p-adic primes correspond to ramified primes assignable to the extension and identified as divisors of the polynomial defined by the products of the root differences for the roots of the polynomial defining space-time space and having interpretation as values of, in general complex, virtual mass squared.

### 1.6.3 p-Adic TGD and fusion of real and p-adic physics to single coherent whole

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.

In string model context one tries to reduce the physics to Planck scale. The price is the inability to say anything about physics in long length scales. In TGD p-adic physics takes care of this shortcoming by predicting the physics also in long length scales.

There were many interpretational and technical questions crying for a definite answer.

1. 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 WCW? Certainly the p-adicization at the level of super-conformal representation is necessary for the p-adic mass calculations.

2. 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. Quite recently I however learned that the problem of making sense about p-adic integration has been for decades central problem in the frontier of mathematics and a lot of profound work has been done along same intuitive lines as I have proceeded in TGD framework. The basic idea is certainly the notion of algebraic continuation from the world of rationals belonging to the intersection of real world and various p-adic worlds.

Despite various uncertainties, the number of the applications of the poorly defined p-adic physics has grown 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.

The key challenge is to fuse various p-adic physics and real physics to single larger structure. This has inspired a proposal for a generalization of the notion of number field by fusing real numbers and various p-adic number fields and their extensions along rationals and possible common algebraic numbers. This leads to a generalization of the notions of embedding space and space-time concept and one can speak about real and p-adic space-time sheets. One can talk about adelic space-time, embedding space, and WCW.

The corresponds of real 4-surfaces with the p-adic ones is induced by number theoretical discretization using points of 4-surfaces  $Y^4 \subset M_c^8$  identifiable as 8-momenta, whose components are assumed to be algebraic integers in an extension of rationals defined by the extension of rationals associated with a polynomial  $P$  with integer coefficients smaller than the degree of  $P$ . These points define a cognitive representation, which is universal in the sense that it exists also in the algebraic extensions of p-adic numbers. The points of the cognitive representations associated with the mass shells with mass squared values identified as roots of  $P$  are enough since  $M^8 - H$  duality can be used at both  $M^8$  and  $H$  sides and also in the p-adic context. The mass shells are special in that they allow for Minkowski coordinates very large cognitive representations unlike the interiors of the 4-surfaces determined by holography by using the data defined by the 3-surfaces at the mass shells. The higher the dimension of the algebraic extension associated with  $P$ , the better the accuracy of the cognitive representation.

Adelization providing number theoretical universality reduces to algebraic continuation for the amplitudes from this intersection of reality and various p-adicities - analogous to a back of a book - to various number fields. There are no problems with symmetries but canonical identification is needed: various group invariant of the amplitude are mapped by canonical identification to various p-adic number fields. This is nothing but a generalization of the mapping of the p-adic mass squared to its real counterpart in p-adic mass calculations.

This leads to surprisingly detailed predictions and far reaching conjectures. For instance, the number theoretic generalization of entropy concept allows negentropic entanglement central for the applications to living matter (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book). One can also understand how preferred p-adic primes could emerge as so called ramified primes of algebraic extension of rationals in question and characterizing string world sheets and partonic 2-surfaces. Preferred p-adic primes would be ramified primes for extensions for which the number of p-adic continuations of two-surfaces to space-time surfaces (imaginings) allowing also real continuation (realization of imagination) would be especially large. These ramifications would be winners in the fight for number theoretical survival. Also a generalization of p-adic length scale hypothesis emerges from NMP [K9].

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 a 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.



### 1.6.4 Infinite primes

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.

After the realization that infinite primes can be mapped to polynomials possibly 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 complexified quaternions and octonions. Complete algebraic, topological and dimensional democracy would characterize the theory.

The infinite primes at the first level of hierarchy, which represent analogs of bound states, can be mapped to irreducible polynomials, which in turn characterize the algebraic extensions of rationals defining a hierarchy of algebraic physics continuable to real and p-adic number fields. The products of infinite primes in turn define more general algebraic extensions of rationals. The interesting question concerns the physical interpretation of the higher levels in the hierarchy of infinite primes and integers mappable to polynomials of  $n > 1$  variables.

## 1.7 An explicit formula for $M^8 - H$ duality

$M^8 - H$  duality is a generalization of momentum-position duality relating the number theoretic and geometric views of physics in TGD and, despite that it still involves poorly understood aspects, it has become a fundamental building block of TGD. One has 4-D surfaces  $Y^4 \subset M_c^8$ , where  $M_c^8$  is complexified  $M^8$  having interpretation as an analog of complex momentum space and 4-D spacetime surfaces  $X^4 \subset H = M^4 \times CP_2$ .  $M_c^8$ , equivalently  $E_c^8$ , can be regarded as complexified octonions.  $M_c^8$  has a subspace  $M_c^4$  containing  $M^4$ .

**Comment:** One should be very cautious with the meaning of "complex". Complexified octonions involve a complex imaginary unit  $i$  commuting with the octonionic imaginary units  $I_k$ .  $i$  is assumed to also appear as an imaginary unit also in complex algebraic numbers defined by the roots of polynomials  $P$  defining holographic data in  $M_c^8$ .

In the following  $M^8 - H$  duality and its twistor lift are discussed and an explicit formula for the dualities are deduced. Also possible variants of the duality are discussed.

### 1.7.1 Holography in $H$

$X^4 \subset H$  satisfies holography and is analogous to the Bohr orbit of a particle identified as a 3-surface. The proposal is that holography reduces to a 4-D generalization of holomorphy so that  $X^4$  is a simultaneous zero of two functions of complex  $CP_2$  coordinates and of what I have called Hamilton-Jacobi coordinates of  $M^4$  with a generalized Kähler structure.

The simplest choice of the Hamilton-Jacobi coordinates is defined by the decomposition  $M^4 = M^2 \times E^2$ , where  $M^2$  is endowed with hypercomplex structure defined by light-like coordinates  $(u, v)$ , which are analogous to  $z$  and  $\bar{z}$ . Any analytic map  $u \rightarrow f(u)$  defines a new set of light-like coordinates and corresponds to a solution of the massless d'Alembert equation in  $M^2$ .  $E^2$  has some complex coordinates with imaginary unit defined by  $i$ .

The conjecture is that also more general Hamilton-Jacobi structures for which the tangent space decomposition is local are possible. Therefore one would have  $M^4 = M^2(x) \times E^2(x)$ . These would correspond to non-equivalent complex and Kähler structures of  $M^4$  analogous to those possessed by 2-D Riemann surfaces and parametrized by moduli space.

### 1.7.2 Number theoretic holography in $M_c^8$

$Y^4 \subset M_c^8$  satisfies number theoretic holography defining dynamics, which should reduce to associativity in some sense. The Euclidian complexified normal space  $N^4(y)$  at a given point  $y$  of  $Y^4$  is required to be associative, i.e. quaternionic. Besides this,  $N^4(i)$  contains a preferred complex Euclidian 2-D subspace  $Y^2(y)$ . Also the spaces  $Y^2(x)$  define an integrable distribution. I have assumed that  $Y^2(x)$  can depend on the point  $y$  of  $Y^4$ .

These assumptions imply that the normal space  $N(y)$  of  $Y^4$  can be parameterized by a point of  $CP_2 = SU(3)/U(2)$ . This distribution is always integrable unlike quaternionic tangent space

distributions.  $M^8 - H$  duality assigns to the normal space  $N(y)$  a point of  $CP_2$ .  $M_c^4$  point  $y$  is mapped to a point  $x \in M^4 \subset M^4 \times CP_2$  defined by the real part of its inversion (conformal transformation): this formula involves effective Planck constant for dimensional reasons.

The 3-D holographic data, which partially fixes 4-surfaces  $Y^4$  is partially determined by a polynomial  $P$  with real integer coefficients smaller than the degree of  $P$ . The roots define mass squared values which are in general complex algebraic numbers and define complex analogs of mass shells in  $M_c^4 \subset M_c^8$ , which are analogs of hyperbolic spaces  $H^3$ . The 3-surfaces at these mass shells define 3-D holographic data continued to a surface  $Y^4$  by requiring that the normal space of  $Y^4$  is associative, i.e. quaternionic. These 3-surfaces are not completely fixed but an interesting conjecture is that they correspond to fundamental domains of tessellations of  $H^3$ .

What does the complexity of the mass shells mean? The simplest interpretation is that the space-like  $M^4$  coordinates (3-momentum components) are real whereas the time-like coordinate (energy) is complex and determined by the mass shell condition. One would have  $Re^2(E) - Im(E)^2 - p^2 = Re(m^2)$  and  $2Re(E)Im(E) = Im(m^2)$ . The condition for the real parts gives  $H^3$  when  $\sqrt{Re^2(E) - Im(E)^2}$  is taken as a time coordinate. The second condition allows to solve  $Im(E)$  in terms of  $Re(E)$  so that the first condition reduces to an equation of mass shell when  $\sqrt{(Re(E)^2 - Im(E)^2)}$ , expressed in terms of  $Re(E)$ , is taken as new energy coordinate  $E_{eff} = \sqrt{(Re(E)^2 - Im(E)^2)}$ . Is this deformation of  $H^3$  in imaginary time direction equivalent with a region of the hyperbolic 3-space  $H^3$ ?

One can look at the formula in more detail. Mass shell condition gives  $Re^2(E) - Im(E)^2 - p^2 = Re(m^2)$  and  $2Re(E)Im(E) = Im(m^2)$ . The condition for the real parts gives  $H^3$ , when  $\sqrt{Re^2(E) - Im(E)^2}$  is taken as an effective energy. The second condition allows to solve  $Im(E)$  in terms of  $Re(E)$  so that the first condition reduces to a dispersion relation for  $Re(E)^2$ .

$$Re(E)^2 = \frac{1}{2}(Re(m^2) - Im(m^2) + p^2)(1 \pm \sqrt{1 + \frac{2Im(m^2)^2}{(Re(m^2) - Im(m^2) + p^2)^2}}). \quad (1.1)$$

Only the positive root gives a non-tachyonic result for  $Re(m^2) - Im(m^2) > 0$ . For real roots with  $Im(m^2) = 0$  and at the high momentum limit the formula coincides with the standard formula. For  $Re(m^2) = Im(m^2)$  one obtains  $Re(E)^2 \rightarrow Im(m^2)/\sqrt{2}$  at the low momentum limit  $p^2 \rightarrow 0$ . Energy does not depend on momentum at all: the situation resembles that for plasma waves.

### 1.7.3 Can one find an explicit formula for $M^8 - H$ duality?

The dream is an explicit formula for the  $M^8 - H$  duality mapping  $Y^4 \subset M_c^8$  to  $X^4 \subset H$ . This formula should be consistent with the assumption that the generalized holomorphy holds true for  $X^4$ .

The following proposal is a more detailed variant of the earlier proposal for which  $Y^4$  is determined by a map  $g$  of  $M_c^4 \rightarrow SU(3)_c \subset G_{2,c}$ , where  $G_{2,c}$  is the complexified automorphism group of octonions and  $SU(3)_c$  is interpreted as a complexified color group.

This map defines a trivial  $SU(3)_c$  gauge field. The real part of  $g$  however defines a non-trivial real color gauge field by the non-linearity of the non-abelian gauge field with respect to the gauge potential. The quadratic terms involving the imaginary part of the gauge potential give an additional condition to the real part in the complex situation and cancel it. If only the real part of  $g$  contributes, this contribution would be absent and the gauge field is non-vanishing.

How could the automorphism  $g(x) \subset SU(3) \subset G_2$  give rise to  $M^8 - H$  duality?

1. The interpretation is that  $g(y)$  at given point  $y$  of  $Y^4$  relates the normal space at  $y$  to a fixed quaternionic/associative normal space at point  $y_0$ , which corresponds is fixed by some subgroup  $U(2)_0 \subset SU(3)$ . The automorphism property of  $g$  guarantees that the normal space is quaternionic/associative at  $y$ . This simplifies the construction dramatically.
2. The quaternionic normal sub-space (which has Euclidian signature) contains a complex sub-space which corresponds to a point of sphere  $S^2 = SO(3)/O(2)$ , where  $SO(3)$  is the quaternionic automorphism group. The interpretation could be in terms of a selection of spin quantization axes. The local choice of the preferred complex plane would not be unique

and is analogous to the possibility of having non-trivial Hamilton Jacobi structures in  $M^4$  characterized by the choice of  $M^2(x)$  and equivalently its normal subspace  $E^2(x)$ .

These two structures are independent apart from dependencies forced by the number theoretic dynamics. Hamilton-Jacobi structure means a selection of the quantization axis of spin and energy by fixing a distribution of light-like tangent vectors of  $M^4$  and the choice of the quaternionic normal sub-space fixes a choice of preferred quaternionic imaginary unit defining a quantization axis of the weak isospin.

3. The real part  $Re(g(y))$  defines a point of  $SU(3)$  and the bundle projection  $SU(3) \rightarrow CP_2$  in turn defines a point of  $CP_2 = SU(3)/U(2)$ . Hence one can assign to  $g$  a point of  $CP_2$  as  $M^8 - H$  duality requires and deduce an explicit formula for the point. This means a realization of the dream.
4. The construction requires a fixing of a quaternionic normal space  $N_0$  at  $y_0$  containing a preferred complex subspace at a single point of  $Y^4$  plus a selection of the function  $g$ . If  $M^4$  coordinates are possible for  $Y^4$ , the first guess is that  $g$  as a function of complexified  $M^4$  coordinates obeys generalized holomorphy with respect to complexified  $M^4$  coordinates in the same sense and in the case of  $X^4$ . This might guarantee that the  $M^8 - H$  image of  $Y^4$  satisfies the generalized holomorphy.
5. Also space-time surfaces  $X^4$  with  $M^4$  projection having a dimension smaller than 4 are allowed. I have proposed that they might correspond to singular cases for the above formula: a kind of blow-up would be involved. One can also consider a more general definition of  $Y^4$  allowing it to have a  $M^4$  projection with dimension smaller than 4 (say cosmic strings). Could one have implicit equations for the surface  $Y^4$  in terms of the complex coordinates of  $SU(3)_c$  and  $M^4$ ? Could this give for instance cosmic strings with a 2-D  $M^4$  projection and  $CP_2$  type extremals with 4-D  $CP_2$  projection and 1-D light-like  $M^4$  projection?

#### 1.7.4 What could the number theoretic holography mean physically?

What could be physical meaning of the number theoretic holography? The condition that has been assumed is that the  $CP_2$  coordinates at the mass shells of  $M_c^4 \subset M_c^8$  mapped to mass shells  $H^3$  of  $M^4 \subset M^4 \times CP_2$  are constant at the  $H^3$ . This is true if the  $g(y)$  defines the same  $CP_2$  point for a given component  $X_i^3$  of the 3-surface at a given mass shell.  $g$  is therefore fixed apart from a local  $U(2)$  transformation leaving the  $CP_2$  point invariant. A stronger condition would be that the  $CP_2$  point is the same for each component of  $X_i^3$  and even at each mass shell but this condition seems to be unnecessarily strong.

**Comment:** One can criticize this condition as too strong and one can consider giving up this condition. The motivation for this condition is that the number of algebraic points at the 3-surfaces associated with  $H^3$  explodes since the coordinates associated with normal directions vanish. Kind of cognitive explosion would be in question.

$SU(3)$  corresponds to a subgroup of  $G_2$  and one can wonder what the fixing of this subgroup could mean physically.  $G_2$  is 14-D and the coset space  $G_2/SU(3)$  is 6-D and a good guess is that it is just the 6-D twistor space  $SU(3)/U(1) \times U(1)$  of  $CP_2$ : at least the isometries are the same. The fixing of the  $SU(3)$  subgroup means fixing of a  $CP_2$  twistor. Physically this means the fixing of the quantization axis of color isospin and hypercharge.

#### 1.7.5 Twistor lift of the holography

What is interesting is that by replacing  $SU(3)$  with  $G_2$ , one obtains an explicit formula from the generalization of  $M^8 - H$  duality to that for the twistorial lift of TGD!

One can also consider a twistorial generalization of the above proposal for the number theoretic holography by allowing local  $G_2$  automorphisms interpreted as local choices of the color quantization axis.  $G_2$  elements would be fixed apart from a local  $SU(3)$  transformation at the components of 3-surfaces at mass shells. The choice of the color quantization axes for a connected 3-surface at a given mass shell would be the same everywhere. This choice is indeed very natural physically since 3-surface corresponds to a particle.

Is this proposal consistent with the boundary condition of the number theoretical holography mean in the case of 4-surfaces in  $M_c^8$  and  $M^4 \times CP_2$ ?

1. The selection of  $SU(3) \subset G_2$  for ordinary  $M^8 - H$  duality means that the  $G_{2,c}$  gauge field vanishes everywhere and the choice of color quantization axis is the same at all points of the 4-surface. The fixing of the  $CP_2$  point to be constant at  $H^3$  implies that the color gauge field at  $H^3 \subset M_c^8$  and its image  $H^3 \subset H$  vanish. One would have color confinement at the mass shells  $H_i^3$ , where the observations are made. Is this condition too strong?
2. The constancy of the  $G_2$  element at mass shells makes sense physically and means a fixed color quantization axis. The selection of a fixed  $SU(3) \subset G_2$  for entire space-time surface is in conflict with the non-constancy of  $G_2$  element unless  $G_2$  element differs at different points of 4-surface only by a multiplication of a local  $SU(3)_0$  element, that is local  $SU(3)$  transformation. This kind of variation of the  $G_2$  element would mean a fixed color group but varying choice of color quantization axis.
3. Could one consider the possibility that the local  $G_{2,c}$  element is free and defines the twistor lift of  $M^8 - H$  duality as something more fundamental than the ordinary  $M^8 - H$  duality based on  $SU(3)_c$ . This duality would make sense only at the mass shells so that only the spaces  $H^3 \times CP_2$  assignable to mass shells would make sense physically? In the interior  $CP_2$  would be replaced with the twistor space  $SU(3)/U(1) \times U(1)$ . Color gauge fields would be non-vanishing at the mass shells but outside the mass shells one would have  $G_2$  gauge fields. There is also a physical objection against the  $G_2$  option. The 14-D Lie algebra representation of  $G_2$  acts on the imaginary octonions which decompose with respect to the color group to  $1 \oplus 3 \oplus \bar{3}$ . The automorphism property requires that 1 can be transformed to 3 or  $\bar{3}$  to themselves: this requires that the decomposition contains  $3 \oplus \bar{3}$ . Furthermore, it must be possible to transform 3 and  $\bar{3}$  to themselves, which requires the presence of 8. This leaves only the decomposition  $8 \oplus 3 \oplus \bar{3}$ .  $G_2$  gluons would both color octet and triplets. In the TDG framework the only conceivable interpretation would be in terms of ordinary gluons and leptoquark-like gluons. This does not fit with the basic vision of TGD.

The choice of twistor as a selection of quantization axes should make sense also in the  $M^4$  degrees of freedom.  $M^4$  twistor corresponds to a choice of light-like direction at a given point of  $M^4$ . The spatial component of the light-like vector fixes the spin quantization axis. Its choice together with the light-likeness fixes the time direction and therefore the rest system and energy quantization axis. Light-like vector fixes also the choice of  $M^2$  and of  $E^2$  as its orthogonal complement. Therefore the fixing of  $M^4$  twistor as a point of  $SU(4)/SU(3) \times U(1)$  corresponds to a choice of the spin quantization axis and the time-like axis defining the rest system in which the energy is measured. This choice would naturally correspond to the Hamilton-Jacobi structure fixing the decompositions  $M^2(x) \times E^2(x)$ . At a given mass shell the choice of the quantization axis would be constant for a given  $X_i^3$ .

## 1.8 Hierarchy of Planck Constants 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.

### 1.8.1 Dark Matter as Large $\hbar$ Phases

D. Da Rocha and Laurent Nottale [E1] 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 that astrophysical systems are at some levels of the hierarchy of space-time sheets macroscopic quantum systems. The space-time sheets in question would carry dark matter.

Nottale's hypothesis would predict a gigantic value of  $h_{gr}$ . Equivalence Principle and the independence of gravitational Compton length on mass  $m$  implies however that one can restrict the values of mass  $m$  to masses of microscopic objects so that  $h_{gr}$  would be much smaller. Large  $h_{gr}$  could 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 [K18].

It is natural to assign the values of Planck constants postulated by Nottale to the space-time sheets mediating gravitational interaction and identifiable as magnetic flux tubes (quanta) possibly carrying monopole flux and identifiable as remnants of cosmic string phase of primordial cosmology. The magnetic energy of these flux quanta would correspond to dark energy and magnetic tension would give rise to negative "pressure" forcing accelerate cosmological expansion. This leads to a rather detailed vision about the evolution of stars and galaxies identified as bubbles of ordinary and dark matter inside magnetic flux tubes identifiable as dark energy.

Certain experimental findings suggest the identification  $h_{eff} = n \times h_{gr}$ . The large value of  $h_{gr}$  can be seen as a way to reduce the string tension of fermionic strings so that gravitational (in fact all!) bound states can be described in terms of strings connecting the partonic 2-surfaces defining particles (analogous to AdS/CFT description). The values  $h_{eff}/h = n$  can be interpreted in terms of a hierarchy of breakings of super-conformal symmetry in which the super-conformal generators act as gauge symmetries only for a sub-algebras with conformal weights coming as multiples of  $n$ . Macroscopic quantum coherence in astrophysical scales is implied. If also Kähler-Dirac action is present, part of the interior degrees of freedom associated with the Kähler-Dirac part of conformal algebra become physical. A possible is that fermionic oscillator operators generate super-symmetries and sparticles correspond almost by definition to dark matter with  $h_{eff}/h = n > 1$ . One implication would be that at least part if not all gravitons would be dark and be observed only through their decays to ordinary high frequency graviton ( $E = hf_{high} = h_{eff}f_{low}$ ) of bunch of  $n$  low energy gravitons.

### 1.8.2 Hierarchy of Planck Constants from the Anomalies of Neuroscience and Biology

The quantal ELF effects of ELF em fields on vertebrate brain have been known since seventies. ELF em fields at frequencies identifiable as cyclotron frequencies in magnetic field whose intensity is about 2/5 times that of Earth for biologically important ions have physiological effects and affect also behavior. What is intriguing that the effects are found only in vertebrates (to my best knowledge). The energies for the photons of ELF em fields are extremely low - about  $10^{-10}$  times lower than thermal energy at physiological temperatures- so that quantal effects are impossible in the framework of standard quantum theory. The values of Planck constant would be in these situations large but not gigantic.

This inspired the hypothesis that these photons correspond to so large a value of Planck constant that the energy of photons is above the thermal energy. The proposed interpretation was as dark photons and the general hypothesis was that dark matter corresponds to ordinary matter with non-standard value of Planck constant. If only particles with the same value of Planck constant can appear in the same vertex of Feynman diagram, the phases with different value of Planck constant are dark relative to each other. The phase transitions changing Planck constant can however make possible interactions between phases with different Planck constant but these interactions do not manifest themselves in particle physics. Also the interactions mediated by classical fields should be possible. Dark matter would not be so dark as we have used to believe.

The hypothesis  $h_{eff} = h_{gr}$  - at least for microscopic particles - implies that cyclotron energies of charged particles do not depend on the mass of the particle and their spectrum is thus universal although corresponding frequencies depend on mass. In bio-applications this spectrum would correspond to the energy spectrum of bio-photons assumed to result from dark photons by  $h_{eff}$  reducing phase transition and the energies of bio-photons would be in visible and UV range

associated with the excitations of bio-molecules.

Also the anomalies of biology (see for instance [K15, K16, K14] ) support the view that dark matter might be a key player in living matter.

### 1.8.3 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.

The recent view about the solutions of Kähler- Dirac action assumes that the modes have a well-defined em charge and this implies that localization of the modes to 2-D surfaces (right-handed neutrino is an exception). Classical  $W$  boson fields vanish at these surfaces and also classical  $Z^0$  field can vanish. The latter would guarantee the absence of large parity breaking effects above intermediate boson scale scaling like  $h_{eff}$ .

## 1.9 Twistors in TGD and connection with Veneziano duality

The twistorialization of TGD has two aspects. The attempt to generalize twistor Grassmannian approach emerged first. It was however followed by the realization that also the twistor lift of TGD at classical space-time level is needed. It turned out that the progress in the understanding of the classical twistor lift has been much faster - probably this is due to my rather limited technical QFT skills.

### 1.9.1 Twistor lift at space-time level

8-dimensional generalization of ordinary twistors is highly attractive approach to TGD [K23]. The reason is that  $M^4$  and  $CP_2$  are completely exceptional in the sense that they are the only 4-D manifolds allowing twistor space with Kähler structure [A7]. The twistor space of  $M^4 \times CP_2$  is Cartesian product of those of  $M^4$  and  $CP_2$ . The obvious idea is that space-time surfaces allowing twistor structure if they are orientable are representable as surfaces in  $H$  such that the properly induced twistor structure co-incides with the twistor structure defined by the induced metric.

In fact, it is enough to generalize the induction of spinor structure to that of twistor structure so that the induced twistor structure need not be identical with the ordinary twistor structure possibly assignable to the space-time surface. The induction procedure reduces to a dimensional reduction of 6-D Kähler action giving rise to 6-D surfaces having bundle structure with twistor sphere as fiber and space-time as base. The twistor sphere of this bundle is imbedded as sphere in the product of twistor spheres of twistor spaces of  $M^4$  and  $CP_2$ .

This condition would define the dynamics, and the original conjecture was that this dynamics is equivalent with the identification of space-time surfaces as preferred extremals of Kähler action. The dynamics of space-time surfaces would be lifted to the dynamics of twistor spaces, which are sphere bundles over space-time surfaces. What is remarkable that the powerful machinery of complex analysis becomes available.

It however turned out that twistor lift of TGD is much more than a mere technical tool. First of all, the dimensionally reduction of 6-D Kähler action contained besides 4-D Kähler action also a volume term having interpretation in terms of cosmological constant. This need not bring anything new, since all known extremals of Kähler action with non-vanishing induced Kähler form are minimal surfaces. There is however a large number of embeddings of twistor sphere of space-time surface to the product of twistor spheres. Cosmological constant has spectrum and depends on length scale, and the proposal is that coupling constant evolution reduces to that for cosmological constant playing the role of cutoff length. That cosmological constant could transform from a mere nuisance to a key element of fundamental physics was something totally new and unexpected.

1. The twistor lift of TGD at space-time level forces to replace 4-D Kähler action with 6-D dimensionally reduced Kähler action for 6-D surface in the 12-D Cartesian product of 6-D twistor spaces of  $M^4$  and  $CP_2$ . The 6-D surface has bundle structure with twistor sphere as fiber and space-time surface as base.

Twistor structure is obtained by inducing the twistor structure of 12-D twistor space using dimensional reduction. The dimensionally reduced 6-D Kähler action is sum of 4-D Kähler action and volume term having interpretation in terms of a dynamical cosmological constant depending on the size scale of space-time surface (or of causal diamond CD in zero energy ontology (ZEO)) and determined by the representation of twistor sphere of space-time surface in the Cartesian product of the twistor spheres of  $M^4$  and  $CP_2$ .

2. The preferred extremal property as a representation of quantum criticality would naturally correspond to minimal surface property meaning that the space-time surface is separately an extremal of both Kähler action and volume term almost everywhere so that there is no coupling between them. This is the case for all known extremals of Kähler action with non-vanishing induced Kähler form.

Minimal surface property could however fail at 2-D string world sheets, their boundaries and perhaps also at partonic 2-surfaces. The failure is realized in minimal sense if the 3-surface has 1-D edges/folds (strings) and 4-surface 2-D edges/folds (string world sheets) at which some partial derivatives of the embedding space coordinates are discontinuous but canonical momentum densities for the entire action are continuous.

There would be no flow of canonical momentum between interior and string world sheet and minimal surface equations would be satisfied for the string world sheet, whose 4-D counterpart in twistor bundle is determined by the analog of 4-D Kähler action. These conditions allow the transfer of canonical momenta between Kähler- and volume degrees of freedom at string world sheets. These no-flow conditions could hold true at least asymptotically (near the boundaries of CD).

$M^8 - H$  duality suggests that string world sheets (partonic 2-surfaces) correspond to images of complex 2-sub-manifolds of  $M^8$  (having tangent (normal) space which is complex 2-plane of octonionic  $M^8$ ).

3. Cosmological constant would depend on p-adic length scales and one ends up to a concrete model for the evolution of cosmological constant as a function of p-adic length scale and other number theoretic parameters (such as Planck constant as the order of Galois group): this conforms with the earlier picture.

Inflation is replaced with its TGD counterpart in which the thickening of cosmic strings to flux tubes leads to a transformation of Kähler magnetic energy to ordinary and dark matter. Since the increase of volume increases volume energy, this leads rapidly to energy minimum at some flux tube thickness. The reduction of cosmological constant by a phase transition however leads to a new expansion phase. These jerks would replace smooth cosmic expansion of GRT. The discrete coupling constant evolution predicted by the number theoretical vision could be understood as being induced by that of cosmological constant taking the role of cutoff parameter in QFT picture [?].

### 1.9.2 Twistor lift at the level of scattering amplitudes and connection with Veneziano duality

The classical part of twistor lift of TGD is rather well-understood. Concerning the twistorialization at the level of scattering amplitudes the situation is much more difficult conceptually - I already mentioned my limited QFT skills.

1. From the classical picture described above it is clear that one should construct the 8-D twistorial counterpart of theory involving space-time surfaces, string world sheets and their boundaries, plus partonic 2-surfaces and that this should lead to concrete expressions for the scattering amplitudes.

The light-like boundaries of string world sheets as carriers of fermion numbers would correspond to twistors as they appear in twistor Grassmann approach and define the analog for the massless sector of string theories. The attempts to understand twistorialization have been restricted to this sector.

2. The beautiful basic prediction would be that particles massless in 8-D sense can be massive in 4-D sense. Also the infrared cutoff problematic in twistor approach emerges naturally and reduces basically to the dynamical cosmological constant provided by classical twistor lift.

One can assign 4-momentum both to the spinor harmonics of the embedding space representing ground states of super-conformal representations and to light-like boundaries of string world sheets at the orbits of partonic 2-surfaces. The two four-momenta should be identical by quantum classical correspondence: this could be seen as a concretization of Equivalence Principle. Also a connection with string model emerges.

3. As far as symmetries are considered, the picture looks rather clear. Ordinary twistor Grassmannian approach boils down to the construction of scattering amplitudes in terms of Yangian invariants for conformal group of  $M^4$ . Therefore a generalization of super-symplectic symmetries to their Yangian counterpart seems necessary. These symmetries would be gigantic but how to deduce their implications?
4. The notion of positive Grassmannian is central in the twistor approach to the scattering amplitudes in  $calN = 4$  SUSYs. TGD provides a possible generalization and number theoretic interpretation of this notion. TGD generalizes the observation that scattering amplitudes in twistor Grassmann approach correspond to representations for permutations. Since 2-vertex is the only fermionic vertex in TGD, OZI rules for fermions generalizes, and scattering amplitudes are representations for braidings.

Braid interpretation encourages the conjecture that non-planar diagrams can be reduced to ordinary ones by a procedure analogous to the construction of braid (knot) invariants by gradual un-braiding (un-knotting).

This is however not the only vision about a solution of non-planarity. Quantum criticality provides different view leading to a totally unexpected connection with string models, actually with the Veneziano duality, which was the starting point of dual resonance model in turn leading via dual resonance models to super string models.

1. Quantum criticality in TGD framework means that coupling constant evolution is discrete in the sense that coupling constants are piecewise constant functions of length scale replaced by dynamical cosmological constant. Loop corrections would vanish identically and the recursion formulas for the scattering amplitudes (allowing only planar diagrams) deduced in twistor Grassmann would involve no loop corrections. In particular, cuts would be replaced by sequences of poles mimicking them like sequences of point charge mimic line charges. In momentum discretization this picture follows automatically.
2. This would make sense in finite measurement resolution realized in number theoretical vision by number-theoretic discretization of the space-time surface (cognitive representation) as points with coordinates in the extension of rationals defining the adèle [?]. Similar discretization would take place for momenta. Loops would vanish at the level of discretization but what would happen at the possibly existing continuum limit: does the sequence of poles integrate to cuts? Or is representation as sum of resonances something much deeper?
3. Maybe it is! The basic idea of behind the original Veneziano amplitudes (see <http://tinyurl.com/yyhwvqbq>) was Veneziano duality. This 4-particle amplitude was generalized by Yoshiro Nambu, Holber-Beck Nielsen, and Leonard Susskind to N-particle amplitude (see <http://tinyurl.com/yyvkv7as>) based on string picture, and the resulting model was called dual resonance model. The model was forgotten as QCD emerged. Later came superstring models and led to M-theory. Now it has become clear that something went wrong, and it seems that one must return to the roots. Could the return to the roots mean a careful reconsideration of the dual resonance model?
4. Recall that Veneziano duality (1968) was deduced by assuming that scattering amplitude can be described as sum over s-channel resonances or t-channel Regge exchanges and Veneziano duality stated that hadronic scattering amplitudes have representation as sums over s- or t-channel resonance poles identified as excitations of strings. The sum over exchanges defined by t-channel resonances indeed reduces at larger values of  $s$  to Regge form.

The resonances had zero width, which was not consistent with unitarity. Further, there were no counterparts for the *sum* of s-, t-, and u-channel diagrams with continuous cuts



in the kinematical regions encountered in QFT approach. What puts bells ringing is the u-channel diagrams would be non-planar and non-planarity is the problem of twistor Grassmann approach.

5. Veneziano duality is true only for s- and t- channels but not been s- and u-channel. Stringy description makes t-channel and s-channel pictures equivalent. Could it be that in fundamental description u-channels diagrams cannot be distinguished from s-channel diagrams or t-channel diagrams? Could the stringy representation of the scattering diagrams make u-channel twist somehow trivial if handles of string world sheet representing stringy loops in turn representing the analog of non-planarity of Feynman diagrams are absent? The permutation of external momenta for tree diagram in absence of loops in planar representation would be a twist of  $\pi$  in the representation of planar diagram as string world sheet and would not change the topology of the string world sheet and would not involve non-trivial world sheet topology.

For string world sheets loops would correspond to handles. The presence of handle would give an edge with a loop at the level of 3-surface (self energy correction in QFT). Handles are not allowed if the induced metric for the string world sheet has Minkowskian signature. If the stringy counterparts of loops are absent, also the loops in scattering amplitudes should be absent.

This argument applies only inside the Minkowskian space-time regions. If string world sheets are present also in Euclidian regions, they might have handles and loop corrections could emerge in this manner. In TGD framework strings (string world sheets) are identified to 1-D edges/folds of 3-surface at which minimal surface property and topological QFT property fails (minimal surfaces as calibrations). Could the interpretation of edge/fold as discontinuity of some partial derivatives exclude loopy edges: perhaps the branching points would be too singular?

A reduction to a sum over s-channel resonances is what the vanishing of loops would suggest. Could the presence of string world sheets make possible the vanishing of continuous cuts even at the continuum limit so that continuum cuts would emerge only in the approximation as the density of resonances is high enough?

The replacement of continuous cut with a sum of *infinitely* narrow resonances is certainly an approximation. Could it be that the stringy representation as a sum of resonances with *finite* width is an essential aspect of quantum physics allowing to get rid of infinities necessarily accompanying loops? Consider now the arguments against this idea.

1. How to get rid of the problems with unitarity caused by the zero width of resonances? Could *finite* resonance widths make unitarity possible? Ordinary twistor Grassmannian approach predicts that the virtual momenta are light-like but complex: obviously, the imaginary part of the energy in rest frame would have interpretation as resonance width.

In TGD framework this generalizes for 8-D momenta. By quantum-classical correspondence (QCC) the classical Noether charges are equal to the eigenvalues of the fermionic charges in Cartan algebra (maximal set of mutually commuting observables) and classical TGD indeed predicts complex momenta (Kähler coupling strength is naturally complex). QCC thus supports this proposal.

2. Sum over resonances/exchanges picture is in conflict with QFT picture about scattering of particles. Could *finite* resonance widths due to the complex momenta give rise to the QFT type scattering amplitudes as one develops the amplitudes in Taylor series with respect to the resonance width? Unitarity condition indeed gives the first estimate for the resonance width. QFT amplitudes should emerge in an approximation obtained by replacing the discrete set of finite width resonances with a cut as the distance between poles is shorter than the resolution for mass squared.

In superstring models string tension has single very large value and one cannot obtain QFT type behavior at low energies (for instance, scattering amplitudes in hadronic string model are concentrated in forward direction). TGD however predicts an entire hierarchy of p-adic length scales with varying string tension. The hierarchy of mass scales corresponding roughly to the lengths and thickness of magnetic flux tubes as thickened cosmic strings and characterized by the value of cosmological constant predicted by twistor lift of TGD. Could this give rise

to continuous QCT type cuts at the limit when measurement resolution cannot distinguish between resonances?

The dominating term in the sum over sums of resonances in  $t$ -channel gives near forward direction approximately the lowest mass resonance for strings with the smallest string tension. This gives the behavior  $1/(t - m_{min}^2)$ , where  $m_{min}$  corresponds to the longest mass scale involved (the largest space-time sheet involved), approximating the  $1/t$ -behavior of massless theories. This also brings in IR cutoff, the lack of which is a problem of gauge theories. This should give rise to continuous QFT type cuts at the limit when measurement resolution cannot distinguish between resonances.

## 2 Bird's Eye of View about the Topics of "Bio-Systems as Conscious Holograms"

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.

The book was written long time ago and necessarily contains mammoth bones- my apologies. The book is organized to three parts.

### 2.1 Organization of "Bio-Systems as Conscious Holograms"

1. The first part of the book contains four chapters about this topic reflecting the development of ideas about TGD Universe as conscious hologram. It also provides background for the applications.

The first chapter is about macroscopic quantum coherence and 4-D spin-glass degeneracy. The latter notion emerged from the huge vacuum degeneracy of Kähler and also involves non-determinism. The twistor lift of TGD introduces to the action a volume term having interpretation in terms of length scale dependent cosmological constant. The cosmological constant can be arbitrarily small so that the idealization of action as Kähler action might be a good approximation in long scales. The non-determinism might reflect the finite non-determinism associated with the space-time surfaces as minimal surfaces, analogous to Bohr orbits for particles identified as 3-surfaces. Second chapter is about what the phrase bio-systems as conscious holograms could mean.

2. The second part of the book is devoted to water memory- Obviously, a connection between these two suggests itself. A discovery - certainly one of the greatest surprises of my professional life - popped up as an outcome of an attempt to understand the mechanism behind water memory for which rather strong support exists now. The idea was that dark nuclei which sizes zoomed up to atomic size scale could provide a representation of genes with dark nucleons consisting of three quarks representing DNA codons. It turned out that the model for dark nucleon consisting of three quarks predicts counterparts of 64 DNAs, 64 RNAs, and 20 amino-acids and allows to identify vertebrate genetic code as a natural mapping of DNA type states to amino-acid type states. The population of dark nuclei would be new life-form possibly responsible for the water memory.

The first chapter is about water memory and somewhat provocatively titled Homeopathy in many-sheeted space-time. Second chapter added rather recently is about cancer as disease of magnetic body. There are two chapters about metabolism and macroscopic quantum coherence and the last chapter is about remote metabolism providing in zero energy ontology a new mechanism of metabolism.

3. The third part of the book is devoted to metabolism. The chapter about metabolism represents a possible model of metabolism based on the identification of universal metabolic energy quanta as increments of zero point kinetic energies emitted or absorbed as particles are transferred between space-time time sheets characterized by different p-adic primes. This model is only one of the many alternatives and very probably out-of date. The basic assumption is however correct: what is required is a system analogous to a laser with population reversal

receiving negative energy signals and dropping to a lower energy state. Remote metabolism is achieved by sending negative energy signals to this kind of system.

The picture discussed in this chapter is in several respect out-of-date but I have included it because it gives a view of how the ideas have developed.

During last 15 years a real understanding of metabolism in terms of zero energy ontology (ZEO) based theory of consciousness and hierarchy of Planck constants  $h_{eff} = n \times h_0$  has emerged. The chapters of this book were written for the first time about two decades and fail to fully reflect this progress.

## 2.2 Organization of “Bio-Systems as Conscious Holograms”

### 3 Sources

The eight online books about TGD [K25, K24, K17, K12, K4, K11, K6, K20] and nine online books about TGD inspired theory of consciousness and quantum biology [K22, K3, K13, K2, K5, K7, K8, K19, K21] are warmly recommended for the reader willing to get overall view about what is involved.

My homepage (<http://tinyurl.com/ybv8dt4n>) contains a lot of material about TGD. In particular, a TGD glossary at <http://tinyurl.com/yd6jf3o7>.

I have published articles about TGD and its applications to consciousness and living matter in *Journal of Non-Locality* (<http://tinyurl.com/ycyrxj4o> founded by Lian Sidorov and in *Prespacetime Journal* (<http://tinyurl.com/ycvktjhn>), *Journal of Consciousness Research and Exploration* (<http://tinyurl.com/yba4f672>), and *DNA Decipher Journal* (<http://tinyurl.com/y9z52khg>), all of them founded by Huping Hu. One can find the list about the articles published at <http://tinyurl.com/ybv8dt4n>. I am grateful for these far-sighted people for providing a communication channel, whose importance one cannot overestimate.

## 3.1 PART I: BIO-SYSTEMS AS CONSCIOUS HOLOGRAMS

### 3.1.1 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 (“massless extremals”, MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

The internal lines of generalized 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 generalized 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 would be full of this kind 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.

ZEO predicts that vacuum functional is maximum for preferred pairs of 3-surfaces located at opposite boundaries of causal diamond (CD). Hence self-organization by quantum jump sequences leads to preferred geometro-temporal patterns rather than asymptotic 3-D patterns. In biology these temporal patterns dominate and it is very difficult to understand this in standard ontology: morphogenesis is basic example of this.

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.

### 3.1.2 Macro-Temporal Quantum Coherence and Spin Glass Degeneracy

The basic objection against quantum consciousness theories is that the de-coherence times for macroscopic quantum states are quite too short. This argument has been put in quantitative form by Mark Tegmark.

These counter arguments are however problematic. First of all, the notions of quantum coherence and de-coherence are problematic in standard physics framework since the non-determinism of the state function reduction is in conflict with the determinism of Schrödinger equation. The intuitive idea is however that one can estimate the de-coherence times as essentially lifetimes of quantum states. Secondly, the estimates for de-coherence times are based on standard physics, and it is quite possible that new physics is essential for understanding living matter. The belief that standard physics is enough is based only on the reductionistic dogma.

Penrose and Hameroff have proposed that some future theory of quantum gravitation makes it possible to replace the phenomenological notion of state function reduction with a more fundamental notion which they call Orch OR, that quantum gravitational effects make possible macroscopic quantum states of required long de-coherence time, and that micro-tubules are the systems, where these effects are especially important so that one might even speak about reduction of the consciousness to the micro-tubular level. Penrose and Hameroff have also proposed that micro-tubules could act as quantum computers. The quantum states involved would be quantum superpositions of tubulin conformations and quantum gravitation would somehow make these quantum superpositions stable. Long enduring quantum superpositions of the conformations of (say tubulin) molecules would allow to perform a multi-verse simulation for the conformational behaviour of the molecules and this would certainly have evolutionary value.

1. *Macrotemporal quantum coherence is suggested by quantum classical correspondence*

TGD inspired theory of consciousness leads to a first principle theory of state function reduction and preparation 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. By quantum-classical correspondence the argument can be formulated at space-time level and configuration space (world of classical worlds (WCW)) level. An especially relevant notion is negentropic entanglement which from the consistency with ordinary quantum measurement theory is described by density matrix proportional to unit matrix. In quantum computation entanglement matrix proportional to a unitary matrix gives rise to negentropic entanglement and by NMP this entanglement is stable against state function reduction by Negentropy Maximization Principle (NMP).

At embedding space level causal diamonds (CDs) define the correlates for coherence regions. At the space-time level coherence regions are identifiable as space-time sheets. They indeed are coherence regions for both classical fields and induced spinor fields defining single particle limit of the quantum theory. By quantum criticality of TGD Universe there is no upper bound for neither the spatial or temporal size of the space-time sheet and one obtains a p-adic hierarchy of coherence lengths and de-coherence times. Finiteness of de-coherence time corresponds to the fact that energy flows to the space-time sheet from larger space-time sheet first and then back. Note that in the standard quantum field theory the entire Minkowski space  $M^4$  is the natural identification for the coherence region, and it is difficult to understand how to describe the reduction to a smaller region of  $M^4$ .

2. *Macrotemporal quantum coherence from spin glass degeneracy?*

At WCW level the argument supporting macroscopic and macrotemporal quantum coherence goes as follows. 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. The intuitive expectation is 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.

One can formulate this argument more rigorously using unitarity conditions implying that forward scattering amplitude for bound states is very large due to the spin glass degeneracy. The almost degenerate spin glass states differ only by their classical gravitational energy so that gravitation is indeed important. The importance of quantum gravitation is also obvious from the fact that genuine quantum gravitational states are state functionals in the world of worlds rather than in world so that they are expected to represent in some sense higher abstraction level than ordinary quantum states in the hierarchy of consciousness.

3. *Hierarchy of Planck constants and dark matter hierarchy*

The non-determinism of Kähler action and ensuing quantum criticality strongly suggests a dark matter hierarchy with levels labelled by values of (effective) Planck constant  $h_{eff} = n \times h$ . The implications are non-trivial already at the level of hadron physics and nuclear physics and imply that condensed matter physics and nuclear physics are not completely disjoint disciplines as reductionism teaches us. One condensed matter application is a model of high  $T_c$  superconductivity predicting that the basic length scales of cell membrane and cell as scales are inherent to high  $T_c$  superconductors.

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. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma. A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerge.

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 the fact that both follow from the non-determinism of Kähler action and relate closely to quantum criticality.

### 3.1.3 Spin Glasses, Complexity, and TGD

Spin glasses represent an exotic phenomenon, which remains poorly understood in the standard theoretical framework of condensed matter physics. Actually, spin glasses provide a prototype of complex systems and methods used for spin glasses can be applied in widely different complex systems.

In this chapter a TGD inspired view about spin glasses is discussed.

1. TGD view about space-time leads to the notion of magnetic flux tubes and magnetic body. Besides spins also long closed magnetic flux tubes would contribute to magnetization. The basic support for this assumption is the observation that the sum of the NFC magnetization and the FC remanence is equal to the NFC magnetization. Magnetic field assignable to spin glass would correspond to a kind of flux tube spaghetti and the couplings  $J_{ij}$  between spins would relate to magnetic flux tubes connecting them.
2. Quantum TGD leads to the notion of "world of classical worlds" (WCW) and to the view about quantum theory as a "complex square root" of thermodynamics (of partition function). The probability distribution for  $\{J_{ij}\}$  would correspond to ground state functional in the space of space-time surfaces analogous to Bohr orbits.
3. Spin glass is a prototype of a complex system. In the TGD framework, the complexity reduces to adelic physics fusing real physics with various p-adic physics serving as correlates of cognition. Space-time surfaces in  $H = M^4 \times CP_2$  correspond to images of 4-surfaces  $X^4 \subset M_c^8$  mapped to  $H$  by  $M^8 - H$  duality.  $X^4$  is identified as 4-surface having as holographic boundaries 3-D mass shells for which the mass squared values are roots of an octonionic polynomial  $P$  obtained as an algebraic continuation of a real polynomial with rational coefficients. The higher the degree of  $P$ , the larger the dimension of the extension of rationals induced by its roots, and the higher the complexity: this gives rise to an evolutionary hierarchy. The dimension of the extension is identifiable as an effective Planck constant so that high complexity involves a long quantum coherence scale.  
TGD Universe can be quantum critical in all scales, and the assumption that the spin glass transition is quantum critical, explains the temperature dependence of NFC magnetization in terms of long range large  $h_{eff}$  quantum fluctuations and quantum coherence at critical temperature.
4. Zero energy ontology predicts that there are two kinds of state function reductions (SFRs). "Small" SFR would be preceded by a unitary time evolution which is scaling and generated by the scaling generator  $L_0$ . This conforms with the fact that relaxation rates for magnetization obey power law rather than exponent law. "Big" SFRs would correspond to ordinary SFRs and would change the arrow of time. This could explain aging, rejuvenation and memory effects.
5. Adelic physics leads to a proposal that makes it possible to get rid of the replica trick by replacing thermodynamics with p-adic thermodynamics for the scaling operator  $L_0$  representing energy. What makes p-adic thermodynamics so powerful is the extremely rapid converges of  $Z$  in powers of p-adic prime  $p$ .

## 3.2 PART II: WATER MEMORY

### 3.2.1 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, and scaling laws

Frequency imprinting and entrainment at preferred frequencies are believed to be fundamental for homeopathy and acupuncture.

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.

The hierarchy of Planck constants explains this scaling law and generalizes it. The two frequencies correspond to  $f_l$  associated with dark photon with  $h_{eff} = n \times h$  and to  $f_h$  associated with ordinary photon giving  $f_h/f_l = n$ . Bio-photons would result in energy conserving decays of dark photons to ordinary photons.

### 2. Basic inputs from TGD

The model for DNA baryon leads to the proposal 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 amino-acids 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.

The findings of Pollack about exclusion zones and fourth phase of water provide additional ideas. In TGD framework exclusion zones would correspond to dark  $H_{3/2}O$  phase of water with every fourth hydrogen atom or proton taken to the dark flux tubes. This makes the exclusion zone negatively charged. The magnetic body of this kind of region would define fundamental representation of the magnetic body of the invader molecule. Not only cyclotron frequencies, but possibly also braiding would be represented, even 2- braiding involving reconnections. This leads to the idea that exclusion zones are primitive life forms having magnetic body containing dark matter. Most importantly, are representation of genetic code in terms of dark proton sequences would be realized at the flux tubes of the magnetic body.

### 3. How immune system might have evolved?

Organism or prebiotic life form living in water must recognize the invader molecule and here reconnection of the flux tubes of magnetic bodies is here the key mechanism: it would provide basic mechanism of attention and recognition. This requires that the strength of magnetic fields at flux tubes are same and organism could vary it by varying the thickness of the flux tube carrying monopole flux. This would also involve cyclotron resonance taking place simultaneously. If dark ELF photons are involved the cyclotron resonances can have energies visible and UV range characterizing bio-photons. This energy range corresponds also to excitation energies of various bio-molecules.

A further element comes from the observation that dark proton sequences could give rise to dark DNA. These sequences would reside at the flux tubes of the magnetic body associated with the exclusion zone. They would define dark variants of proteins and amino-acids. The key idea is that dark variants of amino-acid sequences would have coded not only for the braiding of the magnetic body of the invader but also for the 2-braiding (temporal development of braiding) of the magnetic flux tube patterns defining invader molecule as a dynamical process: dark proteins would mimic physically the braiding of invader molecule's magnetic body.

Dark DNA sequences would have coded this braiding symbolically and their translation to dark amino-acids would transform symbolic representation to a concrete physical one. The emergence of ordinary DNA and amino-acids would have realized the same at biochemical level and amino-acid sequences representing the invader would serve as antigens attaching to the invader molecule. Not only the pattern produced in protein folding but also the temporal pattern of protein folding would be coded by DNA.

### 4. 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. This brings strongly in mind the functioning of immune system: when the organism is exposed to the substance causing the health problem, immune system develops resistance. Maybe something similar happens in homeopathy in the sense that the homeopathic remedy representing the substance induces resistance. A representation carrying information about the biologically important aspects of the substance would be therefore needed.

This suggests that the manufacturing of the homeopathic remedy generates replicating primitive life forms analogous to the exclusion zones. The repeated mechanical agitation could feed to the system metabolic energy and induce the formation of new exclusion zone like regions mimicking the magnetic body original invader molecule or the already existing representations of it. Even quantal evolution at the level of dark DNA could take place. The final outcome would be population of primitive life forms representing the invader. This representation would in turn induce generation of immune response.

### 3.2.2 TGD view about water memory and the notion of morphogenetic field

Besides general problems, which might be regarded as philosophical, the anomalies of the physicalistic world view have served as the source of inspiration. Several poorly understood phenomena have played a central role in the "Poirot-like" process leading to the development of TGD based views about quantum biology. Mention only the effects of ELF em fields on vertebrate brain, biophotons, water memory, Pollack effect, and Comorosan effect. The notion of syntropy by Fantappie, which challenges the belief that the arrow of time is not always the same in living systems, has been also inspiring.

In this article I will discuss the TGD based vision and the above listed phenomena, which are often forgotten. I will also compare the TGD based view with the proposed interpretation of morphogenetic field as em field generated by DNA and realizing genetic code discussed in the articles of Savelev et al, and compare it with the TGD based models of genetic code realized in terms of dark nucleons and dark photons. The findings described in these articles and in the articles of Yolene Thomas about water memory also provide new tests for the TGD based view. As always, this kind of process led to some new ideas and insights.

### 3.2.3 Could cancer be a disease of magnetic body?

Li and Heroux have made a highly interesting discovery. The treatment of cancer cell population by 60 Hz oscillating magnetic field with extremely small strength above 25 nT leads to a reduction of the abnormally large chromosome number of the mitochondria of cancer cells and eventually the cancer cells return to the normal state.

TGD based explanation for the findings relies on the basic notions of TGD inspired quantum biology. The basic notions are magnetic body (MB) and hierarchy of Planck constants  $h_{eff} = n \times h_0$  ( $h = 6h_0$ ) emerging from the adelic physics as a prediction but originally proposed on basis of anomalous effects of ELF em fields in living matter. The value of  $n$  can be relatively small or very large corresponding to flux tubes mediating em and gravitational interactions. The anatomy of MB has remained unclear hitherto but in this article a detailed model is developed allowing to understand the formula  $h_{gr} = h_{eff} = n_{gr}h_0$  for gravitational Planck constant and leading to a further formula for  $h_{gr}$  relating magnetism and gravitation.

A further central notion is TGD based model for water memory as the ability of the MB of water to control the thickness of its flux tubes to entrain with external frequencies and reproduce them. This is a central element in the TGD based view about immune systems and homeopathic effects. Cancer would reduce to a disease of the MB of the system, to a high degree determined by MB of water and homeopathy like treatment based on irradiated water could serve as a cure.

The model is applied both to the findings of Montagnier's group about remote regeneration of DNA without template and to those of Li and Heroux. Also the dramatic effects of 2 Tesla magnetic fields on mice reported by Walter Rawls Jr are discussed.



### 3.3 PART III: METABOLISM

#### 3.3.1 Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I

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 could 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 new vision about me relies on several new ideas that have emerged during years after writing the first draft of this chapter.

1. There are three different views about macroscopic quantum phases. As large  $\hbar$  phases with scaled up quantum lengths, as high  $T_c$  superconductor like systems, and as negentropically entangled structures (negentropic entanglement is purely TGD based notion and stabilized by Negentropy Maximization Principle). In this chapter arguments supporting the equivalence of these descriptions are developed.
2. The valence electron pairs with spin 1 instead of spin 0 emerge as natural candidates for the counterparts of Cooper pairs generating negentropic entanglement in long length scales. Spin 1 valence electron pairs would generate the magnetic flux tubes along which they propagate and this web of flux tubes would bind proteins to larger structures. The role of the phase transitions changing the value of Planck constant in quantum biology has been discussed already earlier. The fact that bio-molecules - in particular sugars and phosphate molecules - tend to maximize the number of covalent bonds supports this view.
3. The completely accidental observation that dark nucleon states corresponds under rather natural assumptions to DNA, RNA, tRNA, and amino-acid states and that vertebrate genetic code emerges under natural assumptions, leads to the idea that the dark nuclear physics realization of the genetic machinery is its primary realization and that chemical realization is secondary realization. This suggest that dark nuclei identified as nuclear strings of dark protons serve as templates for DNA, RNA, and amino-acids.
4. This leads to the vision that the basic purpose of metabolic energy is to make possible re-distribution of negentropic entanglement between distant bio-molecules using the reconnection of the magnetic flux tubes generated by spin 1 electron pairs as a control tool. In photosynthesis the incoming photons would suffer a phase transition to dark photons before being absorbed

by dark electrons and eventually provide their energy to ATP to be used to re-organize ne-gentropic entanglement assignable to the magnetic flux tubes going via ATP molecule. This picture is inspired also by the vision about DNA as topological quantum computer and leads to a more plausible view about how genetic code is realized.

### *3. Many-sheeted photo-synthesis*

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting simple model of photosynthesis is successful both at qualitative and quantitative level.

I have included in this chapter the earlier variant of the quantum model developed before 2007 as such to compare it with the recent view about macroscopic quantum aspects of photosynthesis involving several new ideas. Note that year 2007 is special in the sense that during 2007 the first evidence for the quantal nature of photosynthesis emerged.

### **3.3.2 Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II**

This chapter is second part of the bi-chapter devoted to various aspects of metabolism. The basic topics is TGD inspired view about brain metabolism and molecular motors. I have included to the end of the chapter some rather weird sounding ideas such as an explanation of super-luminality in terms of remote metabolism.

#### *1. Dark matter hierarchy, sensory representations, motor action, and metabolism*

The vision about a hierarchy of generalized EEGs associated with dark matter hierarchy gave a decisive boost leading to 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.

#### *2. Holy trinity of red blood cells, neurons, and astrocytes*

The vision about dark matter hierarchy and various ideas about quantum metabolism allow to develop a general view about how the sensory representations and motor control are realized in terms of MEs. Time mirror mechanism is 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 under-

stood that quantum jump involves also state function preparation process realized as a cascade of self measurements against which only bound state entanglement is stable.

For a long time glial cells were believed to play a rather passive role in the functioning of brain taking care of basic services such as providing metabolic energy and serving as supporting structures for neurons. During the recent years the views about the role of glia have however changed dramatically. In TGD framework the very fact that metabolism relates very closely to the re-organization of negentropic entanglement forces to recheck this view. Also the slowness of glial dynamics as compared to neuronal dynamics suggests that large values of Planck constant responsible for long time time scales and therefore also for the highest levels of consciousness (including functions like long term memory) are assignable to glia.

### 3. *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.

### 4. *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. A possible model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. This idea belongs to the class of ideas which look like curiosity after decade.

I have included to the end of the chapter also other miscellaneous topics such as an old proposal for the possible role of four-wave interactions in the construction of conscious holograms.

### 3.3.3 About Concrete Realization of Remote Metabolism

The idea of “remote metabolism” (or quantum credit card, as I have also called it) emerged more than a decade ago - and zero energy ontology (ZEO) provides the justification for it. The idea is that the system needing energy sends negative energy to a system able to receive the negative energy and make a transition to a lower energy state. This kind of mechanism would be ideal for biology, where rapid reactions to a changing environment are essential for survival. Originally this article was intended to summarize a more detailed model of remote metabolism but the article expanded to a considerably more detailed view about TGD inspired biology than the earlier vision.

It is shown that the basic notions of the theory of Ling about cell metabolism inspired by various anomalies have natural counterparts in TGD based model relying on the notion of magnetic body. Remote metabolism can be considered as a universal metabolic mechanism with magnetic body of ATP, or system containing it, carrying the metabolic energy required by the biological user. In particular, the role of ATP is discussed in Ling’s theory and from the point of view of TGD-inspired theory of consciousness.

It is easy to imagine new technologies relying on negative energy signals propagating to the geometric past and ZEO justifies these speculations. Remote metabolism could make possible a new kind of energy technology. The discoveries of Tesla made more than a century ago plus various free energy anomalies provide excellent material for developing these ideas, and one ends up with a concrete proposal for how dark photons and dark matter could be produced in capacitor-like

systems analogous to cell membranes and acting as Josephson junctions and how energy could be extracted from “large” magnetic bodies.

The model identifies Josephson frequency with the subharmonic of the frequency characterizing the periodicity of a periodic voltage perturbation assumed to correspond to cyclotron frequency in biological applications. Together with quantization conditions for charge and effective Planck constant it leads to precise quantitative predictions for capacitor-like systems acting as dark capacitors. Also a relationship between the magnetic field at the magnetic body of the system and the voltage of the capacitor-like Josephson junction emerges.

The predictions allow new quantitative insights about biological evolution as emergence of Josephson junctions realized as capacitor-like systems both at the level of cell, DNA and proteins, and brain.  $h_{eff}$  can be related to Josephson frequency and cyclotron frequency and thus to measurable parameters.  $h_{eff}$  serves as a kind of intelligence quotient and its maximization requires the maximization of both the voltage and area of the membrane-like capacitor system involved. This is what has happened during evolution. Indeed, the internal cell membranes, cortical layers and DNA double strand in chromosomes are strongly folded, and the value of membrane electric field is roughly twice the value of the electric field for which dielectric breakdown occurs in air. Even 40 Hz thalamocortical resonance frequency can be understood in the framework of the model.

The claimed properties of Tesla’s “cold electricity” strongly suggest interpretation in terms of dark matter in TGD sense. This leads to a proposal that a transition to dark phase occurs when the value of voltage equals the rest mass of charged particle involved. This criterion generalizes to the case of cell membrane and relates the values of  $h_{eff}$ , p-adic prime  $p$ , and threshold potential for various charged particles to each other. The idea that nerve pulse corresponds to the breakdown of super-conductivity as a transition from dark to ordinary phase receives additional support. The resulting picture conforms surprisingly well with the earlier speculations involving dark matter and p-adically scaled variants of weak and color interactions in biologically relevant length scales. An extremely simple mechanism producing ATP involving only the kicking of two protonic Cooper pairs through the cell membrane by Josephson photon as a basic step is proposed. Also the proposal that neutrino Cooper pairs could be highly relevant not only for cognition and but also metabolism finds support.

### 3.3.4 Quantum gravitation and quantum biology in TGD Universe

The finding of Manu Prakash et al that animals without a nervous system behave as if they had it, is a challenge for standard biology. Similar challenges are posed by the observation that organisms without a nervous system, even plants and bacteria, have senses and purposeful motor actions, and are also able to learn. This finding led to a considerably progress in the understanding of TGD inspired quantum biology.

The TGD based view about cell and neuronal membrane, nerve pulse and EEG assumes pre-neural level which is quantal. In this view, cell membranes act as Josephson junctions and communicate sensory input to the magnetic body (MB) of the system as dark Josephson radiation. MB in turn controls the cell by dark cyclotron radiation produced as pulses as MB receives frequency modulated Josephson radiation resonantly.

Gravitational MB of Earth, which consists of very long loop-like flux tubes with gravitational Planck constant introduced by Nottale explains the findings of Blackman and others, is of special interest and assumed to play a key role in metabolism. Gravitationally dark protons would be associated with very long gravitationally dark hydrogen bonds (HBs) so that hydrogen is effectively negatively ionized. Gravitationally dark electrons or their Cooper pairs would in turn accompany gravitationally dark valence bonds connecting metal atoms or their Cooper pairs with molecules of opposite valence (hydrogen peroxide  $H_2O_2$ ). Also the metal atom is effectively ionized. This provides a more accurate view of dark metal ions assumed to play a central role in the TGD inspired quantum biology.

A correct order of magnitude estimate for the upper bound metabolic energy quantum as the energy liberated as a dark proton hydrogen bond becomes ordinary is obtained. A more precise model predicts correctly the nominal value of metabolic energy quantum for proton triplets which appear also in the generation of ATP. For triplets of electron Cooper pairs, the same mechanism predicts an upper bound of the electronic metabolic energy quantum, which corresponds to the so-called miniature potential. This raises the question whether the letters of genetic code could be

realized by the 4 states of electron Cooper pairs and whether the Posner molecule could realize it.

Also the gravitational MB of Sun could be involved and the prediction is that the energy range for the metabolic energy quanta corresponds to the range of visible energies so that photosynthesis could use photon energy to kick dark protons and dark electrons to the gravitational MBs of Earth and Sun to serve as metabolic energy storage.

Electronic metabolism would solve the problem due the lack of ATP machinery inside cilium and near it. This picture leads to a rather detailed model of the role of phosphate in metabolism and also to a detailed model for the pairing of DNA and dark DNA (DDNA) and forces to modify the earlier model somewhat. The quantum gravitational view about metabolism leads also to modifications of the views about nerve pulses: in particular, of the role of biologically important metal ions identified as dark ions.

Cilium can be interpreted as a predecessor of the axonal membrane and the pre-nerve pulses are predicted to be equal to miniature potentials and the reported 'spikes' as analogs of nerve pulses are assigned with de-adhesion of cilium from its neighbor or the surfaces at which the animal moves. The 'spikes' correspond to at least 100 miniature potentials just as real spikes do.

Cilium is modeled as a 2-D quantum gravitational pendulum with gravitational Planck constant controlled by MB using electronic metabolic energy quanta and the resulting model for the motion is in many respects similar to the model of nerve pulse.

Miniature spikes could appear also in plants. For the recently observed spike sequences in fungi, the voltage spike has an amplitude whose order of magnitude is consistent with the electronic metabolic energy quantum.

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