Introduction to ”TGD View about Living Matter and Remote Mental Interactions”

M. Pitkänen,
June 19, 2019
Email: matpitka6@gmail.com.
http://tgdtheory.com/public_html/
Recent postal address: Rinnekatu 2-4 A 8, 03620, Karkkila, Finland.

Contents

1 Basic Ideas Of Topological Geometrodynamics (TGD) 4
  1.1 Basic Vision Very Briefly ................................................. 4
  1.2 Two Visions About TGD And Their Fusion ......................... 7
    1.2.1 TGD as a Poincare invariant theory of gravitation ........... 7
    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 .................................. 8
  1.3 Basic Objections ................................................................. 9
  1.3.1 Topological field quantization ........................................ 9
  1.4 P-Adic Variants Of Space-Time Surfaces ............................. 9
  1.5 The Threads In The Development Of Quantum TGD ................. 10
    1.5.1 Quantum TGD as spinor geometry of World of Classical Worlds 10
    1.5.2 TGD as a generalized number theory ........................... 13
  1.6 Hierarchy Of Planck Constants And Dark Matter Hierarchy .... 17
    1.6.1 Dark matter as large ℏ phases .................................. 17
    1.6.2 Hierarchy of Planck constants from the anomalies of neuroscience and biology .................................. 17
    1.6.3 Does the hierarchy of Planck constants reduce to the vacuum degeneracy of Kähler action? .................. 18
    1.6.4 Dark matter as a source of long ranged weak and color fields .... 19
  1.7 Twistors in TGD and connection with Veneziano duality .......... 19
    1.7.1 Twistor lift at space-time level ................................ 19
    1.7.2 Twistor lift at the level of scattering amplitudes and connection with Veneziano duality .................. 20
2 TGD As A Generalization Of Physics To A Theory Consciousness 23
2.1 Quantum Jump As A Moment Of Consciousness 23
2.2 Negentropy Maximization Principle (NMP) 25
2.3 The Notion Of Self 25
2.4 Relationship To Quantum Measurement Theory 26
2.5 SELves Self-Organize 27
2.6 Classical Non-Determinism Of Kähler Action 28
2.7 P-Adic Physics As Physics Of Cognition 28
2.8 P-Adic And Dark Matter Hierarchies And Hierarchy Of SELves 29

3 Quantum Biology And Quantum Neuroscience In TGD Universe 30
3.1 Basic Physical Ideas 30
3.2 Brain In TGD Universe 32
3.3 Anomalies 33

4 Motivations for “TGD Based View About Living Matter and Remote Mental Interactions” 33
4.1 Topics of “TGD Based View About Living Matter and Remote Mental Interactions” 34

5 Sources 34

6 The contents of the book 35
6.1 PART I: TGD INSPIRED THEORY OF CONSCIOUSNESS 35
6.1.1 Topological Geometrodynamics: Basic Visions 35
6.1.2 Quantum Mind in TGD Universe 35
6.1.3 Life and Death and Consciousness 36
6.1.4 Comparison of TGD Inspired Theory of Consciousness with Some Other Theories of Consciousness 36
6.1.5 TGD Inspired Comments about Integrated Information Theory of Consciousness 37
6.2 PART II: QUANTUM BIOLOGY IN TGD UNIVERSE 38
6.2.1 Quantum Mind, Magnetic Body, and Biological Body 38
6.2.2 Are dark photons behind biophotons? 38
6.2.3 Dark photons from transitions of dark valence electrons as origin of biophotons, and their interaction with carcinogens 40
6.2.4 About concrete realization of remote metabolism 40
6.2.5 Can quantum biology really do without new physics? 41
6.2.6 The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis? 41
6.2.7 Life-like properties observed in a very simple systems 42
6.2.8 Dance of the honeybee and new physics 43
6.3 PART III: QUANTUM NEUROSCIENCE IN TGD UNIVERSE 43
6.3.1 Quantum Mind and Neuro Science 43
6.3.2 Comments about the recent experiments by the group of Michael Persinger 44
6.3.3 Emotions as sensory percepts about the state of magnetic body? 44
6.3.4 Dark valence electrons and color vision 45
6.3.5 Geometric Theory of Bio-harmony 46
6.3.6 An Overall View about Models of Genetic Code and Bio-harmony 47

7 Introduction 47
7.1 3 basic realizations of the genetic code 47
7.2 3 models of bioharmony 48
7.3 About the geometric interpretation of icosahedral and other symmetries 49
7.4 Mistracks 50

8 Interactions between various levels 50
8.1 The independence of the interaction energy on frequency 51
8.2 The independence of cyclotron energy on frequency and Nottale hypothesis 52
CONTENTS

9 Homonymy of the genetic code

9.1 Variations of the genetic code ........................................ 53
9.2 Wobble base pairing ..................................................... 53

10 TGD view about homonymies

10.1 Homonymies for DRNA-3-chord correspondence ..................... 54
10.2 The map DRNA-DtRNA by 3-chords .................................. 56
10.3 Homonymies for RNA-AA correspondence ............................ 56
10.4 Homonymies for RNA-tRNA correspondence .......................... 57

11 Appendix: Tables of basic 3-chords for the icosahedral harmonies with symme-
tries .................................................................................. 58

11.0.1 Artificial Intelligence, Natural Intelligence, and TGD ................. 59

11.1 PART IV: REMOTE MENTAL INTERACTIONS ...................... 60

11.1.1 TGD inspired view about remote mental interactions and paranormal .. 60
11.1.2 How to test TGD based vision about living matter and remote mental inter-
actions? ............................................................................. 60
11.1.3 Hypnosis as remote mental interaction ............................. 60
11.1.4 Meditation, Mind-Body Medicine and Placebo: TGD point of view .... 61
11.1.5 Non-locality in quantum theory, in biology and neuroscience, and in remote 
mental interactions: TGD perspective .................................. 61
11.1.6 Questions about IIT ..................................................... 61
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 37 years ago - would emerge now it would be seen as an attempt trying to solve the difficulties of these approaches to unification.

The basic physical picture behind 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.

1.1 Basic Vision Very Briefly

T(opological) G(еometro)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 imbedding 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 imbedding space metric and parallel translation using spinor connection of imbedding space.

The induction procedure applies to octonionic structure and the conjecture is that for preferred extremals the induced octonionic structure is quaternionic: again one just projects the octonion units. I have proposed that one can lift space-time surfaces in $H$ to 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]. Now the twistor structure would be induced in some sense, and should co-incide 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 space-time surface. This poses constraint on the imbedding of the twistor space of space-time surfaces as sub-manifold in the Cartesian product of twistor spaces.

3. 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 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...
1.1 Basic Vision Very Briefly

A huge extension of 2-D conformal symmetries. Imbedding space $H$ has a number theoretic interpretation as 8-D space allowing octonionic tangent space structure. $M^4$ and $CP_2$ allow quaternionic structures. Therefore standard model symmetries have number theoretic meaning.

4. Induced gauge potentials are expressible in terms of imbedding 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. Particle in space-time can be identified as a topological inhomogenuity 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 distance 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 standard model and general relativity follow as a topological simplification however forcing to increase dramatically 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. A possible resolution of problem is implied by the condition that the modes of the induced spinor fields have well-defined electromagnetic charge. This forces their localization to 2-D string world sheets in the generic case having vanishing weak gauge fields so that parity breaking effects emerge just as they do in standard model. Also string model like picture emerges from TGD and one ends up with a rather concrete view about generalized Feynman diagrammatics. A possible objection is that the Kähler-Dirac gamma matrices do not define an integrable distribution of 2-planes defining string world sheet.

An even strong condition would be that the induced classical gauge fields at string world sheet vanish: this condition is allowed by the topological description of particles. The $CP_2$ projection of string world sheet would be 1-dimensional. Also the number theoretical condition that octonionic and ordinary spinor structures are equivalent guaranteeing that fermionic dynamics is associative leads to the vanishing of induced gauge fields.

The natural action would be given by string world sheet area, which is present only in the space-time regions with Minkowskian signature. Gravitational constant would be present as a fundamental constant in string action and the ratio $h/G/R^2$ would be determined by quantum criticality condition. The hierarchy of Planck constants $h_{eff}/h = n$ 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 $T = 1/h_{eff}G$ 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 super string 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 also induced spinor fields associated with Kähler-Dirac action and de-localized inside 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 imbeddings: 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 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 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 serve as 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] [?, ?, ?]), 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 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 imbedding 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
1.2 Two Visions About TGD And Their Fusion

As already mentioned, TGD 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. The identification of the space-time as a sub-manifold of $H$ 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. 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 possibly existence vapour phase.

What one obtains is what I have christened as many-sheeted space-time (see Fig. [http://tgdtheory.fi/appfigures/manysheeted.jpg](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 system does not possess this kind of field identity. The notion of magnetic body is one of the key players in TGD inspired theory of consciousness and quantum biology.

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. 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.
1.3 Basic Objections

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 is as light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian and interpreted as lines of generalized Feynman diagrams. Also the Euclidian 4-D regions would have 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 Kahler action. In finite length scale resolution these effects can be neglected below UV cutoff and above IR cutoff. One can also speak about strong form of holography.

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 imbedding 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. Particle topologically condenses to several space-time sheets simultaneously and experiences 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 imbeddability to 8-D imbedding space. One can also argue that Poincare invariant theory of gravitation cannot be consistent with General Relativity. The above interpretation allows to understand the relationship to GRT space-time and how 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 metrices of space-time sheets from Minkowski metric. Poincare invariance suggests strongly classical EP for the GRT limit in long length scales at least. One can consider also 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 very large cosmological constant in Einstein-Maxwell theory. Also gauge potentials of 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 thins this leads to models for cell membrane, nerve pulse, and EEG.

1.4 P-Adic Variants Of Space-Time Surfaces

There is a further generalization of the space-time concept inspired by p-adic physics forcing a generalization of the number concept through the fusion of real numbers and various p-adic number fields. One might say that TGD space-time is adelic. Also the hierarchy of Planck constants forces
1.5 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.

The theoretical framework involves several threads.

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 extremely 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 four.

TGD forces the generalization of physics to a quantum theory of consciousness, and represent TGD as a generalized number theory vision leads naturally to the emergence of p-adic physics as physics of cognitive representations. The eight online books [K27, K18, K11, K33, K23, K32, K31, K22] about TGD and nine online books about TGD inspired theory of consciousness and of quantum biology [K26, K3, K15, K21, K7, K8, K10, K21, K30] are warmly recommended to the interested reader.
1.5 The Threads In The Development Of Quantum TGD

1.5.1 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. Quantum theory for extended particles is free(!), classical(!) field theory for a generalized Schrödinger amplitude 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. Particle reactions are identified as topology changes [A8, A11, A12]. 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.

2. During years this naive 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 Euclidean space-time regions and the strong form of General Coordinate Invariance has led to a rather detailed and in many respects unexpected 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!

3. WCW is endowed with metric and spinor structure so that one can define various metric related differential operators, say Dirac operator, appearing in the field equations of the theory $^1$

4. WCW Dirac operator appearing in Super-Virasoro conditions, imbedding space Dirac operator whose modes define the ground states of Super-Virasoro representations, Kähler-Dirac operator at space-time surfaces, and the algebraic variant of $M^4$ Dirac operator appearing in propagators. The most ambitious dream is that zero energy states correspond to a complete solution basis for the Dirac operator of WCW so that this classical free field theory would dictate $M$-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. Given $M$-matrix in turn would decompose to a product of a hermitian square root of density matrix and unitary $S$-matrix.

$M$-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 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 algebra acting as symmetries of the $S$-matrix. Therefore quantum TGD would reduce to group theory in well-defined sense.

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.

---

$^1$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 Kähler action for Euclidian space-time regions 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 Kähler Dirac action in Minkowskian space-time regions. These two possible definitions reflect a duality analogous to AdS/CFT duality.
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 [K28]. 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.

U-matrix elements between M-matrices for various CDs are proportional to the inner products \( \text{Tr}[S^{-n_1} \odot H^i H^j \odot S^{n_2} \lambda] \), 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. \( \odot \) tells that \( S \) acts at the active boundary of CD only. It turns out possible to construct a general representation for the U-matrix reducing its construction to that of S-matrix. S-matrix has interpretation as exponential of the Virasoro generator \( L_{-1} \) of the Virasoro algebra associated with super-symplectic algebra.

5. By quantum classical correspondence the construction of WCW spinor structure reduces to the second quantization of the induced spinor fields at space-time surface. The basic action is so called modified Dirac action (or Kähler-Dirac action) in which gamma matrices are replaced with the modified (Kähler-Dirac) gamma matrices defined as contractions of the canonical momentum currents with the embedding space gamma matrices. In this manner one achieves super-conformal symmetry and conservation of fermionic currents among other things and consistent Dirac equation. The Kähler-Dirac gamma matrices define as anti-commutators effective metric, which might provide geometrization for some basic observables of condensed matter physics. One might also talk about bosonic emergence in accordance with the prediction that the gauge bosons and graviton are expressible in terms of bound states of fermion and anti-fermion.

6. An important result relates to the notion of induced spinor connection. If one requires that 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 neutrino generating super-symmetries forms an exception. The vanishing of also \( Z_0 \) field is possible for Kähler-Dirac action and should hold true at least above weak length scales. This implies that 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 simplifies enormously the mathematics 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 at which 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 massless Dirac equation is satisfied by the nodes so that Kähler-Dirac action gives massless Dirac propagator localizable at the boundaries of the string world sheets.

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 $\sqrt{g}$ 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 manner 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 manner 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.

1.5.2 **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 hyper-counterparts of classical number fields identified as sub-spaces of complexified classical number fields with Minkowskian signature of the metric defined by the complexified inner product, and the notion of infinite prime.

1. **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 reduces 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 structures. 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 imbedding space and space-time concept and one can speak about real and p-adic space-time sheets. One can talk about adelic space-time, imbedding space, and WCW.

The notion of p-adic manifold [K34] identified as p-adic space-time surface solving p-adic analogs of field equations and having real space-time sheet as chart map provided a possible solution of the basic challenge of relating real and p-adic classical physics. One can also speak of real space-time surfaces having p-adic space-time surfaces as chart maps (cognitive maps, “thought bubbles”). Discretization required having interpretation in terms of finite measurement resolution is unavoidable in this approach and this leads to problems with symmetries: canonical identification does not commute with symmetries.

It is now clear that much more elegant approach based on abstraction exists [K36]. The map of real preferred extremals to p-adic ones is not induced from a local correspondence between points but is global. Discretization occurs only for the parameters characterizing string world sheets and partonic 2-surfaces so that they belong to some algebraic extension of rationals. Restriction to these 2-surfaces is possible by strong form of holography. 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 (imaginations) 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 \[K11\].

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.

2. The role of classical number fields

The vision about the physical role of the classical number fields relies on certain speculative questions inspired by the idea that space-time dynamics could be reduced to associativity or co-associativity condition. Associativity means here associativity of tangent spaces of space-time region and co-associativity associativity of normal spaces of space-time region.

1. Could space-time surfaces \(X^4\) be regarded as associative or co-associative (“quaternionic” is equivalent with “associative”) surfaces of \(H\) endowed with octonionic structure in the sense that tangent space of space-time surface would be associative (co-associative with normal space associative) sub-space of octonions at each point of \(X^4\) \[K25\]. This is certainly possible and an interesting conjecture is that the preferred extremals of Kähler action include associative and co-associative space-time regions.

2. Could the notion of compactification generalize to that of number theoretic compactification in the sense that one can map associative (co-associative) surfaces of \(M^8\) regarded as octonionic linear space to surfaces in \(M^4 \times CP_2\) \[K25\]? This conjecture - \(M^8 - H\) duality - would give for \(M^4 \times CP_2\) deep number theoretic meaning. \(CP_2\) would parametrize associative planes of octonion space containing fixed complex plane \(M^2 \subset M^8\) and \(CP_2\) point would thus characterize the tangent space of \(X^4 \subset M^8\). The point of \(M^4\) would be obtained by projecting the point of \(X^4 \subset M^8\) to a point of \(M^4\) identified as tangent space of \(X^4\). This would guarantee that the dimension of space-time surface in \(H\) would be four. The conjecture is that the preferred extremals of Kähler action include these surfaces.

3. \(M^8 - H\) duality can be generalized to a duality \(H \rightarrow H\) if the images of the associative surface in \(M^8\) is associative surface in \(H\). One can start from associative surface of \(H\) and assume that it contains the preferred \(M^2\) tangent plane in 8-D tangent space of \(H\) or integrable distribution \(M^2 (x)\) of them, and its points to \(H\) by mapping \(M^2\) projection of \(H\) point to itself and associative tangent space to \(CP_2\) point. This point need not be the original one! If the resulting surface is also associative, one can iterate the process indefinitely. WCW would be a category with one object.

4. \(G_2\) defines the automorphism group of octonions, and one might hope that the maps of octonions to octonions such that the action of Jacobian in the tangent space of associative or co-associative surface reduces to that of \(G_2\) could produce new associative/co-associative surfaces. The action of \(G_2\) would be analogous to that of gauge group.

5. One can also ask whether the notions of commutativity and co-commutativity could have physical meaning. The well-definedness of em charge as quantum number for the modes of the induced spinor field requires their localization to 2-D surfaces (right-handed neutrino is an exception) - string world sheets and partonic 2-surfaces. This can be possible only for Kähler action and could have commutativity and co-commutativity as a number theoretic counterpart. The basic vision would be that the dynamics of Kähler action realizes number theoretical geometrical notions like associativity and commutativity and their co-notions.

The notion of number theoretic compactification stating that space-time surfaces can be regarded as surfaces of either \(M^8\) or \(M^4 \times CP_2\). As surfaces of \(M^8\) identifiable as a sub-space of
complexified octonions (addition of commuting imaginary unit $i$) their tangent space or normal space is quaternionic- and thus maximally associative or co-associative. These surfaces can be mapped in natural manner to surfaces in $M^4 \times CP^2$ provided one can assign to each point of tangent space a hyper-complex plane $M^2(x) \subset M^4 \subset M^8$. One can also speak about $M^8 - H$ duality.

This vision has very strong predictive power. It predicts that the preferred extremals of Kähler action correspond to either quaternionic or co-quaternionic surfaces such that one can assign to tangent space at each point of space-time surface a hyper-complex plane $M^2(x) \subset M^4$. As a consequence, the $M^4$ projection of space-time surface at each point contains $M^2(x)$ and its orthogonal complement. These distributions are integrable implying that space-time surface allows dual slicings defined by string world sheets $Y^2$ and partonic 2-surfaces $X^2$. The existence of this kind of slicing was earlier deduced from the study of extremals of Kähler action and christened as Hamilton-Jacobi structure. The physical interpretation of $M^2(x)$ is as the space of non-physical polarizations and the plane of local 4-momentum.

Number theoretical compactification has inspired large number of conjectures. This includes dual formulations of TGD as Minkowskian and Euclidian string model type theories, the precise identification of preferred extremals of Kähler action as extremals for which second variation vanishes (at least for deformations representing dynamical symmetries) and thus providing space-time correlate for quantum criticality, the notion of number theoretic braid implied by the basic dynamics of Kähler action and crucial for precise construction of quantum TGD as almost-topological QFT, the construction of WCW metric and spinor structure in terms of second quantized induced spinor fields with modified Dirac action defined by Kähler action realizing the notion of finite measurement resolution and a connection with inclusions of hyper-finite factors of type II$_1$ about which Clifford algebra of WCW represents an example.

The two most important number theoretic conjectures relate to the preferred extremals of Kähler action. The general idea is that classical dynamics for the preferred extremals of Kähler action should reduce to number theory: space-time surfaces should be either associative or co-associative in some sense.

Associativity (co-associativity) would be that tangent (normal) spaces of space-time surfaces associative (co-associative) in some sense and thus quaternionic (co-quaternionic). This can be formulated in two manners.

1. One can introduce octonionic tangent space basis by assigning to the “free” gamma matrices octonion basis or in terms of octonionic representation of the imbedding space gamma matrices possible in dimension $D = 8$.

2. Associativity (quaternionicity) would state that the projections of octonionic basic vectors or induced gamma matrices basis to the space-time surface generates associative (quaternionic) sub-algebra at each space-time point. Co-associativity is defined in analogous manner and can be expressed in terms of the components of second fundamental form.

3. For gamma matrix option induced rather than Kähler-Dirac gamma matrices must be in question since Kähler-Dirac gamma matrices can span lower than 4-dimensional space and are not parallel to the space-time surfaces as imbedding space vectors.

3. 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 rational (hyper-)quaternions and (hyper-)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 continuous 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.

## 1.6 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.

### 1.6.1 Dark matter as large \( \hbar \) phases

D. Da Rocha and Laurent Nottale \[21\] have proposed that Schrödinger equation with Planck constant \( \hbar \) replaced with what might be called gravitational Planck constant \( h_{\text{gr}} = \frac{GmM}{v_0} \) (\( h = c = 1 \)). \( v_0 \) is a velocity parameter having the value \( v_0 = 144.7 \pm 7 \text{ km/s giving } v_0/c = 4.6 \times 10^{-4} \).

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 \( h_{\text{gr}} \). 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 \( h_{\text{gr}} \) would be much smaller. Large \( h_{\text{gr}} \) 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 \[K20\].

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 \( h_{\text{eff}} = n \times h_{\text{gr}} \). The large value of \( h_{\text{gr}} \) can be seen as a manner 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 \( h_{\text{eff}}/h = n \) 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 \( h_{\text{eff}}/h = n > 1 \). 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 \( (E = h f_{\text{high}} = h_{\text{eff}} f_{\text{low}}) \) of bunch of \( n \) low energy gravitons.
1.6 Hierarchy Of Planck Constants And Dark Matter Hierarchy

1.6.2 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 $h_{\text{eff}} = h_{\text{Gr}}$ - 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 $h_{\text{eff}}$ 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 [K16, K17, K29]) support the view that dark matter might be a key player in living matter.

1.6.3 Does the hierarchy of Planck constants reduce to the vacuum degeneracy of Kähler action?

This starting point led gradually to the recent picture in which the hierarchy of Planck constants is postulated to come as integer multiples of the standard value of Planck constant. Given integer multiple $h = nh_0$ of the ordinary Planck constant $h_0$ is assigned with a multiple singular covering of the imbedding space [K6]. One ends up to an identification of dark matter as phases with non-standard value of Planck constant having geometric interpretation in terms of these coverings providing generalized imbedding space with a book like structure with pages labelled by Planck constants or integers characterizing Planck constant. The phase transitions changing the value of Planck constant would correspond to leakage between different sectors of the extended imbedding space. The question is whether these coverings must be postulated separately or whether they are only a convenient auxiliary tool.

The simplest option is that the hierarchy of coverings of imbedding space is only effective. Many-sheeted coverings of the imbedding space indeed emerge naturally in TGD framework. The huge vacuum degeneracy of Kähler action implies that the relationship between gradients of the imbedding space coordinates and canonical momentum currents is many-to-one: this was the very fact forcing to give up all the standard quantization recipes and leading to the idea about physics as geometry of the “world of classical worlds”. If one allows space-time surfaces for which all sheets corresponding to the same values of the canonical momentum currents are present, one obtains effectively many-sheeted covering of the imbedding space and the contributions from sheets to the Kähler action are identical. If all sheets are treated effectively as one and the same sheet, the value of Planck constant is an integer multiple of the ordinary one. A natural boundary condition would be that at the ends of space-time at future and past boundaries of causal diamond containing the space-time surface, various branches co-incide. This would raise the ends of space-time surface in special physical role.

A more precise formulation is in terms of presence of large number of space-time sheets connecting given space-like 3-surfaces at the opposite boundaries of causal diamond. Quantum criticality presence of vanishing second variations of Kähler action and identified in terms of conformal invari-
ance broken down to to sub-algebras of super-conformal algebras with conformal weights divisible by integer $n$ is highly suggestive notion and would imply that $n$ sheets of the effective covering are actually conformal equivalence classes of space-time sheets with same Kähler action and same values of conserved classical charges (see Fig. [http://tgdtheory.fi/appfigures/planchierarchy.jpg](http://tgdtheory.fi/appfigures/planchierarchy.jpg) or Fig. ?? the appendix of this book). $n$ would naturally correspond the value of $h_{eff}$ and its factors negentropic entanglement with unit density matrix would be between the $n$ sheets of two coverings of this kind. p-Adic prime would be largest prime power factor of $n$.

### 1.6.4 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 $h_{eff}$.

### 1.7 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 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.

#### 1.7.1 Twistor lift at space-time level

8-dimensional generalization of ordinary twistors is highly attractive approach to TGD [K37]. 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 coincides 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 imbeddings 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 imbedding 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 [L10].

1.7.2 Twistors in TGD 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 imbedding 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 $\mathcal{N}$. 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 $\mathcal{N} = 4$ SUSYs. TGD provides a possible generalization and number theoretic interpretation of this notion. TGD generalizes the observation that scattering amplitudes in twistor Grassmannian 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 Grassmannian approach correspond to representations for permutations. Since 2-vertex 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 adele $\mathbb{A}$. 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/yyhvqfbq](http://tinyurl.com/yyhvqfbq)) 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/yyvkkfaa](http://tinyurl.com/yyvkkfaa)) 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
1.7 Twistors in TGD and connection with Veneziano duality

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 with.

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 algebrable (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 $1/(t - m_{\text{min}}^2)$, where $m_{\text{min}}$ 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 TGD As A Generalization Of Physics To A Theory Consciousness

General Coordinate Invariance forces the identification of quantum jump as quantum jump between entire deterministic quantum histories rather than time=constant snapshots of single history. The new view about quantum jump forces a generalization of quantum measurement theory such that observer becomes part of the physical system. The basic idea is that quantum jump can be identified as momentum of consciousness. Thus a general theory of consciousness is unavoidable outcome. This theory is developed in detail in the books [K26, K3, K15, K2, K7, K8, K10, K21, K30].

It is good to list first the basic challenges of TGD inspired theory of consciousness. The challenges can be formulated as questions. Reader can decide how satisfactory the answers proposed by TGD are.

1. What does one mean with quantum jump? Can one overcome the basic problem of the standard quantum measurement theory, that which forcing Bohr to give up totally the idea about objective reality?

2. How do the experienced time and geometric time relate in this framework? How the arrow of subjective time translates to that of geometric time?

3. How to define conscious information? Is it conserved or even increased during time evolution as biological evolution suggests? How does this increase relate to second law implied basically by the randomness of state function reduction?

4. Conscious entities/selves/observers seem to exist. If they are real how do they emerge?

2.1 Quantum Jump As A Moment Of Consciousness

The identification of quantum jump between deterministic quantum histories (WCW spinor fields) as a moment of consciousness defines microscopic theory of consciousness. Quantum jump involves the steps...
where $U$ is informational “time development” operator, which is unitary like the S-matrix characterizing the unitary time evolution of quantum mechanics. $U$ is formally analogous to Schrödinger time evolution of infinite duration. The time evolution can however interpreted as a sequence of discrete scalings and Lorentz boosts of causal diamond (CD) and the time corresponds to the change of the proper time distance between between the tips of CD.

In TGD framework S-matrix is generalized to a triplet of U-, M-, and S-matrices. M-matrix is a hermitian square root of density matrix between positive and negative energy states multiplied by universal S-matrix depending on the scale of CD only. The square roots of projection operators form an orthonormal basis. U-matrix and S-matrix are completely universal objects characterizing the dynamics of evolution by self-organization.

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 $S^n$, where $S$ is the S-matrix associated with the minimal CD. This conforms with the idea about unitary time evolution as exponent of Hamiltonian discretized to integer power of $S$.

U-matrix elements between M-matrices for various CDs are proportional to the inner products $\text{Tr}[S^{-n_1} \circ H^i H^j \circ S^{n_2} \lambda]$, 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 turns out possible to construct a general representation for the U-matrix reducing its construction to that of S-matrix.

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

In ZEO U-matrix should correspond relates zero energy states to each other and M matrices defining the rows of U matrix should be assignable to a fixed CD. Zero energy states should have wave function in the moduli space of CDs such that the second boundary of every CD would belong to a boundary of fixed light-cone but second boundary would be free with possible constraint that the distance between the tips of CD is multiple of $CP^2$ time.

Zero energy states of ZEO correspond in positive energy ontology to physical events and break time reversal invariance. This because either the positive or negative energy part of the state is reduced/equivalently prepared whereas the second end of CD corresponds to a superposition of (negative/positive energy) states with varying particle numbers and single particle quantum numbers just as in ordinary particle physics experiment.

The first state function reduction at given boundary of CD must change the roles of the ends of CDs. This reduction can be followed by a sequence of reductions to the same boundary of CD and not changing the boundary nor the parts of zero energy states associated with it but changing the states at the second end and also quantum distribution of the second boundary in the moduli space of CDs. In standard measurement theory the follow-up reductions would not affect the state at all.

The understanding of how the arrow of time and experience about its flow emerge have been the most difficult problem of TGD inspired theory of consciousness and I have considered several proposals during years having the geometry of future light-cone as the geometric core element.

1. The basic objection is that the arrow of geometric time alternates at imbedding space level but we know that arrow of time looks the same in the part of the Universe we live. Possible exceptions however exist, for instance phase conjugate laser beams seem to obey opposite arrow of time. Also biological phenomena might involve non-standard arrow of time at some levels. This led Fantappie [?] to introduce the notion of syntropy. This suggests that the arrow of time depends on the size scale of CD and of space-time sheet.
2. It took some time to realize that the solution of the problem is trivial in ZEO. In the ordinary quantum measurement theory one must assume that state function reduction can occur repeatedly: the assumption is that nothing happens to the state during repeated reductions. The outcome is Zeno effect: the watched pot does not boil.

In TGD framework situation is different. Repeated state function reduction leaves the already reduce parts of zero energy state invariant but can change the part of states at the opposite boundary. One must allow a delocalization of the second boundary of CDs and one assumes that the second tip has quantized distance to the fixed one coming as multiple of $CP_2$ time. Also Lorentz boosts leaving the second CD boundary invariant must be allowed. One must therefore introduce a wave function in the moduli space of CDs with second boundary forming part of fixed light-cone boundary ($\delta M_4 \times CP_2$).

3. The sequence of state function reductions on a fixed boundary of CD leads to the increase of the average temporal distance between the tips of CDs and this gives rise to the experience about flow of time as shifting of contents of perception towards future if the change is what contributes to conscious experience and gives rise to a fixed arrow of time.

4. Contrary to original working hypothesis, state function reduction in the usual sense does not solely determine the ordinary conscious experience. It can however contribute to conscious experience and the act of free will is a good candidate in this respect. TGD view about realization of intentional action assumes that intentional actions involve negative energy signals propagating backwards in geometric time. This would mean that at some level of CD hierarchy the arrow of geometric time indeed changes and the reduction start to occur at opposite boundary of CD at some level of length scale hierarchy.

2.2 Negentropy Maximization Principle (NMP)

Information is the basic aspect of consciousness and this motivates the introduction of Negentropy Maximization Principle (NMP) \[K11\] as the fundamental variational principle of consciousness theory. The amount of negentropy of zero energy state should increase in each quantum jump. The ordinary entanglement entropy is also non-negative so that negentropy could be at best zero. Since p-adic physics is assumed to be a correlate of cognition, it is natural to generalizes Shannon entropy to its number theoretic variant by replacing the probabilities appearing as arguments of logarithms of probabilities with their p-adic norms. This gives negentropy which can be positive so that NMP can generates entanglement.

Consistency with quantum measurement theory allows only negentropic density matrices proportional to unit matrix and negentropy has the largest positive value for the largest power of prime factor of the dimension of density matrix. Entanglement matrix proportional to unitary matrix familiar from quantum computation corresponds to unit density matrix and large $h_{eff} = n \times h$ states are excellent candidates for forming negentropic entanglement (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book).

The interpretation of negentropic entanglement is as a rule. The instances of the rule correspond to the pairs appearing in the superposition and the large the number of pairs is, the higher the abstraction level of the rule is. NMP is not in conflict with the second law since negentropy in the sense of NMP is not single particle property. Ordinary quantum jumps indeed generate entropy at the level of ensemble as also quantum jumps for states for which the density matrix is direct sum of unit matrices with various dimensions.

NMP forces the negentropic entanglement resources of the Universe to grow and thus implies evolution. I have coined the name “Akashic records” for these resources forming something analogous to library. It has turned out that the only viable option is that negentropic entanglement is experienced directly.

2.3 The Notion Of Self

The concept of self seems to be absolutely essential for the understanding of the macroscopic and macro-temporal aspects of consciousness and would be counterpart for observer in quantum measurement theory.
1. The original view was that self corresponds to a subsystem able to remain un-entangled under the sequential informational “time evolutions” $U$. It is however unclear how it could be possible to avoid generation of entanglement.

2. In ZEO the situation changes. Self corresponds to a sequence of quantum jumps for which the parts of zero energy states at either boundary of CD remain unchanged. Therefore one can say that self defined in terms of parts of states assignable to this boundary remains unaffected as sub-system and does not generate entanglement. At the other boundary changes occur and give rise to the experience of time flow and arrow of time since the average temporal distance between the tips of CD tends to increase.

When the reductions begin to occur at the opposite boundary of CD, self “falls asleep”: symmetry suggests that new self living in opposite direction of geometric time is generated. Also in biological the change of time direction at some level of hierarchy might take place.

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

4. Self corresponds in neuro science to self model defining a model for organism and for the external world. Information or negentropy seems to be necessary for understanding self. Negentropically entangled states - Akashic records - are excellent candidates for selves and would thus correspond to dark matter in TGD sense since the number of states in superposition corresponds to the integer $n$ defining $h_{eff}$. It is enough that self is potentially conscious: this could mean that it conscious experience about self is generated only in interaction free measurement. Repeated state function reductions to given boundary of CD is second possibility. This would assign irreversibility and definite arrow of time and experience of time flow with self.

5. CDs would serve as imbedding space correlates of selves and quantum jumps would be followed by cascades of state function reductions beginning from given CD and proceeding downwards to the smaller scales (smaller CDs). At space-time level space-time sheets in given $p$-adic length scale would be the natural correlates of selves. One ends also ends up with concrete ideas about how the localization of the contents of sensory experience and cognition to the “upper” (changing) boundary of CD could take place. One cannot exclude the possibility that state function reduction cascades could also take place in parallel branches of the quantum state.

2.4 Relationship To Quantum Measurement Theory

TGD based quantum measurement has several new elements. Negentropic entanglement and hierarchy of Planck constants, NMP, the prediction that state function reduction can take place to both boundaries of CD implying that the arrow of geometric time can change (this is expected to occur in microscopic scales whether the arrow of time is not established), and the possibility to understand the flow and arrow of geometric time.

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

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

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

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

Standard quantum measurement theory involves also the notion of state preparation which reduces to the notion of self measurement. In ZEO state preparation corresponds at some level of the self hierarchy to the a state function reduction to boundary opposite than before. In biology sensory perception and motor action would correspond to state function reduction sequences at opposite boundaries of CDs at some levels of the hierarchy.

Self measurement is governed by Negentropy Maximization Principle (NMP) stating that the information content of conscious experience is maximized. In the self measurement the density matrix of some subsystem of a given self localized in zero modes (after ordinary quantum measurement) is measured. The self measurement takes place for that subsystem of self for which the reduction of the entanglement entropy is maximal in the measurement. In p-adic context NMP can be regarded as the variational principle defining the dynamics of cognition. In real context self measurement could be seen as a repair mechanism allowing the system to fight against quantum thermalization by reducing the entanglement for the subsystem for which it is largest (fill the largest hole first in a leaking boat).

2.5 Selvses Self-Organize

The fourth basic element is quantum theory of self-organization based on the identification of quantum jump as the basic step of self-organization [K19]. Quantum entanglement gives rise to the generation of long range order and the emergence of longer p-adic length scales corresponds to the emergence of larger and larger coherent dynamical units and generation of a slaving hierarchy. Energy (and quantum entanglement) feed implying entropy feed is a necessary prerequisite for quantum self-organization. Zero modes represent fundamental order parameters and localization in zero modes implies that the sequence of quantum jumps can be regarded as hopping in the zero modes so that Haken’s classical theory of self organization applies almost as such. Spin glass analogy is a further important element: self-organization of self leads to some characteristic pattern selected by dissipation as some valley of the “energy” landscape.

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

ZEO brings in important additional element to the theory of self-organization. The maxima of Kähler function corresponds to the most probable 3-surfaces. Kähler function receives contributions only from the Euclidian regions (“lines” of generalized Feynman diagrams) whereas the contribution to vacuum functional from Minkowskian regions is exponent of imaginary action so that saddle points with stationary phase are in question in these regions. In ZEO 3-surfaces are replaced by pairs of 3-surfaces at opposite boundaries of CD. The maxima actually correspond to temporal patterns of classical fields connecting these 3-surfaces: this means that self-organization is four spatiotemporal rather than spatial patterns - a crucial distinction from the usual view allowing to understand the evolution of behavioral patterns quantally. In biology this allows to understand temporal evolutions of organisms as the most probable self-organization patterns having as correlates the evolutions of the magnetic body of the system.

2.6 Classical Non-Determinism Of Kähler Action

A further basic element is non-determinism of Kähler action. This led to the concepts of association sequence and cognitive space-time sheet, which are not wrong notions but replaced by new ones.

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

2. In the case that non-determinism is located to a finite time interval and is microscopic, this sequence of 3-surfaces has interpretation as a simulation of a classical history, a geometric correlate for contents of consciousness. When non-determinism has long lasting and macroscopic effect one can identify it as volitional non-determinism associated with our choices. Association sequences relate closely with the cognitive space-time sheets defined as space-time sheets having finite time duration.

Later a more detailed view about non-determinism in the framework of ZEO has emerged and quantum criticality is here the basic notion. The space-time surface connecting two 3-surfaces at the ends of CD is not unique. Conformal transformations which act trivially at the ends of space-time surface generate a continuum of new extremals with the same value of Kähler action and classical conserved quantities. The number \( n \) of conformal equivalence classes is finite and defines the value of \( h_{\text{eff}} \) (see Fig. [http://tgdtheory.fi/appfigures/planckhierarchy.jpg](http://tgdtheory.fi/appfigures/planckhierarchy.jpg) or Fig. ?? in the appendix of this book). There exists a hierarchy of breakdowns of conformal symmetry labelled by \( n \). The fractal hierarchy of CDs gives rise to fractal hierarchy of non-determinisms of this kind.

2.7 P-Adic Physics As Physics Of Cognition

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

A more precise formulation of this vision requires a generalization of the number concept obtained by fusing reals and p-adic number fields along common rationals (in the case of algebraic extensions among common algebraic numbers). This picture is discussed in [K24]. The application this notion at the level of the imbedding space implies that imbedding space has a book like structure with various variants of the imbedding space glued together along common rationals (algebraics, see Fig. http://tgdtheory.fi/appfigures/book.jpg or Fig. ?? in the appendix of this book). The implication is that genuinely p-adic numbers (non-rationals) are strictly infinite as real numbers so that most points of p-adic space-time sheets are at real infinity, outside the cosmos, and that the projection to the real imbedding space is discrete set of rationals (algebraics). Hence cognition and intentionality are almost completely outside the real cosmos and touch it at a discrete set of points only.

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

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

2.8 P-Adic And Dark Matter Hierarchies And Hierarchy Of Selves

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

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

2. The space-time sheets with large Planck constant can be in thermal equilibrium with ordinary ones without the loss of quantum coherence. For instance, the cyclotron energy scale associated with EEG turns out to be above thermal energy at room temperature for the level of dark matter hierarchy corresponding to magnetic flux quanta of the Earth’s magnetic field with the size scale of Earth and a successful quantitative model for EEG results [K5].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [K5]. The general prediction is that Universe is a kind of inverted Mandelbrot fractal for which each bird’s eye of view reveals new structures in long length and time scales representing scaled down copies of standard physics and their dark variants. These structures would correspond to higher levels in self hierarchy. This prediction is consistent with the belief that 75 per cent of matter in the universe is dark.

1. Living matter and dark matter

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of EEG [K5]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K9, K5]. A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [K5].
2.8 P-Adic And Dark Matter Hierarchies And Hierarchy Of Selves

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

2. Dark matter hierarchy and the notion of self

The vision about dark matter hierarchy leads to a more refined view about self hierarchy and hierarchy of moments of consciousness \([K4, K5]\). The larger the value of Planck constant, the longer the life-time of self measured as the increase of the average distance between tips of CDs appearing in the quantum superposition during the period of repeated reductions not affecting the part of the zero energy state at the other boundary of CD. Quantum jumps form also a hierarchy with respect to p-adic and dark hierarchies and the geometric durations of quantum jumps scale like \( h \).

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self experience subselves as separate mental images. Averaging over experiences of sub-selves of sub-self would however occur.

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

The basic question is what time scale can one assign to the geometric duration of quantum jump measured naturally as the size scale of the space-time region about which quantum jump gives conscious information. This scale is naturally the size scale in which the non-determinism of quantum jump is localized. During years I have made several guesses about this time scales but zero energy ontology and the vision about fractal hierarchy of quantum jumps within quantum jumps leads to a unique identification.

CD as an imbedding space correlate of self defines the time scale \( \tau \) for the space-time region about which the consciousness experience is about. The temporal distances between the tips of CD as come as integer multiples of \( CP_2 \) length scales and for prime multiples correspond to what I have christened as secondary p-adic time scales. A reasonable guess is that secondary p-adic time scales are selected during evolution and the primes near powers of two are especially favored. For electron, which corresponds to Mersenne prime \( M_{127} = 2^{127} - 1 \) this scale corresponds to 1 seconds defining the fundamental time scale of living matter via 10 Hz biorhythm (alpha rhythm). The unexpected prediction is that all elementary particles correspond to time scales possibly relevant to living matter.

Dark matter hierarchy brings additional finesse. For the higher levels of dark matter hierarchy \( \tau \) is scaled up by \( h/h_0 \). One could understand evolutionary leaps as the emergence of higher levels at the level of individual organism making possible intentionality and memory in the time scale defined \( \tau \).

Higher levels of dark matter hierarchy provide a neat quantitative view about self hierarchy and its evolution. Various levels of dark matter hierarchy would naturally correspond to higher levels in the hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question. The level would determine also the time span of long term memories as discussed in \([K5]\). The emergence of these levels must have meant evolutionary leap since long term memory is also accompanied by ability to anticipate future in the same time scale. This picture would suggest that the basic difference between us and our cousins is not at the level of genome as it is usually understood but at the level of the hierarchy of magnetic bodies \([K9, K3]\). In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible social rules and moral.
3 Quantum Biology And Quantum Neuroscience In TGD Universe

Quantum biology - rather than only quantum brain - is an essential element of Quantum Mind in TGD Universe. Cells, biomolecules, and even elementary particles are conscious entities and the biological evolution is evolution of consciousness so that it would be very artificial to restrict the discussion to brain, neurons, or microtubules.

3.1 Basic Physical Ideas

The following list gives the basic elements of TGD inspire quantum biology.

1. Many-sheeted space-time allows the interpretation of the structures of macroscopic world around us in terms of space-time topology. Magnetic/field body acts as intentional agent using biological body as a sensory receptor and motor instrument and controlling biological body and inheriting its hierarchical fractal structure. Fractal hierarchy of EEGs and its variants can be seen as communication and control tools of magnetic body. Also collective levels of consciousness have a natural interpretation in terms of magnetic body. Magnetic body makes also possible entanglement in macroscopic length scales. The braiding of magnetic flux tubes makes possible topological quantum computations and provides a universal mechanism of memory. One can also understand the real function of various information molecules and corresponding receptors by interpreting the receptors as addresses in quantum computer memory and information molecules as ends of flux tubes which attach to these receptors to form a connection in quantum web.

2. Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept of TGD inspired view about Quantum Mind to biology. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG and its fractal variants are identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted. Living system is identified as a kind of Indra’s net with biomolecules representing the nodes of the net and magnetic flux tubes connections between them. The reconnection of magnetic flux tubes and phase transitions changing Planck constant and therefore the lengths of the magnetic flux tubes are identified as basic mechanisms behind DNA replication and analogous processes and also behind the phase transitions associated with the gel phase in cell interior. The braiding of magnetic flux makes possible universal memory representation recording the motions of the basic units connected by flux tubes. Braiding also defines topological quantum computer programs updated continually by the flows of the basic units. The model of DNA as topological quantum computer is discussed as an application. In zero energy ontology the braiding actually generalize to 2-braiding for string world sheets in 4-D space-time and brings in new elements.

3. Zero energy ontology (ZEO) makes possible the proposed p-adic description of intentions and cognitions and their transformations to action. Time mirror mechanism (see Fig. http://tgdtheory.fi/appfigures/timemirror.jpg or Fig. ?? in the appendix of the book) based on sending of negative energy signal to geometric past would apply to both long term memory recall, remote metabolism, and realization of intentional acting as an activity beginning in the geometric past in accordance with the findings of Libet. ZEO gives a precise content to the notion of negative energy signal in terms of zero energy state for which the arrow of geometric time is opposite to the standard one. The associated notion of causal diamond (CD) is essential element and assigns to elementary particles new fundamental time scales which are macroscopic: for electron the time scale is 1 second, the fundamental biorhythm. An essentially new element is time-like entanglement which allows to understand among other things the quantum counterparts of Boolean functions in terms of time-like entanglement in fermionic degrees of freedom.

4. The assignment of dark matter with a hierarchy of Planck constants gives rise to a hierarchy of macroscopic quantum phases making possible macroscopic and macrotemporal quantum
coherence and allowing to understand evolution as a gradual increase of Planck constant. The model for dark nucleons leads to a surprising conclusion: the states of nucleons correspond to DNA, RNA, tRNA, and amino-acids in a natural manner and vertebrate genetic code as correspondence between DNA and amino-acids emerges naturally. This suggests that genetic code is realized at the level of dark hadron physics and living matter in the usual sense provides a secondary representation for it.

The hierarchy of Planck constants emerges from basic TGD under rather general assumptions. The key element is the huge vacuum degeneracy which implies that preferred non-vacuum extremals of Kähler action form a 4-D spin glass phase. The basic implications following from the extreme non-linearity of Kähler action is that normal derivatives of imbedding space coordinates at 3-D light-like orbits of partonic 2-surfaces and at space-like 3-surfaces at ends of CDs are many-valued functions of canonical momentum densities: this is one of the reasons that forced to develop physics as an infinite-D Kähler geometry vision instead of trying to develop path integral formalism or canonical quantization. A convenient manner to treat the situation is to introduce local many-sheeted covering of imbedding space such that the sheets are completely degenerate at partonic 2-surfaces. This leads in natural manner to the hierarchy of Planck constants as effective hierarchy hierarchy and integer multiples of Planck constants emerge naturally.

5. p-Adic physics can be identified as physics of cognition and intentionality. The hierarchy of p-adic length scales predicts a hierarchy of universal metabolic quanta as increments of zero point kinetic energies. Negentropic entanglement (see Fig. http://tgdtheory.fi/ appfigures/cat.jpg or Fig. ?? in the appendix of this book) possible for number theoretic entanglement entropy makes sense for rational (and even algebraic) entanglement and leads to the identification of life as something residing in the intersection of real and p-adic worlds. NMP respects negentropic entanglement and the attractive idea is that the experience of understanding and positively colored emotions relate to negentropic entanglement.

6. Living matter as conscious hologram is one of the basic ideas of TGD inspired biology and consciousness theory. The basic objection against TGD is that the interference of classical fields is impossible in the standard sense for the reason that that classical fields are not primary dynamical variables in TGD Universe. The resolution is based on the observation that only the interference of the effects caused by these fields can be observed experimentally and that many-sheeted space-time allows to realized the summation of effects in terms of multiple topological condensations of particles to several parallel space-time sheets. One concrete implication is fractality of qualia. Qualia appear in very wide range of scales: our qualia could in fact be those of magnetic body. The proposed mechanism for the generation of qualia realizes the fractality idea.

3.2 Brain In TGD Universe

Brain cognizes and one should find physical correlates for cognition. Also the precise role of brain in information processing and its relationship to metabolism should be understood. Here magnetic body brings as a third player to the couple formed by environment and organism.

1. An attractive idea is that the negentropic entanglement can be assigned with magnetic flux tubes somehow and that ATP serves as a correlate for negentropic entanglement. This leads to a rather detailed ideas about the role of phosphate bond and provides interpretation for the fact that the number of valence bonds tend to be maximized in living matter. In a loose sense one could even call ATP a consciousness molecule. The latest view encourages to consider the possibility that negentropic entanglement with what might be called Mother Gaia is what is transferred in metabolism.

2. The view about the function of brain differs from the standard view. The simplest option is that brain is a builder of symbolic representations building percepts and giving them names rather than the seat of primary qualia relevant to our conscious experience. Sensory organs would carry our primary qualia and brain would build sensory percepts as standardized mental images by using virtual sensory input to the sensory organs. The new view about time
3.3 Anomalies

is absolutely essential for circumventing the objections against this vision. The prediction is that also neuronal and even cell membranes define sensory maps with primary qualia assignable to the lipids serving as pixels of the sensory screen. These qualia would not however represent our qualia but lower level qualia. At this moment it is not possible to choose between these two options.

3. The role of EEG and its various counterparts at fractally scaled frequency ranges is to make possible communications to the various onion-like layers of the magnetic body and the control by magnetic body. Dark matter at these layers could be seen as the intentional agent and sensory perceiver.

3.3 Anomalies

Various anomalies of living matter have been in vital role in the development of not only TGD view about living matter but also TGD itself.

1. TGD approach to living matter was strongly motivated by the findings about strange behavior of cell membrane and of cellular water, and gel behavior of cytoplasm. Also the findings about effects of ELF em fields on vertebrate brain were decisive and led to the proposal of the hierarchy of Planck constants found later to emerge naturally from the non-determinism of Kähler action. Rather satisfactorily, the other manner to introduce the hierarchy of Planck constants is in terms of gravitational Planck constant: at least in microscopic scales the equivalence of these approaches makes sense and leads to highly non-trivial predictions. The basic testable prediction is that dark photons have cyclotron frequencies inversely proportional to their masses but universal energy spectrum in visible and UV range which corresponds to the transition energies for biomolecules so that they are ideal for biocontrol at the level of both magnetic bodies and at the level of biochemistry.

2. Water is in key role in living matter and also in TGD inspired view about living matter. The anomalies of water lead to a model for dark nuclei as dark proton strings with the surprising prediction that DNA, RNA, anino-acids and even tRNA are in one-one correspondence with the resulting 3-quark states and that vertebrate genetic code emerges naturally. This leads to a vision about water as primordial life form still playing a vital role in living organisms. The model of water memory and homeopathy in turn generalizes to a vision about how immune system might have evolved.

3. Metabolic energy is necessary for conscious information processing in living matter. This suggests that metabolism should be basically transfer of negentropic entanglement from nutrients to the organism. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would make possible the transfer of negentropy.

4 Motivations for “TGD Based View About Living Matter and Remote Mental Interactions”

The latest TGD inspired articles related to quantum biology, quantum mind, and remote mental interactions were published in JNLRMI around 2003. Several new ideas related to basic TGD, TGD inspired quantum biology and theory of consciousness have emerged during the subsequent 8 years: for a short summary about the development of ideas see the article [L1].

My original intention was to write just single article trying to give a summary about the progress of quantum TGD first and after that I will discuss the implications for quantum TGD based view about biology, consciousness and remote mental interactions and similar anomalies.

As usually happens, also now I realized that I am not able to write this kind of short article. The amount of topics has grown during years quite large and is scattered around to several books and gradually I began to feel desperate. I simply could not decide what should I take and what should I leave. Finally I drifted to the predictable outcome: I decided to wrote several articles with topic restricted to the recent state of quantum TGD itself, TGD inspired views about consciousness, and some basic aspects of biology, neuroscience, and remote mental interactions. The decision
was made easy after recalling that I had written a series of three articles to the journal Journal of Consciousness Exploration and Research founded by Huping Hu. It was rather easy to add the developments that had happened during last three years to these articles and write a new article about remote mental interactions and about testing the vision. The final step was the realization that it is natural to organize the article in a form of book.

There are other arguments in defence of book format. For a long time the basic challenge of TGD has been to give a precise meaning for heuristic ideas and loosely formulated concepts. Why this kind of approach requiring scanning through of all what one has written is so fruitful is that it forces to realize that definitions which have seemed obvious, are not at all obvious after all. At this stage when so little is known, internal consistency is an extremely valuable constraint on free imagination. Although reprocessing all this topic requires patience, it helps so identify internal inconsistencies. There has been quite a flux of ideas during last years and it is also very useful to allow them to interact.

Therefore the outcome was six articles transformed into chapters of a book. The reader should not be scared. I have tried to write these chapters so that one could read them in any order and there are links to the material at my homepage.

Later I have written many new chapters so that the total page number grew so large that I decided to divide the book into two pieces. In part I I have discussed TGD inspired visions about consciousness and quantum biology. In part II about TGD based views about neuroscience and remote mental interactions are represented. I however kept also the version without division.

4.1 Topics of “TGD Based View About Living Matter and Remote Mental Interactions”

The book has 4 parts.

1. The 1st part of the book contains one chapter about TGD itself and two chapters about TGD inspired theory of consciousness. The remaining two chapters are devoted to a comparison with some other theories of consciousness, in particular the integrated information theory of consciousness (IIT) by Tononi and Koch.

2. In 2nd part TGD inspired quantum biology is discussed at general level. The notion of magnetic body (MB) carrying dark matter is introduced first. There are two chapters about the role of dark photons as source of bio-photons. The notion of remote metabolism inspired by zero energy ontology (ZEO) is discussed in one chapter. There is a chapter about the necessity of new quantum physics in living systems. Two remaining chapters are devoted to applications.

3. In the 3rd part TGD inspired neuroscience is discussed. There is a chapter about the experiments by Michael Persinger’s group related to the possible role of bio-photons identified as decay products of dark photons in neuroscience. There is a chapter proposing that emotions could be regarded as sensory percepts about the state of the magnetic body (MB), a chapter about the possible role of dark valence electrons in color vision, and a chapter about geometric theory of bio-harmony suggesting that the “music of light” realized as 3-chords defining bio-harmony provides a realization of genetic code, and could serve as a correlate of emotions at molecular level. The last chapter about artificial intelligence in relation to natural intelligence was inspired by the well-known claims about Sophie robot.

4. In the 4th part remote mental interactions are discussed. A chapter describing a general model is followed by several chapters devoted to possible applications. These chapters have appeared also as articles in the journal devoted to remote mental interactions edited by Lian Sidoroff.

5 Sources

The eight online books about TGD [K27, K18, K33, K23, K14, K32, K31, K22] and nine online books about TGD inspired theory of consciousness and quantum biology [K26, K3, K15, K2, K7]
The contents of the book

Part I: TGD Inspired Theory of Consciousness

6.1 Topological Geometrodynamics: Basic Visions

1. The first vision is generalization of Einstein’s geometrization program based on the idea that the Kähler geometry of the world of classical worlds (WCW) with physical states identified as classical spinor fields on this space would provide the ultimate formulation of physics.

2. Second vision is number theoretical and involves three threads. The first thread relies on the idea that it should be possible to fuse real number based physics and physics associated with various p-adic number fields to a single coherent whole by a proper generalization of number concept. Second thread is based on the hypothesis that classical number fields could allow one to understand the fundamental symmetries of physics and imply quantum TGD from purely number theoretical premises with associativity defining the fundamental dynamical principle both classically and quantum mechanically. The third thread relies on the notion of infinite primes whose construction has amazing structural similarities with second quantization of super-symmetric quantum field theories. In particular, the hierarchy of infinite primes and integers allows to generalize the notion of numbers so that given real number has infinitely rich number theoretic anatomy based on the existence of infinite number of real units.

3. The third vision is based on TGD inspired theory of consciousness, which can be regarded as an extension of quantum measurement theory to a theory of consciousness raising observer from an outsider to a key actor of quantum physics.

The basic aspects of quantum classical correspondence are discussed. Strong form of General Coordinate Invariance implies strong form of holography and effective 2-dimensionality. Weak form of electric magnetic duality and simple general condition on preferred extremals of Kähler action imply that TGD indeed reduces to almost topological QFT defined by Chern-Simons terms located at space-like at ends of CDs and light-like 3-surfaces defined by the orbits of partonic 2-surfaces defining wormhole throats at which the signature of induced metric changes. A further reduction of action to sum of areas of minimal surfaces is conjectured on basis of effective 2-dimensionality. Feynman diagrams have direct interpretation in terms of space-time topology and ZEO leads to a dramatic simplification of the Feynman diagrammatics and suggest a close connection with twistorial diagrams. Induced gauge field concept makes impossible the superposition of classical fields in TGD Universe. This is a grave objection circumvented by simple observation: only the superposition of their effects is observed and many-sheeted space-time implies it.

6.1.2 Quantum Mind in TGD Universe

The basic difficulties and challenges of Quantum Mind program are analyzed. The conclusion is that the recent form of quantum theory is not enough to overcome the challenges posed by the
philosophical problems of quantum physics and quantum mind theories, and the puzzles of quantum biology and quantum neuroscience. Certain anomalies of recent day biology giving hints about how quantum theory should be generalized serve as an introduction to the summary of the aspects of quantum TGD especially relevant to the notion of Quantum Mind. These include the notions of many-sheeted space-time and field (magnetic) body, zero energy ontology, the identification dark matter as a hierarchy of phases with large value of Planck constant, and p-adic physics proposed to define physical correlates for cognition and intentionality.

Especially relevant is the number theoretic generalization of Shannon entropy: this entropy is well defined for rational or even algebraic entanglement probabilities and its minimum as a function of the prime defining p-adic norm appearing in the definition of the entropy is negative. Therefore the notion of negentropic entanglement makes sense in the intersection of real and p-adic worlds and is negative: this motivates the proposal that living matter resides in this intersection.

TGD inspired theory of consciousness is introduced as a generalization of quantum measurement theory. The notions of quantum jump and self defining the generalization of the notion of observer are introduced and it is argued that the notion of self reduces to that for quantum jump. Negentropy Maximization Principle reproduces standard quantum measurement theory for ordinary entanglement but respects negentropic entanglement so that the outcome of state function reduction is not random for negentropic entanglement. The new view about the relationship of experienced time and geometric time combined with zero energy ontology is claimed to solve the basic philosophical difficulties of quantum measurement theory and consciousness theory. The identification of the quantum correlates of sensory qualia and Boolean cognition, emotions, cognition and intentionality and self-referentiality of consciousness is discussed.

6.1.3 Life and Death and Consciousness

Life and death belong to the greatest mysteries of science. The development of quantum theories of consciousness has made possible to say something non-trivial also about life and death. In this article I describe TGD inspired theory of consciousness and the view that it provides about life and death. There are several notions which are new from the point of view of standard physics. From the point of view of TGD inspired theory of consciousness the most important ones are Zero Energy Ontology (ZEO), Causal Diamond (CD), Negentropy Maximization Principle (NMP). One can say that self as conscious entity is a sequence of repeated state function reductions at the same boundary of CD and not affecting or states at it - Zeno effect- and that self dies as the first reduction to the opposite boundary of CD is forced by NMP and means reincarnation of self as time-reversed self.

From the point of view of TGD inspired quantum biology the identification of dark matter has $\hbar_{eff}/\hbar = n$ phases of ordinary matter having non-standard value of Planck constant is central: these phases allow to understand living matter as macroscopically quantum coherent phases. Second key notion is that of field body, in particular magnetic body. This is implied by TGD view about space-time as 4-D surface of certain 8-D space-time and means that physical systems have besides ordinary identity also field identity so that one can talk about magnetic body (MB). MB takes the role of intentional agent using biological body as motor instrument and sensory receptor: this for instance explains EEG as a communications and control tool.

6.1.4 Comparison of TGD Inspired Theory of Consciousness with Some Other Theories of Consciousness

This work has been inspired by two books. The first book “On intelligence” is by Jeff Hawkins. The second book “Consciousness: the science of subjectivity” is by Antti Revonsuo.

Jeff Hawkins has developed a highly interesting and inspiring vision about neo-cortex, one of the few serious attempts to build a unified view about what brain does and how it does it. Since key ideas of Hawkins have quantum analogs in TGD framework, there is high motivation for developing a quantum variant of this vision. The vision of Hawkins is very general in the sense that all parts of neo-cortex would run the same fundamental algorithm, which is essentially checking whether the sensory input can be interpreted in terms of standard mental images stored as memories. This process occurs at several abstraction levels and involve massive feedback. If it succeeds at all these levels the sensory input is fully understood.
TGD suggests a generalization of this process. Quantum jump as a moment of consciousness and a sequence of quantum jumps inducing repeated state function reduction at the same boundary of causal diamond (CD) as self would be the basic identifications. These would define the fundamental algorithm realized in all scales defining an abstraction hierarchy. Negentropy Maximization Principle (NMP) would be the variational principle driving this process and in optimal case lead to an experience of understanding at all levels of the scale hierarchy realized in terms of generation of negentropic entanglement. The analogy of NMP with second law suggests strongly thermodynamical analogy and p-adic thermodynamics used in particle mass calculations might be also seen as effective thermodynamics assignable to NMP.

In the following I will first discuss the ideas of Hawkins and then summarize some relevant aspects of quantum TGD and TGD inspired theory of consciousness briefly in the hope that this could make representation comprehensible for the reader having no background in TGD (I hope I have achieved this). The representation involves some new elements: reduction of the old idea about motor action as time reversal of sensory perception to the anatomy of quantum jump sequence in zero energy ontology (ZEO); interaction free measurement for photons and photons as a non-destructive reading mechanism of memories and future plans (time reversed memories) represented 4-dimensionally as negentropically entangled states approximately invariant under quantum jumps (this resolves a basic objection against identifying quantum jump as moment of consciousness) leading to the identification of analogs of imagination and internal speech as fundamental elements of cognition; and a more detailed quantum model for association and abstraction processes.

I will also compare various theories and philosophies of consciousness with TGD approach following the beautifully organized representation of Revonsuo. Also anomalies of consciousness are briefly discussed. My hope is that this comparison would make explicit that TGD based ontology of consciousness indeed circumvents the difficulties against monistic and dualistic approaches and also survives the basic objections that I have been able to invent hitherto.

6.1.5 TGD Inspired Comments about Integrated Information Theory of Consciousness

Integrated Information Theory (IIT) is a theory of consciousness originally proposed by Giulio Tononi. The basic goal of IIT is to abstract from neuroscience axioms about consciousness hoped to provide constraints on physical models. IIT relies strongly on information theory. The basic problem is that the very definition of information is not possible without introducing conscious observer so that circularity cannot be avoided. IIT identifies a collection of few basic concepts and axioms such as the notions of mechanism (computer program is one analog for mechanism), information, integration and maximally integrated information (maximal interdependence of parts of the system), and exclusion. Also the composition of mechanisms as kind of engineering principle of consciousness is assumed and leads to the notion of conceptual structure, which should allow to understand not only cognition but entire conscious experience.

A measure for integrated information (called $\Phi$) assignable to any partition of system to two parts is introduced in terms of relative entropies. Consciousness is identified with a maximally integrated decomposition of the system to two parts ($\Phi$ is maximum). The existence of this preferred decomposition of the system to two parts besides computer and program running in it distinguishes IIT from the computational approach to consciousness. Personally I am however afraid that bringing in physics could bring in physicalism and reduce consciousness to an epiphenomenon. Qualia are assigned to the links of network. IIT can be criticized for this assignment as also for the fact that it does not say much about free will nor about the notion of time. Also the principle fixing the dynamics of consciousness is missing unless one interprets mechanisms as such.

In this article IIT is compared to the TGD vision relying on physics and on general vision about consciousness strongly guided by the new physics predicted by TGD. At classical level this new physics involves a new view about space-time and fields (in particular the notion of magnetic body central in TGD inspired quantum biology and quantum neuroscience). At quantum level it involves Zero Energy Ontology (ZEO) and the notion of causal diamond (CD) defining 4-D perceptive field of self; p-adic physics as physics of cognition and imagination and the fusion of real and various p-adic physics to adelic physics; strong form of holography (SH) implying that 2-D string world sheets and partonic surfaces serve as “space-time genes”; and the hierarchy of Planck constants making possible macroscopic quantum coherence.
Number theoretic entanglement entropy (EE) makes sense as number theoretic variant of Shannon entropy in the p-adic sectors of the adelic Universe. Number theoretic EE can be negative and corresponds in this case to genuine information: one has negentropic entanglement (NE). TGD inspired theory of consciousness reduces to quantum measurement theory in ZEO. Negentropy Maximization Principle (NMP) serves as the variational principle of consciousness and implies that NE can can only increase - this implies evolution. By SH real and p-adic 4-D systems are algebraic continuations of 2-D systems (“space-time genes”) characterized by algebraic extensions of rationals labelling evolutionary levels with increasing algebraic complexity. Real and p-adic sectors have common Hilbert space with coefficients in algebraic extension of rationals so that the state function reduction at this level can be said to induce real and p-adic 4-D reductions as its shadows.

NE in the p-adic sectors stabilizes the entanglement also in real sector (the sum of real (ordinary) and various p-adic negentropies tends to increase) - the randomness of the ordinary state function reduction is tamed by cognition and mind can be said to rule over matter. Quale corresponds in IIT to a link of a network like structure. In TGD quale corresponds to the eigenvalues of observables measured repeatedly as long as corresponding sub-self (mental image, quale) remains conscious.

In ZEO self can be seen as a generalized Zeno effect. What happens in death of a conscious entity (self) can be understood and it accompanies re-incarnation of time reversed self in turn making possible re-incarnation also in the more conventional sense of the word. The death of mental image (sub-self) can be also interpreted as motor action involving signal to geometric past: this in accordance with Libet’s findings.

There is much common between IIT and TGD at general structural level but also profound differences. Also TGD predicts restricted pan-psychoism. NE is the TGD counterpart for the integrated information. The combinatorial structure of NE gives rise to quantal complexity. Mehanisms correspond to 4-D self-organization patterns with self-organization interpreted in 4-D sense in ZEO. The decomposition of system to two parts such that this decomposition can give rise to a maximal negentropy gain in state function reduction is also involved but yields two independent selves. Engineering of conscious systems from simpler basic building blocks is predicted. Indeed, TGD predicts infinite self hierarchy with sub-selves identifiable as mental images. Exclusion postulate is not needed in TGD framework. Also network like structures emerge naturally as p-adic systems for which all decompositions are negentropically entangled inducing in turn corresponding real systems.

6.2 PART II: QUANTUM BIOLOGY IN TGD UNIVERSE

6.2.1 Quantum Mind, Magnetic Body, and Biological Body

The chapter is devoted to some applications of TGD inspired view about Quantum Mind to biology. Magnetic body carrying dark matter and forming an onionlike structure with layers characterized by large values of Planck constant is the key concept. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG is identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted.

Living system is identified as a kind of Indra’s net with biomolecules representing the nodes of the net and magnetic flux tubes connections between then. The reconnection of magnetic flux tubes and phase transitions changing Planck constant and therefore the lengths of the magnetic flux tubes are identified as basic mechanisms behind DNA replication and analogous processes and also behind the phase transitions associated with the gel phase in cell interior. The braiding of magnetic flux makes possible universal memory representation recording the motions of the basic units connected by flux tubes. Braiding also defines topological quantum computer programs updated continually by the flows of the basic units. The model of DNA as topological quantum computer is discussed as an application.

A vision about quantum metabolism in TGD Universe is proposed. The new element is the idea that the presence of ATP at magnetic flux tube is a necessary prerequisite for negentropic entanglement between its ends. ATP could be seen as a molecule of consciousness in this picture. Also a possible modification of second law to take into account negentropic entanglement is discussed. TGD approach to living matter was strongly motivated by the findings about strange
behavior of cell membrane and of cellular water, and gel behavior of cytoplasm. These findings are briefly discussed in TGD framework by bringing in magnetic flux tubes as a new element. Water is in key role in living matter and TGD inspired view about water and its anomalies is discussed.

6.2.2 Are dark photons behind biophotons?

TGD approach leads to a prediction that bio-photons result when dark photons with large value of effective Planck constant and large wavelength transform to ordinary photons with same energy. The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness served as a particular motivation for developing a more detailed view about bio-photons.

1. The anatomy of quantum jump in zero energy ontology (ZEO) allows one to understand basic aspects of sensory and cognitive processing in the brain without ever mentioning the brain. Sensory perception - motor action cycle with motor action interpreted as time-reversed sensory perception directly reflects the fact that state function reductions occur as sequences to the same boundary of causal diamond (CD) (which itself or rather, quantum superposition of CDs, changes in the process such that either the upper or lower boundaries of all CDs involved are localized at the same light-cone boundary). The first reduction of sequence corresponds to genuine state function reduction and the next induce changes only at the second boundary giving rise to experience flow of time and arrow of time.

2. Also the abstraction and de-abstraction processes in various scales which are essential for neural processing emerge already at the level of quantum jump. The formation of associations is one aspect of abstraction since it combines different manners to experience the same object. Negentropic entanglement of two or more mental images (CDs) gives rise to rules in which superposed $n$-particle states correspond to instances of the rule or association of $n$ events. Schrödinger cat serves as an example: the superposition of living cat-closed bottle and dead-cat-open bottle gives a quantum representation for the rule that it is not good idea to open the bottle. Cat attending to/quantum entangling with the bottle is conscious about the rule. Tensor product formation generating negentropic entanglement between new mental images and earlier ones generates longer sequences of memory mental images and gives rise to negentropy gain generating experience of understanding, recognition, something which has positive emotional coloring. Quantum superposition of perceptively equivalent zero energy states in given resolution gives rise to averaging. Increasing the abstraction level means poorer resolution so that the insignificant details are not perceived.

3. Various memory representations should be approximately invariant under the sequence of quantum jumps. Negentropic entanglement gives rise to this kind of stabilization. The assumption that self model is a negentropically entangled system which does not change in state function reduction, leads to a problem. If the conscious information about this kind of subself corresponds to change of negentropy in quantum jump, it seems impossible to get this information. Quite generally, if moment of consciousness corresponds to quantum jump and thus change, how is it possible to carry conscious information about quantum state? Interaction free measurement however allows to circumvent the problem: non-destructive reading of memories and future plans becomes possible in arbitrary good approximation. This memory reading mechanism can be formulated for both photons and phonons and these two reading mechanisms could correspond to visual memories as imagination and auditory memories as internal speech. Therefore dark photons decaying to bio-photons could be crucial element of imagination. The notion of bio-phonon could also make sense and even follow as a prediction. The identification of dark photons responsible for the reading of memories with EEG is suggested by the strong correlation of latter with the contents consciousness. This would also suggest a correlation of bio-photon emission with EEG for which there is a considerable evidence. The indications that bio-photons are associated only with the right hemisphere suggests that at least some parts of right hemisphere prefer dark photons and are thus specialized to visual imagination: spatial relationships are the speciality of the right hemisphere. Some parts the of left hemisphere at least might prefer dark photons in IR
energy range transforming to ordinary phonons in ear or dark phonons: left hemisphere is indeed the verbal hemisphere specialized to linear linguistic cognition.

4. After the writing of the original version of the chapter it turned out that there are good justifications for the proposal that the energy spectrum of dark photons might be universal and do not depend on the mass of the charged particle. This requires that $h_{\text{eff}}$ is proportional to the mass of the charged particle. This conforms with the hypothesis that bio-photons result in the transformation of dark photons to ordinary photons and the hypothesis cyclotron frequencies code serve as kind of passwords characterizing the ion. Dark ions could also affect ordinary matter by inducing molecular transitions in visible and UV range by transforming first to bio-photons.

In the following I shall discuss bio-photons in TGD Universe as decay products of dark photons and propose among other things an explanation for the hyperbolic decay law in terms of quantum coherence and echo-like mechanism guaranteeing replication of memory representations. Applications to biology, neuroscience, and consciousness are discussed and also the possible role of bio-photons for remote mental interactions is considered. Also the phenomenon of Taos hum is discussed as a possible evidence for biophonons.

6.2.3 Dark photons from transitions of dark valence electrons as origin of bio-photons, and their interaction with carcinogens

The possible role of bio-photons in living matter is becoming gradually accepted by biologists and neuroscientists. Bio-photons serve as a diagnostic tool and it seems that their intensity increases in non-healthy organism. I have proposed that bio-photons emerge from what I call dark photons, which are ordinary photons but have non-standard value $h_{\text{eff}} = n\hbar_0$ of Planck constant.

In this article the consequences of the hypothesis that dark photons emerging from the transitions of dark valence electrons of any atom possessing lonely unpaired valence electron could give rise to part of bio-photons in their decays to ordinary photons. The hypothesis is developed by considering a TGD based model for a finding, which served as a starting point of the work of Popp: the irradiation of carcinogens with light at wavelength of 380 nm generates radiation with wavelength 218 nm so that the energy of the photon increases in the interaction. Also the findings of Veljkovic about the absorption spectrum of carcinogens have considerably helped in the development of the model.

The outcome is a proposal for dark transitions explaining the findings of Popp and Veljkovic. The spectrum of dark photons also suggests a possible identification of metabolic energy quantum of $.5 \text{ eV}$ and of the Coulomb energy assignable to the cell membrane potential. The possible contribution to the spectrum of bio-photons is considered, and it is found that spectrum differs from a smooth spectrum since the ionization energies for dark valence electrons depending on the value of $h_{\text{eff}}$ as $1/h_{\text{eff}}^2$ serve as accumulation points for the spectral lines. Also the possible connections with TGD based models of color vision and of music harmony are briefly discussed.

6.2.4 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. $h_{\text{eff}}$ can be related to Josephson frequency and cyclotron frequency and thus to measurable parameters. $h_{\text{eff}}$ 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 di-electric 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 $h_{\text{eff}}$, $p$-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.

6.2.5 Can quantum biology really do without new physics?

Quantum biology is now taken rather seriously. Photosynthesis and avian navigation are two key applications of quantum biology. The basic problem in both cases is posed by the fact that the magnetic interaction energy in Earth’s magnetic field is roughly million times smaller than thermal energy. The so called radical-pair mechanism (RPM) was proposed already at 60’s as a possible solution to the problem posed by anomalously large effect in EPR and NMR experiments. According to RPM, a radical pair is accompanied by electron pair, which is in a superposition of spin triplet and singlet states and behaves as quantum coherent system for a time sufficiently long to induce chemical effects. The hyperfine interaction of the members of the electron pair with the nuclei of radicals would amplify the effect. The neutralization of radical pair puts an end to the coherence interaction period.

The proposal is that RPM gives rise to chemical compass making possible avian navigation. There is however a problem. RPM has been observed in laboratory only for magnetic fields in the range 1 mT- 10 T. Earth’s magnetic field is only 2 per cent of the lower bound so that it is quite possible that RPM is not at work.

This opens up the door for new quantum physics proposed by TGD based model of quantum biology. In this approach magnetic body acts as an intentional agent using biological body as a sensory receptor and motor instrument. Macroscopic quantum coherence is made possible by dark matter realized as a hierarchy of $h_{\text{eff}} = n \times h$ phases.

In this chapter RMP is summarized and compared with the TGD based vision. Also the possible connection between avian navigation and circadian clock suggested by the fact that both involve
photoreceptor known as cryptochrome and a possible connection with gravitaxis are considered in TGD framework.

6.2.6 The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis?

During almost two decades I have returned repeatedly to the fascinating but unfortunately unrecognized work of Roschin and Godin about rotating magnetic systems. With the recent advances in TGD it has become clear that the reported strange effects such as the change of weight proportional to the rotation velocity of rollers taking place above 3.3 Hz rotation frequency and rapid acceleration above 9.2 Hz up to frequency 10 Hz could provide clues for developing a general vision about morphogenesis of magnetic body, whose flux quanta can carry Bose-Einstein condensates of dark charged ions with given mass and charge if the hypothesis \( h_{\text{eff}} = n \times h = h_{\text{gr}} \) identifying dark matter as phases with non-standard value of Planck constant holds true.

The generalization of Chladni mechanism would provide a general model for how magnetic flux tubes carrying charged particles with given mass at given flux tube drift to the nodal surfaces giving rise to magnetic walls in the field of standing or even propagating waves assignable to “topological light rays” (MEs). Ordinary matter would in turn condense around these dark magnetic structures so that Chladni mechanism would serve as a general mechanism of morphogenesis. This mechanism could be universal and work even in astrophysical systems (formation of planets).

The change of weight correlating with the direction of rotation (parity breaking) and rapid acceleration could be understood in terms of momentum and angular momentum transfer by dark photons liberated in the quantum phase transition of many-particle states of dark charged particles to from cyclotron Bose-Einstein condensates giving rise to analogs of superconductivity and spontaneous magnetization.

There is also evidence that the presence of light source below massive object affects its weight by about .1 per cent. This effect could be explained along the same lines. Zero Energy Ontology and the proposed mechanism remote metabolism at the level of dark matter is however needed and this would force to modify dramatically the views about basic interactions at the level of dark matter.

An increase of weight \( \Delta g/g \simeq 2 \times 10^{-4} \) is observed for electrets: this number has appeared in TGD already earlier and in TGD framework could have interpretation in terms of dark matter layer with mass \( M_D \simeq 2 \times 10^{-4} M_E \) at distance of Moon. More generally, any living system could be accompanied by a magnetic body with this mass fraction and lose it in biological death. Amusingly, this change of weight happens to consistent with the ”weight of soul” claimed to be 21 g.

6.2.7 Life-like properties observed in a very simple systems

The physicists working in Emory University have made very interesting discovery. The very simple system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls and are not bi-stable. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation.

Where does the metabolic energy come from? The proposal of the experimenters that stochastic resonance feeds the needed metabolic energy leaves open its source. The resemblance with living cells suggests that the attempt to interpret the findings solely in terms of non-equilibrium thermodynamics might miss something essential - the metabolism.

One can develop a model for the system based on TGD inspired quantum biology. This involves the notion of magnetic body carrying dark matter identified as \( h_{\text{eff}} = n \times h \) phases; a network of magnetic flux tubes (magnetic body) controlling biological body (now charged plastic balls) and responsible for coherence and synchrony (of the crystal-like phase now); the control of the oscillations of BB by cyclotron radiation (now the plastic ball system) resulting from decays of cyclotron condensates of charged particles (now protons and Ar ions). The source of metabolic energy would come from dark nucleosynthesis explaining nuclear transmutations occurring in living
6.3 PART III: QUANTUM NEUROSCIENCE IN TGD UNIVERSE

6.3.1 Quantum Mind and Neuro Science

The article discusses some applications of TGD inspired view about Quantum Mind to neuroscience. Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept.

A general model for qualia is introduced. The identification of the correlates of the fundamental qualia as quantum number increments for a subsystem is in a complete analogy with the identification of quantum numbers as characterizers of physical states. A general classification of qualia based on thermodynamical notions is discussed and a mechanism generating sensory qualia is proposed. Also the question whether some qualia could correspond also to those of magnetic body is raised.

The interaction of subsystem $S$ representing self with environment $E$ is assumed to generate a negentropic entanglement between $S$ and environment $E$. As long as this negentropic entanglement
 lasts, qualia are experienced. After the state function reduction eliminating this entanglement, there can be only a memory of qualia. There is clearly a resemblance with Orch OR of Penrose and Hameroff. During negentropic entanglement there is polarization in scale of $S \otimes E$ and $S$ and $E$ carry opposite quantum numbers. After the state function reduction negentropic entanglement and polarization prevail only in the scale $S$ and $S$ has vanishing net quantum numbers. “Quantum number increments $\Delta Q$ in quantum jump” therefore correspond to the reduction of charges of subsystem in the state function reduction process. The system is analogous to a capacitor whose size scale is that of $S \otimes E$ during the sensation of quale and that of $S$ after it. In ZEO one can consider states of $S$ at both upper and lower boundaries of $CD$ and assign $\Delta Q$ with this time evolution so that quantum classical correspondence is realized.

The capacitor model for sensory receptor based on the idea that sensory qualia are generated in the analog of di-electric breakdown introducing a flow of large number of particles with quantum numbers characterizing the quale. A model for the cell membrane as sensory receptor and as qualia chart with lipids serving as its pixels is developed. Although sensory organs are assumed to define the seats if the fundamental qualia, also neurons would define sensory homunculi not necessarily responsible for sensory mental images at our level of self hierarchy. Cell membrane is assumed to be a quantum critical system taken to mean that it is near to a vacuum extremal of so called Kähler action. This explains large parity breaking in living matter (chiral selection) very difficult to understand in standard model. The model explains the peak frequencies of visible light for photoreceptors and predicts that bio-photons and bunches of EEG photons result as decay products of same dark photons with energies mostly in visible range.

Few years after the writing of the first version of this chapter a progress in the understanding of self. Self can be identified as a sequence of quantum jumps as originally proposed but assuming that the quantum jump sequence correspond to a repeated state function reduction at the same boundary of CD. In ordinary quantum measurement theory repeated reduction would not change the state at all. This also the case for the second boundary of CD., say positive energy boundary. Now the parts of zero energy states associated with the negative energy boundary change. Besides this one has a wave function in the moduli space of the second boundary. Moduli include also the temporal distance between the tips of CD. The statistical increase of this distance gives rise to the flow and arrow of psychological time and self can be identified as the sequence of quantum jumps giving rise to a state function reduction at the same boundary of CD. The capacitor discharge corresponds to a sequence of state function reductions to a fixed boundary of CD.

The model of nerve pulse relies on the hypothesis that axonal membrane defines a Josephson junction. The ground state of the axon corresponds to a propagating soliton sequence for the phase difference over the membrane mathematically analogous to a sequence of coupled gravitational penduli with a constant phase difference between neighboring penduli. Nerve pulse is generated as one kicks one of the oscillating penduli. The model of nerve pulse explains the generation of EEG. The resonance frequencies of EEG can be understood as sums and differences of the harmonics of cyclotron frequencies of biologically important dark ions and of Josephson frequency.

A model of bio-photons is discussed. The motivation comes from the observations that bio-photons could be interpreted as decay products of large $\hbar$ EEG photons resulting in the energy conserving transformation to ordinary photons at visible and UV energies.

6.3.2 Comments about the recent experiments by the group of Michael Persinger

Michael Persinger’s group reports three very interesting experimental findings related to EEG, magnetic fields, photon emissions from brain, and macroscopic quantum coherence. The findings also provide support for the proposal of Hu and Wu that nerve pulse activity could induce spin flips of spin networks assignable to cell membrane. In this article I analyze the experiments from TGD point of view. It turns out that the experiments provide support for several TGD inspired ideas about living matter - namely, magnetic flux quanta as generators of macroscopic quantum entanglement, dark matter as a hierarchy of macroscopic quantum phases with large effective Planck constant, DNA-cell membrane system as a topological quantum computer with nucleotides and lipids connected by magnetic flux tubes with ends assignable to phosphate containing molecules, and the proposal that “dark” nuclei consisting of dark proton strings could provide a representation of the genetic code. The proposal of Hu and Wu translates into the assumption that lipids of the two layers of the cell membrane are accompanied by dark protons which arrange themselves
6.3 PART III: QUANTUM NEUROSCIENCE IN TGD UNIVERSE

6.3.3 Emotions as sensory percepts about the state of magnetic body?

What emotions are? How emotions are created? How they are represented: in brains, at body, or somewhere else? Emotions can be divided into lower level emotions and higher level emotions. What does this correspond to?

1. TGD inspired answer to the questions is that emotions are sensory percepts about the state of magnetic body (MB). Sensory-motor loop generalizes: various glands excreting hormones to blood stream and binding to receptors give rise to the analog of motor output.

2. Neural transmitters binding to receptors serve as bridges allowing to build connected networks of neurons from existing building bricks. They are accompanied by flux tube networks giving rise to tensor networks as quantum coherent entangled structures serving as correlates of mental images and allowing classical signalling with light velocity using dark photons. In a similar manner hormones give rise to networks of ordinary cells implying in particular that emotional memories are realized in (biological) body (BB). Nervous system gives information about the state of these networks to brain. Hypothalamus serves as the analog of motor cortex excreting hormones controlling the excretion of hormones at lower level glands.

3. The hierarchy of Planck constants defines a hierarchy of dark matters and $h_{eff} = n \times$ defines a kind of IQ. The levels of MB corresponding to large/small values of $n$ would correspond to higher/lower emotions.

MB decomposes to two basic parts: the part in the scale of BB and formed by networks having cells and larger structures as nodes (forming a fractal hierarchy) and the part in the scales larger than BB.

1. In the scales of BB (short scales) the dynamics involves topological dynamics of the flux tube network and sensory percepts can be accompanied by conscious-to-us desire to change the state of MB and thus of BB and could be seen as intentions induced by the comparison between what happened and what were the expectations. The outcome would be state function reduction replacing the behavioral pattern with a new one giving better hopes for achieving the goal. In zero energy ontology (ZEO) behavioral pattern is represented as quantum superposition of 4-D MBs so that time aspect is naturally involved with emotions.

2. In the scales larger than that of BB (long scales) the change the topology is not easy and the dynamics involves oscillations of MB - analogs of Alfwen waves - and analogs of ordinary motor actions changing the shape of flux tubes but leaving its topology unaffected. Alfwen waves with cyclotron frequencies and generalized Josephson frequencies assignable to cell membrane as Josephson junction would be involved. The size scale of particular onion-like layer of MB corresponds to the wavelength scale for cyclotron frequencies and is proportional to $h_{eff}/h = n$ for dark photons. For instance, alpha band in EEG corresponds to the scale of Earth but the energy scale of dark photons is that of bio-photons.

The TGD inspired model of music harmony gives as a side product a model of genetic code predicting correctly the numbers of codons coding for amino-acids for vertebrate code. The model allows to see sensory percepts about the dynamics in large scales as analog of music experience. The notes of 3-chords of the harmony correspond to light as dark photons and frequencies defining the notes of the chord: cyclotron radiation and generalized Josephson radiation from cell membrane would represent examples of dark light. Music expresses and creates emotions and music harmonies would correspond to various emotional states/moods realized at the level of DNA and its dark counterpart (dark nuclei represented as dark proton sequences). MB would be like a music instrument with flux tubes serving as strings. It is difficult to assign any specific desire to large scale sensory percepts about MB and the interpretation as higher emotions - or rather feelings - makes sense.
6.3.4 Dark valence electrons and color vision

By its large orbital radius dark valence electron (dark in TGD sense, $h_{eff} = n \times h$) sees atomic nucleus and other electrons, which are ordinary, effectively as an object of charge $Z_{eff} = 1$. The spectrum of bound state energies and transition energies is scaled down by the factor $(h/h_{eff})^2$. This irrespective of what the atom is. The only condition is that there is single unpaired valence electron guaranteed if $Z$ for the atom is odd. For even $Z$ odd number of valence electrons must be associated with valence bonds: this would be the case for OH radical for instance.

The dynamics of dark valence electrons is universal with universal transition energy spectrum. One obtains a fractal hierarchy of dynamics labelled by the value of $(h/h_{eff})^2$, where $h_{eff} = n \times h_0$, $h_0$ the minimal value of Planck constant, not necessary equal to $h$ so that one has $h = n_0 \times h_0$. The quantum critical dynamics characterizing living matter in TGD Universe is indeed universal.

The dark photon communications in living matter could utilize these universal energy spectra besides cyclotron energy spectrum and Larmor spectrum assignable to dark particles at flux tubes and the spectrum of generalized Josephson frequencies assignable to cell membrane.

In particular, vision and even other sensory modalities could rely on the transitions induced by the absorption of dark valence electron. In TGD also other sensory percepts are communicated from sensory receptors to the sensory areas of cortex and also here same universal transitions of dark valence electrons might be involved. This hypothesis when combined with the earlier ideas about color qualia leads to a highly predictive and testable model for the perception of colors. In particular the condition $h = n_0 \times h_0$, $n_0 > 1$, is necessary for the model to work. $n_0 = 4$ and $n_0 = 6$ look the most realistic options. For $n_0 = 4$ the number of values of $n = 8, 9, 10$ and correspond to the number 3 of color sensitive receptors whereas $n_0 = 6$ the number of values $n = 12, 13, 14, 15$ suggests the existence of a fourth color receptor sensitive to red light.

The statistical aspects of color summation can be understood from TGD inspired theory of consciousness in terms of the hypothesis that self experiences the mental images of sub-self as kind of statistical averages. The identification of quark colors as fundamental color qualia, the entanglement of quarks and antiquarks to form states in one-one correspondence with charged gluons, and the twistor space of $CP_2$ play key roles in the model of color summation.

6.3.5 Geometric Theory of Bio-harmony

For some years ago I developed a model of music harmony. As a surprising side product a model of genetic code predicting correctly the number of codons coding given amino-acid emerged. Since music expresses and creates emotions, one can ask whether genes could have “moods” characterized by these bio-harmonies. The fundamental realization could be in terms of dark photon triplets replacing phonon triplets for ordinary music.

1. The model relies on the geometries of icosahedron and tetrahedron and representation of 12-note scale as so called Hamiltonian cycle at icosahedron going through all 12 vertices of icosahedron. The 20 faces correspond to allowed 3-chords for harmony defined by given Hamiltonian cycle. This brings in mind 20 amino-acids (AAs).

2. One has three basic types of harmonies depending on whether the symmetries of icosahedron leaving the shape of the Hamiltonian cycle is $Z_6$, $Z_4$ or $Z_2$. For $Z_2$ there are two options: $Z_{2,rot}$ is generated by rotation of $\pi$ and $Z_{2,refl}$ by reflection with respect to a median of equilateral triangle.

3. Combining together one harmony from each type one obtains union of 3 harmonies and if there are no common chords between the harmonies, one has $20 + 20 + 20$ 3-chords and a strong resemblance with the code table. To given AA one assigns the orbit of given face under icosahedral isometries so that codons correspond to the points of the orbit and orbit to the corresponding AA. 4 chords are however missing from 64. These one obtains by adding tetrahedron. One can glue it to icosahedron along chosen face or keep is disjoint.

4. The model in its original form predicts 256 different harmonies with 64 3-chords defining the harmony. DNA codon sequences would be analogous to sequences of chords, pieces of music. Same applies to mRNA. Music expresses and creates emotions and the natural proposal is that these bio-harmonies correlate with moods that would appear already at molecular level.
They could be realized in terms of dark photon triplets realized in terms of light and perhaps even music (living matter is full of piezo-electrets). In fact, also the emotions generated by other art forms could be realized using music of dark light.

The model of music harmony is separate from the model of genetic code based on dark proton triplets and one of the challenges has been to demonstrate that they are equivalent. This inspires several questions.

1. Could the number of harmonies be actually larger than 256 as the original model predicts? One could rotate the 3 fused Hamilton’s cycles with respect to each by icosahedral rotations other leaving the face shared by icosahedron and tetrahedron invariant. There are however conditions to be satisfied.

   (a) There is a purely mathematical restriction. If the fused 3 harmonies have no common 3-chords the number of coded AAs is 20. Can one give up the condition of having no common 3-chords and only require that the number of coded AAs is 20?

   (b) There is also the question about the chemical realizability of the harmony. Is it possible to have DNA and RNA molecules to which the 3-chords of several harmonies couple resonantly? This could leave only very few realizable harmonies.

2. The model predicts the representation of DNA and RNA codons as 3-chords. Melody is also an important aspect of music. Could AAs couple resonantly to the sums of the frequencies (modulo octave equivalence) of the 3-chords for codons coding for given AA? Could coding by the sum of frequencies appear in the coupling of tRNA with mRNA by codewords and coding by separate frequencies to the letterwise coupling of DNA and RNA nucleotides to DNA during replication and transcription?

3. What about tRNA. Could tRNA correspond to pairs of harmonies with 20+20+444 codons? What about single 20+4=24 codon representation as kind of pre-tRNA?

4. What is the origin of 12-note scale? Does genetic code force it? The affirmative answer to this question relies on the observation that 1-1 correspondence between codons and triplets of photons requires that the frequency assignable to the letter must depend on its position. This gives just 12 notes altogether. Simple symmetric arguments fix the correspondence between codons and 3-chords highly uniquely: only 4 alternatives are possible so that it would be possible to listen what DNA sequences sounds in given mood characterized by the harmony.

5. What disharmony could mean? A possible answer comes from 6 Hamiltonian cycles having no symmetries. These disharmonies could express “negative” emotions.

6.3.6 An Overall View about Models of Genetic Code and Bio-harmony

7 Introduction

During last years kind of brain storming period has occurred in the model of bio-harmony [L2]. A lot of ideas, some of them doomed to be short lived, have emerged, and it seems that now it its time for a thorough cleanup and integration with the general ideas of TGD inspired quantum biology.

TGD leads to 3 basic realizations of genetic code: this is now relatively well established part of TGD inspired quantum biology. One can also consider 3 realization also for bio-harmony. The question is which of them is the realistic one or whether several options can be considered.

7.1 3 basic realizations of the genetic code

In TGD Universe there are at least 3 realizations of the genetic code.

Besides biochemical realization one has a realization in terms of dark nuclei realized as dark proton sequences and possibly in terms of more general sequences involving effective dark neutrons. The states of 3 dark protons defining the dark codon have multiplet decomposition 64 + 64+ 40
+ 20 corresponding to dark variants of DNA, RNA, tRNA, and amino-acids (AA). I will denote these dark variants by DDNA, DRNA, DtRNA, and DAA.

If one allows also dark analogs of neutrons by allowing negatively charged color bonds between protons, the number of code letters doubles: this could relate to the recently constructed Hachimoji DNA [?] (see http://tinyurl.com/y2mcjb4r) discussed from TGD viewpoint in [L12].

Dark photon 3-chords assignable to the realization of bio-harmony with the note scale identified as Hamilton cycle on a polytope with triangular faces gives a third realization coupling dark and ordinary representations together. I have proposed 3 realizations in terms of icosahedral and tetrahedral [L2], icosahedral and toric [L6], and icosahedral and dodecahedral [L12] geometries (for the latter 5-chords would effectively reduce to 3-chords).

If there is DDNA-DNA, DRNA-RNA, DAA-AA pairing, the negative charges of DNA, RNA, and tRNA nucleotides finds explanation in terms of positive charge of dark proton sequence. For AAs the situation is not clear since the charge per unit length for amino-acids varies and depends on pH. DAA-AA pairing would require that dark analogs of neutrons are present in the dark proton sequence.

### 7.2 3 models of bioharmony

There are now 3 models of bioharmony [L2, L6, L12] making very similar predictions. Harmony for given graph is defined as a Hamiltonian cycle connecting neighboring points and going through all points of the graph without self-intersections. Scale is identified by assigning notes to the vertices and faces correspond to the chords of the harmony obtained in this manner. Bio-harmonies are fusions of 3 or 4 sub-harmonies.

1. The original proposal - icosa-tetrahedral bio-harmony - is based on the fusion of 3 icosahedral harmonies with symmetry groups \( Z_6, Z_4, \) and \( Z_2 \) permuting the triangles of given orbit of \( Z_n \). Given icosahedral harmony corresponds to an imbedding of 12-note scale as a Hamilton cycle at icosahedron. The 12 vertices of icosahedron are identified as the notes of 12-note scale and 20 triangular faces define the 3-chords of the harmony.

The distance between nearest vertices is assumed to correspond to quint that is scaling of the frequency by 3/2. Each cycle defines a collection of 20 3-chords defining an icosahedral harmony. Octave equivalence is used to map the 12 frequencies obtained to single octave. There is however a slight inconsistency since 12 quints corresponds to slightly more than 7 octaves as already Pythagoras realized. The addition of tetrahedron to icosahedral harmony is interpreted as an addition of one vertex adding one note which should be very near to one of the 12 notes.

Icosahedral harmonies are characterized by a symmetry group \( Z_n, n = 6, 4, 2, 1 \), \( n = 1 \) corresponds to chaotic cycles, which might serve as correlate for dis-harmony and might relate to the correlates of emotions: at the level of genetic code is AA would be coded by single DNA codon.

Icosahedron decomposes to orbits of \( Z_n \) consisting of triangles or equivalently chords. The chords can be classified further by the frequency ratios correlating with the emotional effect. One has the orbits \( 3 \times 6 + 2 = 20 \) for \( Z_6, 5 \times 4 = 20 \) for \( Z_4 \) and \( 10 \times 2 = 20 \) for \( Z_2 \). \( Z_6 \) harmony is unique but there are 3 \( Z_4 \) and even more \( Z_2 \) harmonies for which \( Z_2 \) can correspond to rotation by \( \pi \) or reflection. This can be understood as breaking of symmetry splitting the \( Z_6 \) orbits to pieces. This gives 60 = 2 + 20 + 20 3-chords. The numbers of chords at give orbit rather neatly correspond the numbers of DNA codons coding for given AA.

4 chords and DNAs and AAs are however missing. Tetrahedral harmony would add \( 3 + 1 = 4 \) chords: \( Z_3 \) would the symmetry group instead of \( Z_4 \). This would be due to the symmetry breaking due to gluing of one-tetrahedral face with icosahedral face, which is however counted as separate face and corresponds to 1-triangle orbit under \( Z_3 \) permuting its vertices. This gives 64 3-chords corresponding to codons of genetic code.

3 + 1 decomposition would naturally correspond to (ile, ile, ile, met) 4-plet coded by codons AUX. The numbers of codons coding given AA identified as orbit of \( Z_n \) come out almost correctly. The only exception is trp-stop doublet for which doublet decomposes to stop and singlet. One must understand the reason for this symmetry breaking - it might just the need...
to have stop codon and this could be arranged if there is no tRNA coupling to this codon. Note that for some code variants stop codon UAG corresponds to Pyl and UGA to Sec. Since music generates and expresses emotions, the interpretation would be in terms of moods. Even molecules would have moods.

2. Also icosa-dodecahedral and icosa-toric harmonies contain the $\mathbb{Z}_6$ and $\mathbb{Z}_4$ icosaehedral harmonies ($20_1$ and $20_2$) so that one must only add the missing 10 doublets and 3+1 codons assigned to tetrahedron in icosa-tetrahedral case.

The dodecahedral harmony with 6 chords arranged in doublets is unique from the uniqueness of the Hamiltonian cycle [L12]. The icosa-dodecahedral harmony would give $20_1 + 20_2 + 12_1 + 12_2 = 64$. 12 decomposes into 6 $\mathbb{Z}_2$ doublets so that one has 12 doublets. The realization of scale for dodecahedral harmony would in $20^7$ powers of rational scaling $x$ such that $x^{20}$ is as near to a power of two as possible [L12]. $x = 2^{1/20}$ would correspond to the Eastern variant of well-tempered scale.

There are objections against icosa-dodecahedral harmony. Chords are 5-chords rather than 3-chords. The 5-chords of dodecahedral harmony however turn out to be equivalent to 3-chords as far as information content is considered [L12]. The number of vertices for dodecahedron is 20, not 12, but one could argue that dodecahedron corresponds to Eastern harmony having micro-intervals. Two copies of the dodecahedral harmony are needed. What could distinguish between these copies will be discussed later. Also 3+1 is missing.

3. The icosaehedral-toric harmony [L6] decomposes as $20_1 + 20_2 + 24 = 64$ involving torus with 24 triangles and 12 vertices. Toric harmony has $\mathbb{Z}_{24}$ as isometries and gives 12 doublets. One could argue that the fusion of icosaehedral and toric harmonies is geometrically un-natural. One must be however cautious if the geometric realization is in extension of rationals. Also now 3+1 is missing.

The considerations in the sequel suggests that the icosa-tetrahedral option is the most realistic if not unique.

7.3 About the geometric interpretation of icosaehedral and other symmetries

The geometric interpretation of icosaehedral and possible other geometries is a challenge. The 60-element group $A_5$ of rotations - alternating group of 5-letters - acts as orientation preserving isometries of icosaehedron.

1. Since Galois group is central in adelic physics, and all finite groups can appear as Galois groups, one can ask whether icosaehedral group and tetrahedral groups could act as Galois group for some extension of rationals relevant for biology. Going to web gives an affirmative answer [A9] (see [http://tinyurl.com/y4qsea6h](http://tinyurl.com/y4qsea6h)). Icosahedral symmetry appears as Galois group of the general quintic equation! The lowest order polynomial equation not allowing closed expressions for the roots.

Galois theory (see [http://tinyurl.com/y6e955xe](http://tinyurl.com/y6e955xe)) allows to understand the situation in terms of the discriminant defined as product $D = \prod_{i<j}(r_i - r_j)^2$, where $r_i$ are the roots of the irreducible polynomial considered. $S_n$ is the symmetry group in the generic case and odd permutations of $S_n$ change the sign of $D$. If $D$ is square of rational number in the field $K$ considered (which can be also extension of rationals now), Galois group reduces to alternating group $A_5$.

Remark: For octahedron and its dual cube the group is $S_4$ and can be realized as Galois group of 4th order polynomials. For tetrahedron the group is $A_4$ and can be also realized as Galois group of 4th order polynomials for which discriminant is square in $K$.

2. Icosahedral and dodecahedral geometries having the same isometry group are common in biology, and one can wonder whether there could be a geometric realization - perhaps at the level of magnetic body. This might somehow relate also to the frequent appearance of Golden mean involving $\sqrt{5}$ in biology and Golden angle rated to the fifth root of unity.
3. $M^8 - H$ duality provides besides the usual formulation of TGD also a formulation in complexified $M^8$ identified as complexified octonions [L4]. The associativity of the tangent or normal space of space-time surface is assumed as a dynamical principle and implies quaternionicity. Quaternions have $SO(3)$ as automorphism group analogous to Galois group and have the finite isometry groups of Platonic solids as finite subgroups. Could quaternionicity give a connection with the geometric picture? In adelic physics discretizations of space-time points as points with coordinates in the extension of rationals are in central role. Could discretizations contain orbits of the Platonic isometries as quaternionic Galois groups? This could also give to the geometric picture although icosahedral symmetries are not obvious in the geometry of say DNA.

4. Is the genetic code really unique as its dark nucleus realization and the fact that the isometry groups of Platonic solids are finite subgroups of quaternionic isomorphisms suggests? Could any Galois group give rise to an analog of bioharmony and of genetic code? Could the recent genetic code correspond to a first step in the process going beyond the solvable polynomial equations?

Could one realize the icosahedron and 24-torus as imagined object in the algebraic extension of rationals? Could the $n$-dimensional discrete geometric objects assignable to $n$-dimensional extensions of rationals have quite generally this kind of representations as a generalized Platonic solid in algebraic extension. Could they define cognitive harmonies as Hamiltonian cycles? Could one imagine also cognitive variant of genetic code whereas as sensory/biological variant of genetic code would be forced by dark proton physics?

7.4 Mistracks

In the attempts to understand the connection with standard realization of the genetic code I have also considered the possibility that the frequencies of 3-chord might be mapped to their sum in the interactions. This possibility was considered in the model of homonymy [L8]. In the light of afterwisdom this proposal looks ad hoc.

Also a proposal for how 12-note scale could quite concretely correspond DNA codons was discussed [L9]. The idea was to assign notes with individual letters of the codon such that the note depends on the position of the letter whereas the model of harmony assignment the chord to the entire codon represented as entangled state of 3 dark protons. It is now clear this proposal very probably cannot realize all possible harmonies and is in conflict with the general model which as such fixes the correspondence between chords and codons without any additional assumptions.

8 Interactions between various levels

One challenge is to understand how the various realizations of the genetic code interact with each other. There are DX-DY interactions, DX-Y interactions and X-Y interactions and in living matter they should occur in long length scales so that they should be mediated by dark photons.

1. How dark photon triplets assumed to be generated by dark nucleon sequences interact with ordinary DNA? Here one can bring in rather stable ideas of TGD inspired view about quantum biology. Dark matter in TGD sense represents long length scale quantum coherence and bio-chemistry short scale coherence. The interaction is therefore between long and short scales.

2. There are two manners to interact: frequency resonance and energy resonance. Frequency resonance mediates long length scale interactions and if DX-X pairing exists, the exchange
of dark photon triplets - 3-chords - allows long range DX-DY interactions. DX-X interaction by energy resonance is short range interaction so that X-(DX-DY)-Y interaction would give rise to long range interaction between X-Y as interaction induced by dark level (MB).

3. DX-X interaction involves energy resonance and transformation of dark photons to ordinary photons with the same energy. Bio-photons would be an outcome of the transition $h_{\text{eff}} \rightarrow h$. Also the reversal of this transition and more general transitions $h_{\text{eff},1} \rightarrow h_{\text{eff},2}$ are of course possible.

Bio-photons have a universal energy spectrum corresponding to molecular and atomic transition energies. This is possible if they result from dark cyclotron photons if the condition $h_{\text{eff}} = h_{\nu} = GMm/v_0$ introduced originally by Nottale and implying that the cyclotron energy does not depend on the mass of the charged particle producing the dark cyclotron photons.

8.1 The independence of the interaction energy on frequency

Dark matter as a hierarchy phases labelled by $h_{\text{eff}}/h_0 = n$ identifiable as a dimension of extension of rationals implies evolutionary hierarchy: $n$ serves as a kind of IQ. This strongly suggests that ordinary matter is controlled by dark matter at MB and mimics its behavior.

Evolution would not proceed by change and necessity but would be a process controlled and guided by MB. MB would be an active intentional agent guiding the evolution. Situation in biology would be much like that in modern technological society where intentional technical progress leads to more and more refined products. How could this be realized at the level of basic bio-molecules? One should also understand how genetic code evolves gradually to a more refined form.

1. The selection of basic bio-molecules having energy resonance with their dark variants mediated by dark photon 3-chords by change would be extremely ineffective process. MB should have mechanisms of tuning the energies of dark photons to achieve energy resonance.

This is achieved if the value of $h_{\text{eff}}$ at the flux tubes mediating the interaction can be controlled. Since the length of flux tube is proportional to the $h_{\text{eff}}$ by Uncertainty Principle, the variation of $h_{\text{eff}}$ would mean variation of the length $L$ of the flux tube: a kind of motor action of MB. Cyclotron frequencies are proportional to the value of monopole magnetic field $B$ at flux tube and by flux quantization one has $B \propto 1/S$, $S$ the area of flux tube cross section (which for monopole flux tubes is closed 2-surface). The variation of the thickness/area of the flux tube, second motor action of MB, would allow to vary cyclotron frequencies.

2. The ideal situation concerning the coupling to ordinary matter would be that same chemical transition with fixed energy for given molecule could couple to several frequencies. This would be achieved if the cyclotron energy is constant.

The condition that the cyclotron energies in a coupling to a given molecule do not depend on the frequency requires that $h_{\text{eff},i}$ at flux tube $i$ compensates this dependence. MB can vary the value of $B$ to vary frequencies and the value of $h_{\text{eff},i}$ to keep energy unaffected. The areas $S$ and length $L$ of flux tubes are varied so that the volume remains unaffected. $B \propto 1/S$ and $L \propto h_{\text{eff}}$ by Uncertainty Principle. $E_c \propto h_{\text{eff}}B = \text{constant}$ implies that $L/S$ is constant. $S$ increases like $S \rightarrow x^2S$ and $L \rightarrow x^2L$ in the scaling changing $f_c \rightarrow f_c/x^2$. The magnetic energy $E_{\text{magn}} = B^2SL \propto L/S$ of the flux tube is not changed. Kind of energy criticality would be in question - one would have a large number of flux tube configurations with the same energy and volume ideal for control purposes. Quantum criticality is actually basic dynamical principle of quantum TGD allowing to predict the spectrum of various coupling parameters.

3. Besides cyclotron frequencies Josephson energies are central in TGD based model of nerve pulse and EEG. Josephson energy $E_J = 2eV$ and cyclotron frequency $f_c = ZeB/m$ do not depend on $h_{\text{eff}}$. An attractive possibility is that cyclotron photons couple to Josephson junctions meaning that they become Josephson photons and then transform to ordinary photons inducing molecular transitions.
4. In the case of bio-harmony the frequencies would be rational multiples of basic frequency and by separating common numerator they are certain integer multiples \( f_i = n_i f_0 \) of a basic frequency \( f_0 \). The integers \( n_i \) have decomposition to products of powers of certain primes: \( n_i = \prod p_i^{k_i} \) and each of \( p_i \) appears as some maximal power \( k_i,\text{max} \). If one has \( n = \prod p_i^{k_i,\text{max}} n_0 \) one can obtain \( h_{\text{eff},i} = h_{\text{eff}}/n_i \). In this manner one would obtain the desired independence of \( E_{\text{c},i} \) on \( f_i \). For Pythagorean scale only primes \( p=2 \) and \( p=3 \) would be involved.

All codons coding for given AA could have coupling energy. Unless the values of Planck constants and frequencies associated with flux tubes coupling to given codon are fixed, one could have same transition energy for all letters but this is an unrealistic condition. Transition energies are naturally different and can code for letters if not even codons. For this option only the correct combination of frequencies and values of \( h_{\text{eff},i} \) allows resonant coupling.

The 3-chords associated with different harmonies would naturally correspond to the same energy. The physics of emotions would not be directly visible at the level of chemistry: chemist would certainly agree with this. The values of Planck constants would characterize the frequencies: I have indeed speculated that nucleotides could be labelled by values of \( \hbar \). Number theory would be essential for the understanding life at the level of genes: Galois groups would characterize the nucleotides. Galois groups code for complexity at the level of dark matter so that the behavior guided by the MB of molecule would depend on the \( IQ = n = h_{\text{eff}}/h_0 \) of MB.

8.2 The independence of cyclotron energy on frequency and Nottale hypothesis

Is the independence of interaction energy on frequencies consistent with \( h_{\text{ge}} = GMm/v_0 \) hypothesis \( \text{EL} \) \( \text{K20} \) \( \text{K35} \) \( \text{K38} \)? Here one might encounter difficulties. The division by \( n_i \) should change one of the parameters appearing in the formula. The interpretation has been \( m \) corresponds to the dark proton mass at the end of the flux tube connecting it to large mass \( M \). If so \( m \) cannot be varied.

Could \( M \) be varied?

1. The parameter \( v_0 \approx 2^{-11} \) can be varied by powers of two, which do not affect the notes identified by octave equivalence.

2. Could \( M \) correspond to atomic or molecular mass in good approximation equal to sum of atomic numbers \( A \) of atoms involved? The divisors of the total atomic number \( A_{\text{tot}} \) would define the allowed integers \( n_i \) characterizing the frequencies of Pythagorean scale in the model of bio-harmony. One must have \( h_{\text{ge}}/h > 1 \) with requires \( M > h/Gm = 1.3 \times 10^{19} m_p v_0 \). For \( v_0 = 2^{-11} \) this corresponds to \( M > h/Gm = 6 \times 10^{15} m_p \). The scale of a water blob with \( A = 20 \) containing this number of protons is about 70 \( \mu \), which is of order cell size. One can wonder how \( A_{\text{tot}} \) could be kept as divisible by \( n_i \) characterizing the frequencies of the Pythagorean scale. The problem is that an addition of one proton spoils the divisibility conditions completely.

3. The solution of the problem could be based on a more precise view about \( h_{\text{eff}} \) \( \text{EL} \). The understanding of the variation of Newton’s constant - too large to be due to experimental errors - led to the realization of the meaning of the fact that space-time surfaces can be regarded simultaneously coverings of 2-fold \( M^4 \) and \( n_1 \) fold \( CP_2 \) and that one has \( n = n_1 n_2 \) in \( h_{\text{eff}}/h_0 = n \) and \( n_1 \) would have interpretation as the number of flux tubes which are parallel in \( M^4 \) and can be even disjoint. This would give \( h_{\text{ge}} \propto n_1 \) and the factors of \( n_1 \) should correspond to the integers characterizing the notes of the 12-note scale. One could perhaps say that effectively single proton is replaced with \( n_1 \) protons located at different flux tubes so that also proton mass becomes \( n_1 m \). One would have effectively a Bose-Einstein condensate like state of \( n_1 \) protons (at different flux tubes).

4. In the Pythagorean representation of octave the notes correspond to powers \( (3/2)^k \), \( k = 0, 1, ..., 11 \), if \( 3/2)^{12} \approx 2^7 \) is not included. The corresponding integers are \( 2^k \). Only powers of primes \( p=2 \) and \( p=3 \) are involved and one just have \( n_1 \propto 2^{11}2^{11} \). If one increases the number of octaves involved to 14 to get a representation for chords needed to
avoid the mapping of two dark codons to same 3-chords, one must have $n \times 3^{23} \times 2^{23} = 6^{23}$.

One can consider also simpler representations using integers expressible in terms of powers of primes $p = 2, 3, 5$ but one must give up exact quint cycle in this case. Interestingly, a good guess for the standard value $h$ of $h_{eff}$ is as $h = 6h_0$ [L8] [L7].

5. Small p-adic primes $p = 2$, $p = 3$ and perhaps also $p = 5$ (Golden Mean) are expected to be of special importance in TGD inspired biology [K13]. $p = 2$ seems to appear everywhere and there is also support for $p = 3$ in biology [?] [?] (see http://tinyurl.com/ycesc5mq): great evolutionary leaps seem to correspond to time scales coming in powers of 3.

6. The branching of the flux tube bundle to $n_i$ sub-bundles $N_i = n/n_i$ could correspond to the reduction $h_{eff} \to h_{eff}/n_i$. This could be seen as reduction of $h_{eff}$. One can also consider phase transitions reducing $n$ to $n/n_i$.

9 Homonymy of the genetic code

In the following I will discuss briefly the basic facts about genetic code at Wikipedia level with emphasis on the poorly understood aspects of the code. There are two interesting phenomena: synonymy and homonymy. Synonymy means several names for AA or tRNA codon so that that several RNAs are mapped to the sama AA or tRNA codon: the understanding of the genetic code is the understanding of synonymy.

Homonymy means that the same RNA codon can correspond to several tRNAs or even AAs. A general TGD based view about homonymy differing from that discussed in [L8] based on the recent understanding of the interaction between various representations of the genetic code is described below.

9.1 Variations of the genetic code

There exists also as many as 31 genetic codes (see http://tinyurl.com/ydeeyhjl) and an interesting question is whether this relates to the context dependence. Mitochondrial codes differs from the nuclear code and there are several of them. The codes for viruses, prokaryotes, mitochondria and chloroplasts deviate from the standard code. As a rule, the non-standard codes break U-C or A-G symmetries for the third code letter. Some examples are in order (see http://tinyurl.com/puw82x8).

1. UUU can code Leu instead of Phe and CUG can code Ser rather than Leu. In bacteria the GUG and UUG coding for Val and Leu normally can serve as Start codons.

2. UGA can code to Trp rather than Stop: in this case the broken symmetry is restored since also UGG codes for Trp.

3. There is variation even in human mitochondrial code (see http://tinyurl.com/puw82x8). In 2016, researchers studying the translation of malate dehydrogenase found that in about 4 per cent of the mRNAs encoding this enzyme the UAG Stop codon is naturally used to encode the AAs Trp and Arg. This phenomenon is known as Stop codon readthrough (see https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5133446/).

4. There is also a variant of genetic code in which there are 21st and 22nd AAs Sec and Pyl coded by Stop codons. UGA can code for Sec and Stop in the same organism. UAG can code for Pyl instead of Stop and introduces additional breaking of A-G symmetry for the third letter (UAA to Stop and UAG to Pyl).

9.2 Wobble base pairing

Wobble base pairing (see http://tinyurl.com/y73se8vs) emerges from the observation that the number of tRNAs pairing with mRNAs is smaller than 45 and considerably smaller than that of mRNAs. The needed minimum number of tRNAs is 32. Therefore the RNA-tRNA pairing cannot be 1-1 and some mRNA codons must correspond to several tRNA codons.
### Remark:
One could ask whether mRNAs code for tRNAs just like DNAs code for AA. Homonymy for mRNA-tRNA pairing implies that the pairing can be many-to-1 only in given context.

1. According to the standard code, the first two bases of mRNA codon corresponds to two last bases of tRNA anti-codon and obey standard code. Wobble base pairing hypothesis applies to the pairing of the 3rd mRNA base to the 1st base in tRNA anticodon. At the level of chemistry the hypothesis is that the position of the first tRNA anticodon base pairing with the third mRNA base is variable and allows it to pair with several bases appearing as 3rd base in mRNA. This homonymy would be due to “wobbling” of the position of the first tRNA anticodon.

2. In the original model for wobble base pairing tRNA bases contain besides standard A, C, G, U also inosine I as a modification of G obtained by dropping NH$_2$ from the 6-cycle of G. It has turned out that there are actually variants of C and 5 variants of U (see [http://tinyurl.com/y73se8vs](http://tinyurl.com/y73se8vs)). The large amount of homonymy for tRNAs forces to ask whether chemistry alone really dictates the genetic code.

3. The first tRNA letter is assumed to be spatially wobbling so that the association of tRNA with RNA is not unique and mRNA-tRNA pairing involves both synonymy and homonymy as the two tables for the pairing of the 1st 5’ anticodon base of tRNA and 3rd 3’ codon base of mRNA show. In the second column bold letters for mRN bases allow to read the standard pairing with tRNA codons in the first column and non-bold letters allow to deduce the non-standard behavior.

4. The first table (see [http://tinyurl.com/y73se8vs](http://tinyurl.com/y73se8vs)) represents the original Watson-Crick proposal.

   (a) The pairings of the 3rd letter of mRNA codon to the 1st letter of tRNA anti-codon are following.
   - U $\rightarrow$ G.
   - G $\rightarrow$ U
   - \{A, C or U\} $\rightarrow$ I.

   The 2nd and 3rd tRNA letters A and C are paired with the 1st and 2nd mRNA letters in the canonical manner. There are only 3 tRNA letters, which implies that the number of tRNAs is smaller than maximal.

   (b) There is single 1-to-many pairing: U $\rightarrow$ \{G, I\} giving rise to 2-fold homonymy.

5. Revised pairing rules (see [http://tinyurl.com/y73se8vs](http://tinyurl.com/y73se8vs)) are more complex since the number of tRNA bases is larger (U has 5 variants and C has 2 variants). All mRNA letters have 1-to-many pairing. Even if one counts the variants of U as single U there is 4-fold homonymy for U and homonymies for other codons. For A one has 9-fold homonymy.

   These variations do not induce variation in DNA $\rightarrow$ AA pairing if the AA associated with the homonyms of tRNA are identical. This seems to be the case almost always since the variation of the genetic code is surprisingly small. This raises the question whether there is some mechanism eliminating to high degree the expected effects of homonymy in mRNA $\rightarrow$ tRNA pairing.

### 10 TGD view about homonymies

One should understand the homonymies of the genetic code [LS]. One can imagine homonymies at the level of DDNA-3-chord and DRNA-3-chord correspondences and between RNA-AA and RNA-tRNA correspondences.
10.1 Homonymies for DRNA-3-chord correspondence

It is possible that homonymies are present already at the dark photon level in the sense that the sub-harmonies have common chords.

1. Are the icosahedral orbits for different symmetry groups $Z_6$, $Z_4$, $Z_2$ disjoint? If they contain common triangles, the outcome is homonymy for dark codons unless one can scale the 12-note scales with respect to each other (different keys) to avoid common chords.

This question finds an answer from the tables of $\mathbb{L}_2$ representing the chords. If the two scales considered contain 3-chords with the same frequency ratios this can happen. $Z_6$ harmony contains chords of same type with whole note intervals: $C_x, D_x, E_x,\ldots$, $x = m, 6, 9$ coding the frequency ratios as is done in popular music. If second harmony contains several types such that they are not separated by a multiple of whole note interval, at least one common chord is unavoidable also for shifted harmonies.

2. From the tables 1 and 2 of Appendix one finds that for $Z_6$ and 2 $Z_4$ harmonies this is indeed the case and they have 2-chords involving 2 quints in common: 6-orbit and 4-orbit containing $x = 9$ 3-chords have 2 common chords. One has homonymy at dark level. If entire orbits are mapped to the same AA there would be 8 AAs in the same multiplet. Some DDNA and DRNA codons are mapped to the same 3-chord of dark photons. This problem is shared by all 3 models of bio-harmony.

3. For the unique $Z_6$ harmony and 3 $Z_{2,rot}$ (table 3 of Appendix) of harmonies common chords can be avoided by shifting the latter harmonies by a half-note. The reason is that the chords of same type are now separated by a multiple of whole note interval. For $Z_{2,refl}$ harmonics (table 4 of Appendix) the chords of same type are separated by odd number of half-notes so that common chords are unavoidable since 3-chords of the same type appear. There are also common chords with $Z_4$ harmony.

4. $Z_6$ and $Z_{2,rot}$ harmonies possess no common chords by a shift by odd number of half notes. $Z_4$ and $Z_{2,rot}$ and $Z_4$ and $Z_6$ possess at least 2 common chords. $Z_{2,refl}$ possesses more common chords with $Z_4$ and $Z_6$.

The fusion of $Z_6$, $Z_4$, and $Z_{2,rot}$ harmonies with 2 common chords between in $Z_6 \cap Z_4$ $Z_4 \cap Z_{1,rot}$ seems seems to be best that one can achieve. This would give $1 \times 2 \times 3 = 6$ harmonies altogether unless one obtains new harmonies by by relative shifts of the key.

How to solve the problem?

1. The above described homonymies involving 6plets involve either 6-plet or 2-plet as second multiplet so that these deviations cannot be due to homonymy at the level of DRNA-3-chord correspondence.

2. Should one take seriously the puzzle that teased Pythagoras and led him to seriously consider that the structure of the Universe based on rationals has serious flaw in it. 12 quints give slightly more than 7 octaves: one has $(3/2)^{12} = 129.746337890625$ rather than $(3/2)^{12} = 128$ so that one obtains slightly more than octave under octave equivalence.

Why not represent notes as powers of algebraic number $2^{1/12}$ and this is indeed done in practice (in rational approximation of course) but very musical people notice the difference and dislike this representation. There should be something deep in the representation of the scale in terms of rationals as TGD indeed predicts. Note that a strict resonance is not required, it represents only the optimal situation.

3. Repeating the quint cycle gives slightly displaced chords: one can of course do this several times $\mathbb{L}_2$. Could these slightly displaced chords represent DDNA and RNA codons as 3-chords otherwise mapped to the same chords? This would also mean that the corresponding DNAs and RNAs correspond to 3-chords with at least one note differing only slightly. This kind of notes is shared by 5 chords in icosa-tetrahedral harmony. The addition of second quite cycle means that the integers $n_i = 2^k 3^{23-k}$ characterize the notes of the 3-chords and $2^k 3^{23-k}$ and $2^k 123^{11-k}$ represent the nearby notes.
4. The minimal modification would replace only minimum number of notes in the problematic chords with new ones. A stronger modification would replace the problematic chords with displaced variants with notes in the second quint cycle. One could also do the same for all chords and say that the number of codons for non-problematic dark codons is doubled.

One could also consider the doubling of each letter of the codon so that each chord would be replaced with 8 almost copies except in the case of homonymic AAs. A non-homonymic AA coded by $n$ RNAs would be coded by $8n$ 3-chords. If the frequency differences are small enough this is not seen at the level of transition energies of AAs: this must be the case for non-homonymous AAs. For homonymous RNAs the energy differences must be seen and remove the homonymy. This DRNA-3-chord homonymy would be analogous to the RNA-tRNA homonymy.

5. One can consider the problem from a different perspective. For Hachimoji DNA [?] (see [http://tinyurl.com/y2mcjb4r](http://tinyurl.com/y2mcjb4r)) the number of DNA letters seem to double so that codon is replaced with 8 codons. An explanation based on the Pythagorean dilemma was discussed in [L12]. In the model it was however assumed that the doubling of dark DNA and DNA is real being due to the possibility of having also negatively charged color bonds between dark protons so that dark proton is effectively dark neutron (this might happen even in ordinary nuclear physics in nuclear string model [K12]). The Pythagorean double covering of 3-chords could describe the doubling of codons. The doubling would not occur for the codons for which one has the homonymy - a prediction, which could be perhaps tested.

### 10.2 The map DRNA-DtRNA by 3-chords

The map $64 \rightarrow 40$ for DRNA-DtRNA inducing the corresponding map for $RNA - tRNA$ is not unique since there are many manners to reduces $64$ to $40$. Could this relate to tRNA-RNA homonymy? Consider icosa-tetrahedral code $20 + 20 + 20 + 4 = (3 \times 6 + 2) + (5 \times 4) + (10 \times 2) + (3 + 1)$ as example.

1. Suppose $Z_2$ is the divisor group (also $Z_4$ and $Z_3 \subset Z_6$ can be considered) so that the orbit can split to two and two tRNAs are associated with given amino-acid coded by $n$ codons. At the first step one can take $20_1 + 20_2 + 20_3 + 4 \rightarrow 20_1 + 10_2 + 10_3 + 4 = 44$. Also $10_1 + 20_2 + 10_3 + 4$ and $10_1 + 10_2 + 20_2 + 4$ can be considered. Since $Z_4$ has $Z_2$ as subgroup, the simplest manner to achieve $20_k = 10_k$ is to divide all orbits to 2 $Z_2$ cosets. This can be carried out in 3 manners.

2. One must get rid of 4 tRNAs. This can be achieved in several manners. In $20_1 = 3 \times 6 + 2$ one could have $6 + 2 \rightarrow 3 + 1$: there are 3 alternatives. In $20_2 = 5 \times 4$ one could have $5 \times 4 \rightarrow 3 \times 4 + 2 + 2$ (10 manners). In $20_3 = 10 \times 2$ one can take two 2:s to 1 (45) manners.

3. Could all these maps be realized and could they correspond to different maps at the level of dark codons? If the independence of resonances energies on frequencies is true with an appropriate choice of $h_{\text{eff},i}$, it would seem that in all these cases same chemical tRNA is possible.

### 10.3 Homonymies for RNA-AA correspondence

There are two basic types of homonymies involving bio-molecules.

1. RNA-AA correspondence can vary somewhat and there are 31 variants of genetic code. RNA-tRNA homonymies are common and wobble phenomenon could be regarded as as such homonomy. This homony is poorly understood.

I made the first attempt to understand homonymies in [LS] but failed to realize one absolutely essential feature. Despite RNA-tRNA homonymies there are practically no RNA-AA homonymies. They might be completely absent for given genetic code. There must be a simple explanation for this.
2. In TGD framework the genetic code is replaced with 3 codes. There is DRNA-DtRNA code mapping 64 DRNA codons to 40 DtRNA codons and DtRNA − DAA code mapping 40 DtRNA codons to 20 DAAAs. The composition of these codes gives DRNA-DAA code inducing the RNA-AA code.

The highly non-trivial fact is that one has what mathematician would call commuting triangle: RNA-tRNA-AA = RNA-AA for given code. All the homonymies of RNA-tRNA code are possibly completely compensated for given RNA-AA code. This must have simple explanation and once one has made this question, one also knows its answer in TGD framework.

3. For Hamiltonian cycles the \( n(A) \) codons coding for given AA corresponds to orbit of a fixed codon at the orbit having symmetry group \( Z_{n(A)} \). Genetic code maps the codons at the orbit to the AA corresponding to the orbit and replaces the symmetry group \( Z_n \) with trivial group \( Z_n/Z_n = Z_1 \).

Remark: There are 6 chaotic icosahedral Hamiltonian cycles with symmetry group \( Z_1 \) so that therefore 20 amino-acids each coded by single codon. Could one interpret the 20 amino-acids with the chaotic representation of chaotic icosahedral Hamiltonian cycle?

For RNA-tRNA correspondence similar process is possible. Now one replaces \( Z_n/Z_k \) where \( k \) is factor of \( n \).

Consider icosa-tetrahedral code as an example. \( k = 2 \) is simplest choice since it divides \( n = 6, 4, 2 \) for icosahedral codes but not for tetrahedral code for which one has \( n = 3 \): (ile, ile, ile, met) would naturally correspond to the 2 orbits under tetrahedral \( Z_3 \). This symmetry appears only for icosa-tetrahedral option. For other options one can explain it as an outcome of symmetry breaking for doublets and (ile,ile) and symmetry broken (ile,met) would have ile in common. This looks un-natural.

One can indeed construct 64 → 40 map for DRNA and DtRNA codons by replacing some orbits with their \( Z_2 \) cosets but this map is not completely unique. This is possible for all code candidates, which all contain \( Z_6 \) and \( Z_4 \) symmetric icosahedral harmonies giving rise to amino-acids corresponding to 3 6-orbits and one 2-orbit for \( Z_4 \) symmetry and 5 4-orbits with \( Z_4 \) symmetry. The remaining orbits are 3-orbit and 1-orbit for tetrahedral symmetry broken to \( Z_3 \) and 2-plets for \( Z_2 \) orbits.

There are however codes for which RNA-AA correspondence is non-standard. As explained above, the simultaneous replacement UUC-Leu → UUC-Phe and UUG-Leu → UUG-Ser can take place. Also AUG-met → CUG-met and GUG-met → GUG-met can occur.

A general explanation could be as follows. If the two homonymous amino-acids - Phe and Leu and Leu and Ser in the first example and met and Leu and Val in the second example- have very nearly same transition energy, and if the 3-chords correspond transition energies of AA irrespective of frequencies, homonymy becomes possible.

This problem can be avoided if the tRNA pairing second AA with the RNA codon is not present. Both options might be realized in the same organism. It could also happen that second AA is so far from energy resonance that it is only rarely translated.

10.4 Homonymies for RNA-tRNA correspondence

Could the possibility of several harmonies/moods with different chords increase the number of tRNA codons from the minimal value 40? Are these homonymies forced by necessity or do their reflect freedom of MB to choose? Do dialects emerge already at the molecular level and do they have some practical advantage?

1. Could the possibility of several moods demand more than the minimal number of tRNAs. Harmonies correspond to different collections of triplets \( (n_1, n_2, n_3) \) characterizing the chord.

It was however already noticed that the variation of the Planck constants \( h_{eff} \rightarrow h_{eff}/n_k \) associated with the flux tubes can modify the cyclotron energies. This would mean that the emotions are not directly seen at the level of molecular transitions as bio-chemist would certainly argue. If energy resonance couples dark photons to ordinary matter it could be
possible to guarantee the coupling energy does not depend on the values of frequencies of the 3-chord at flux tubes. This would suggest that there is no motivation to increase the number of tRNAs for the lack of required resonance energies.

2. Could a large number of tRNAs as mediators of RNA-AA pairing be something chosen intentionally by MB rather than being forced by chemical limitations. Could surplus of different tRNAs be a safer option when some tRNAs are not produced. In natural languages there is large number of dialects and new are born all the time.

No hard-wired correspondence would exist at chemical level. MB would be to some degree creative and able to build tRNAs from the stuff that it happens to find from the lab! Biology could be creative already at RNA-tRNA level and this flexibility could emerge from the intelligence coded by $h_{eff} = n$: the larger the number of factors of $n$ the higher the intelligence of the system would be.

This flexibility might also explain the homonymy at RNA-AA level and different genetic codes as a formation of dialects.

11 Appendix: Tables of basic 3-chords for the icosahedral harmonies with symmetries

The tables below give list for the three types of 3-chords for the 11 harmonies possessing symmetries. One must remember that the reversal of the orientation for the cycle induces the transformation $C \leftrightarrow C$, $F^\# \leftrightarrow F^\#$, $H \leftrightarrow C^\#$, $F \leftrightarrow G$, $D \leftrightarrow B^\flat$, $E \leftrightarrow G^\#$, $A \leftrightarrow D^\#$ and produces a new scale with minor type chords mapped to major type chords and vice versa. Also one must remember that all 3-chords except those which are simple majors or minors lack the third so that their emotional tone remains uncharacterized. For instance, $C_6$ does could be replaced with $Cm_6$ and $G_7$ with $Gm_7$. The reader can check the chords by direct inspection of the figures. The convention used is that vertex number one corresponds to $C$ note.

<table>
<thead>
<tr>
<th>$(n_0, n_1, n_2)$</th>
<th>0-chords</th>
<th>1-chords</th>
<th>2-chords</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2, 12, 6)</td>
<td>(Faug, Gaug)</td>
<td>(Cm, Dm, Em, F#m, G#m, Bm)</td>
<td>(C9, D9, E9, F#9, G#9, B9)</td>
</tr>
<tr>
<td></td>
<td>(F6, G6, A6, B6, C#6, D#6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1:** Table gives various types of 3-chords for harmonies with $Z_6$ rotational symmetry. Note that half-octave shift is an exact symmetry. Note that $G^aug = CEG^+_4$, $F^aug$ act as bridges between the groups related by half octave shift. The chords have been arranged so that they form orbits of $Z_6$. “Amino-acid chords” correspond to preferred chords at the orbits.

<table>
<thead>
<tr>
<th>$(n_0, n_1, n_2)$</th>
<th>0-chords</th>
<th>1-chords</th>
<th>2-chords</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0, 16, 4)</td>
<td>(D7, D6, G#7, G#6)</td>
<td>(B9, B9, E9, F9)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(G#4+, A9−, C4+, D#9−)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Emaj7, Gmaj7, Bmaj7, C#maj7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(C9−, A9−, F#9−, D9−)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4, 8, 8)</td>
<td>(Cex3, Ex2, F#ex3, B#ex2)</td>
<td>(Dmaj7, E9−, A7, A6)</td>
<td>(B9, F9, C9, G9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(G#maj7, B9−, D#7, D#6)</td>
<td>(E9, B9, F#9, C#9)</td>
</tr>
</tbody>
</table>

**Table 2:** Table gives various types of 3-chords for the two harmonies with $Z_4$ symmetry. 4-plots represent the orbits. First cycle has no harmonic loners. Second cycle gives rise to bio-harmony (4, 8, 8) for which 0-quint chords are dissonant.
Table 3: Table gives various types of 3-chords for harmonies with \( Z_2 \) rotation symmetry acting as half-octave shift. The doublets represent 2-chord orbits.

<table>
<thead>
<tr>
<th>( (n_0, n_1, n_2) )</th>
<th>0-chords</th>
<th>1-chords</th>
<th>2-chords</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0, 16, 4)</td>
<td>((Em, Bm), (Cm, Fm)), ((Dm, Gm))</td>
<td>((D9, G9))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>((G6, C6), (A6, D6))</td>
<td>((E9, B9))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>((D4, G4), ((B4, F4)))</td>
<td>((Cm), (Fm))), ((Dm), (Gm)))</td>
<td>((G6, C6), (B6, D6)))</td>
</tr>
<tr>
<td>(2, 12, 6)</td>
<td>((Ax4, D)))</td>
<td>((C), (F))), ((D), (G)))</td>
<td>((A), (B))), ((C), (D)))</td>
</tr>
<tr>
<td></td>
<td>((Am, D), ((A6, D6)))</td>
<td>((C), (D))), ((B), (G)))</td>
<td>((E), (F))), ((A), (B)))</td>
</tr>
<tr>
<td>(4, 8, 8)</td>
<td>((Ax2, H, D))</td>
<td>((C), (F))), ((D), (G)))</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Table gives various types of 3-chords for harmonies with single reflection symmetry.

<table>
<thead>
<tr>
<th>( (n_0, n_1, n_2) )</th>
<th>0-chords</th>
<th>1-chords</th>
<th>2-chords</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2, 12, 6)</td>
<td>((Ax4, Ax))</td>
<td>((C), (F))), ((D), (G)))</td>
<td>((A), (B))), ((C), (D)))</td>
</tr>
<tr>
<td></td>
<td>((Ax2, Ax))</td>
<td>((C), (F))), ((D), (G)))</td>
<td>((A), (B))), ((C), (D)))</td>
</tr>
<tr>
<td>(4, 8, 8)</td>
<td>((Ax1, D, Ax))</td>
<td>((C), (F))), ((D), (G)))</td>
<td>((A), (B))), ((C), (D)))</td>
</tr>
<tr>
<td>(2, 12, 6)</td>
<td>((H))</td>
<td>((D), (G)))</td>
<td>((C), (F))), ((D), (G)))</td>
</tr>
<tr>
<td>(2, 12, 6)</td>
<td>((G), (D))</td>
<td>((C), (F))), ((D), (G)))</td>
<td>((A), (B))), ((C), (D)))</td>
</tr>
<tr>
<td>(2, 12, 6)</td>
<td>((F), (E))</td>
<td>((C), (F))), ((D), (G)))</td>
<td>((A), (B))), ((C), (D)))</td>
</tr>
</tbody>
</table>

11.0.1 Artificial Intelligence, Natural Intelligence, and TGD

Recently a humanoid robot known as Sophia has gained a lot of attention in net. Sophia uses AI, visual data processing, and facial recognition. Sophia imitates human gestures and facial expressions and is able to answer questions and make simple conversations on predefined topics. The AI program used analyzes conversations, extracts data, and uses it to improve responses in the future. To a skeptic Sophia looks like a highly advanced version of ELIZA.

Personally I am rather skeptical about strong AI relying on a mechanistic view about intelligence. This leads to transhumanism and notions such as mind uploading. It is however good to air out one’s thinking sometimes.

Computers should have a description also in the quantal Universe of TGD and this forces to look more precisely about the idealizations of AI. This process led to a change of my attitudes. The fusion of human consciousness and presumably rather primitive computer consciousness but correlating with the program running in it might be possible in TGD Universe, and TGD inspired quantum biology and the recent ideas about prebiotic systems provide rather concrete ideas in attempts to realize this fusion.

TGD also strongly suggests that there is also what might be called Natural Intelligence relying on 2-D cognitive representations defined by networks consisting of nodes (neurons) and flux tubes (axons with nerve pulse patterns) connecting them rather than linear 1-D representation used by AI. The topological dynamics of these networks has Boolean dynamics of computer programs as a projection but is much more general and could allow to represent objects of perceptive field and number theoretic cognition.
11.1 PART IV: REMOTE MENTAL INTERACTIONS

11.1.1 TGD inspired view about remote mental interactions and paranormal

I have proposed a general vision about what remote mental interactions and related phenomena could be in TGD Universe around 2003. A lot of progress that has taken place since then, and this motivates the reconsideration of this vision. The general vision is that both biology, consciousness, and remote mental interactions and related phenomena labelled as paranormal are predicted to share the same basic mechanisms, and that the proposed vision provides basic concepts and the language allowing to speculate and build simple models. One cannot of course take the proposed models too seriously at the level of details.

The new ideas that have emerged since 2003 are summarized and parapsychological phenomena are discussed at general level. Also some applications of the basic vision are discussed. The notion of conscious hologram is discussed from the point of view of remote mental interactions. The notion of magnetic body is in decisive role as it is also in the understanding of quantum biology in TGD framework. TGD inspired model for OBEs relying on the notion of magnetic body is summarized. The idea is that OBEs could correspond to sensory experiences assignable to magnetic body rather than real body. Also the connections with the work of other researchers, such as Shnoll, Persinger, and Tiller are discussed briefly. The challenge of testing the vision is also considered.

11.1.2 How to test TGD based vision about living matter and remote mental interactions?

The general TGD inspired vision is that both biology, consciousness, and remote mental interactions and related phenomena labelled as paranormal share the same basic mechanisms. This purpose of this chapter is to summarize the new physics effects involved with the TGD inspired quantum view about consciousness and living matter and its applications to remote mental interactions and related phenomena. Also tests are discussed when possible. By the universality of the mechanisms most of the tests reduce to tests for a new physics predicted by TGD.

11.1.3 Hypnosis as remote mental interaction

In TGD framework one can argue that hypnosis represents an example about the fact that brain is not “private property”: hypnotist uses the biological body and brain of the subject as instrument. Therefore remote mental interaction is in question. This idea generalizes: if one accepts self hierarchy, one can assign to any kind of higher level structure - family, organization, species, .... - a higher level self and magnetic body carrying dark matter, and these magnetic bodies can use lower level magnetic bodies as their instruments to realize their intentions. Biological bodies would be an important level in the hierarchy, which would continue down to cellular, molecular, and perhaps to even lower levels.

This view challenges the prevailing views about brain as a sole seat of consciousness and the assumption that conscious entities assigned with brains are completely isolated. Given magnetic body can use several biological bodies although one can assign to it the one providing the sensory input - at least during wake-up state. Note however that it is easy to produce illusion that some foreign object is part of biological body.

For more than decade ago I proposed a model for so called bicamerality based on the notion of semitrance. In semitrance the brain of subject becomes partially entangled with a higher level self - in this case the self of family or more general social group uses the biological body of member for its purposes. Higher level self gives its commands and advice interpreted by the bicameral as “God’s voice”. The consciousness of schizophrenic might be basically bicameral. Also hypnotic state and dream consciousness are candidates for bicameral consciousness.

In this article I develop essentially this idea but using as input the recent understanding of about TGD inspired theory of consciousness and quantum biology and end up with a proposal for a detailed mechanism for how the magnetic body hijacks some parts of the brain of the subject: prefrontal cortex and anterior cingulate cortex are argued to be the most plausible targets of hijacking. Also a mechanism explaining how the sensory hallucinations and motor actions are induced by hypnotist by inhibiting a halting mechanism preventing imagined motor actions to become real and sensory imagination to become “qualiafied”.
11.1.4 Meditation, Mind-Body Medicine and Placebo: TGD point of view

The chapter represents TGD inspired answers to Lian Sidorov’s questions concerning meditation, mind-body medicine and placebo in quantum biology framework. To help the reader, some aspects of TGD inspired theory of consciousness and quantum biology are summarized since several new insights inspired by the notions of magnetic body and dark matter have emerged lately. This includes improved views about quantum metabolism and prebiotic life: the basic input comes from the claimed free energy phenomena interpreted in TGD framework. Water structures representing simplified analogs of basic biomolecules suggested by water splitting producing so called Brown’s gas might be highly relevant also for the ordinary metabolism. The main new input concerning remote mental interactions comes from a possible answer to the question whether TGD based ontology of physics could allow the “shamanistic” view that the experiences (say encounters with strange life forms assigned with distant civilizations) induced by various psychedelics used in the spiritual practices of indigenous people could be genuine remote sensory perceptions rather than hallucinations. Affirmative answer would mean a direct and testable connection between neuropharmacology and remote sensory perception with serotonin defining the crucial neurotransmitter and pineal gland (“third eye”) serving as a candidate for the brain area of special importance in this respect.

Concerning the questions about meditation, mind-body medicine and placebo, the key concept is that of magnetic body. Usually organism and environment are seen as members of an interacting pair: organism receives sensory data from environment and controls it. Now magnetic body appears as a third party, “intentional agent” using biological body as a kind of interface between magnetic body and environment. Various “motor actions” of the magnetic body are highly relevant for both consciousness and biochemistry. The pairs formed by various information molecules and corresponding receptors could define plug-ins to the Indra’s net (or Internet) defined by the magnetic bodies and Josephson radiation emitted by Josephson currents assignable to receptors would propagate along flux tubes. Meditation can be seen as “bodily exercise” of the magnetic body and a method to improve the communications between magnetic body and biological body. In healing magnetic body would be the active participant and healing would be also the healing of magnetic body. The placebo effect could be seen as an outcome of intentions of magnetic body affecting biological body.

11.1.5 Non-locality in quantum theory, in biology and neuroscience, and in remote mental interactions: TGD perspective

Non-locality seems to be a basic aspect of what it is to be living. Living system is elementary particle like coherent unit. The phenomenon of memory suggests temporal non-locality. Also remote mental interactions - if real - suggest non-locality. In fact, non-locality - both spatial and temporal - is the basic element of entire quantum TGD, and in particular, of its applications to quantum biology, neuroscience, theory of consciousness, and also of remote mental interactions.

In the sequel I make kind of pseudo deduction of the picture provided by Topological Geometrodynamics (TGD) by starting from empirical findings loosely related to non-locality rather than problems of General Relativity or of particle physics. The hope is that this could make the basic ideas of TGD easier to grasp. Also the mathematical framework and its interpretation as they are now are briefly discussed and the some applications to TGD inspired theory of consciousness and quantum biology are discussed.

11.1.6 Questions about IIT

Integrated Information Theory (IIT) is a neuro- and computer science based theory of consciousness proposed originally by Tononi. This article is a critical summary of IIT and its comparison with TGD inspired theory of consciousness. Basic criticism relates to the circular definition of consciousness leading to a paradox. The printing of a text by printer is a conscious process if no-one knows the text but not so if some-one knows the text. One could test IIT by looking if a system with large Φ (say classical computer in which program is running) has the properties associated with living conscious systems (self-organization in presence of energy feed, metabolism, responsiveness,...). Also the questions about possible experimental testing of IIT raised by the participants of the panel are discussed.
REFERENCES

Mathematics


Cosmology and Astro-Physics


Books related to TGD


ARTICLES ABOUT TGD


[K38] Pitkänen M. About the Nottale’s formula for $h_{gr}$ and the possibility that Planck length $l_{P}$ and CP$_{2}$ length $R$ are identical giving $G = R^{2}/h_{eff}$. In *Hyper-finite Factors and Dark Matter Hierarchy.* Online book. Available at: [http://www.tgdtheory.fi/tgdhtml/neuplanck.html#vzerovariableG](http://www.tgdtheory.fi/tgdhtml/neuplanck.html#vzerovariableG) 2018.

Articles about TGD


Articles about TGD


Articles about TGD


