

The latest progress in TGD

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1 Introduction

I started to develop TGD for 43 years ago (towards end of 1977). During last 30 years the understanding of the mathematical aspects of TGD and its connection with the empirical world has developed rapidly. Therefore it seems appropriate give an overall view about the developments as links (mostly) to blog postings. Below I list blog links to Quantum TGD, its applications to physics, to biology and to consciousness theory with the intention to give an overall view about the sometimes tortuous development of the ideas (I did not receive the final form of TGD from heaven and have been forced to work hardly for more than four decades!).

2 Basic Quantum TGD

TGD differs in several respects from quantum field theories and string models. The basic mathematical difference is that the mathematically poorly defined notion of path integral is replaced with the mathematically well-defined notion of functional integral defined by the Kähler function defining Kähler metric for WCW ("worlds of classical worlds"). Apart from the notion of quantum jump, quantum TGD is essentially a theory of classical WCW spinor fields with WCW spinors represented as fermionic Fock states. It has been clear from the beginning that the gigantic super-symplectic symmetries generalizing ordinary super-conformal symmetries are crucial for the existence of WCW Kähler metric [K7, K5, K18]. The detailed identification of Kähler function and WCW Kähler metric has however turned out to be a difficult problem.

It is now clear that WCW geometry can be understood in terms of the analog of AdS/CFT duality between fermionic and space-time degrees of freedom (or between Minkowskian and Euclidian space-time regions) allowing to express Kähler metric either in terms of Kähler function or in terms of anti-commutators of WCW gamma matrices identifiable as super-conformal Noether super-charges for the symplectic algebra assignable to $\delta M_{\pm}^4 \times CP_2$. The string model description of gravitation emerges and also the TGD based view about dark matter becomes more precise.

The understanding of scattering amplitudes has been the main goal. S-matrix codes for them in standard QFTs. The notion of S-matrix turned however to be a continual headache. I failed to find any general principle providing a unitary S-matrix, even less a general construction recipe.

It turned out that entire quantum theory needed a profound modification based on three new ideas.

1. The emergence of zero energy ontology (ZEO) was one important step towards the goal and meant a profound modification of the standard ontology solving the basic paradox of quantum measurement theory. Zero energy states as superpositions of classical deterministic time evolutions connecting initial and final states at boundaries of causal diamond (CD) would replace quantum states as time=constant snapshots. The counterpart of S-matrix would be defined in terms of entanglement coefficients between the members of state pairs at boundaries of causal diamond (CD). But does one obtain a unitary S-matrix or something more general?
2. Number theoretic vision about TGD in turn predicted a hierarchy of Planck constants $h_{eff} = nh_0$ labelling the phases of ordinary matter identifiable as dark matter. n is identifiable as dimension of extension of rationals as a degree of a real polynomial determining the space-time in the space of complexified octonions O_c in the picture based on $M^8 - H$ duality. Hierarchy of Planck constants means a
3. The most recent step occurred towards the end of 2020. The basic observation was that Kähler metric has properties very similar to those of unitary S-matrix. Both the complex analogs of probabilities and their real counterparts sum up to unity, and the rows of the Kähler metric as matrix are orthogonal just as in

the case of a unitary S-matrix. One obtains the analogs of unitarity conditions and under some additional conditions Kähler metric indeed defines unitary S-matrix. To obtain positive real probabilities a much milder condition stating that the complex analogs of probabilities define coordinates for Teichmueller space.

One must provide the base space of the Hilbert space bundle (the "world of classical worlds" (WCW)) with a Kähler metric of the base space extending to a Kähler metric in the bundle having WCW spinor fields as a fiber. This would mean a geometrization of Hilbert space level analogous to that introduced by Einstein at the level of space-time.

This picture poses rather tight constraints on the counterpart of S-matrix. In particular, the infinite-D isometry group of WCW provides extremely powerful constraints. A further important input was the realization that the induction procedure for the spinors of H as restriction to space-time surface generalizes to a second quantized free spinor field of H expressible in terms of the modes of H -spinors. This fixes completely fermionic propagators (actually quark propagators since leptons can be constructed as 3-quark states at single partonic 2-surface). The counterpart of S-matrix is obtained as vacuum expectation values of the quantities constructed in terms of the fermionic and bosonic generators of supersymplectic algebra associated with the isometries of WCW and assigned with partonic 2-surfaces acting as topological vertices. The condition that normal ordering divergences vanish, fixes the details of the construction.

The following postings give an overall view about rather tortuous development of ideas involving many sidetracks. I could of course bury all documents about the sidetracks. I however think that there is no point in pretending that the final vision would have emerged in a single flash. The text in the beginning of sections reflect the situation when this text was prepared and are in many respects out-of-date.

2.1 Physics as geometry of "world of classical worlds" (WCW)

1. Recent View about Kähler Geometry and Spin Structure of "World of Classical Worlds"
2. The vanishing of super-conformal charges as a gauge conditions selecting preferred extremals of Kähler action
3. About the twistorial description of light-likeness in 8-D sense using octonionic spinors
4. Updated view about the Kähler geometry of "world of classical worlds"
5. What TGD is and what it is not
6. What TGD is and what it is not
7. Updated View about Kähler geometry of WCW
8. The relation between U- and M-matrices

9. Could one define dynamical homotopy groups in WCW?
10. How it went?
11. Tensor nets and S-matrices
12. Tetrahedral equation of Zamolodchikov
13. Could $\mathcal{N} = 2$ super-conformal algebra be relevant for TGD?
14. The analog of unitary S-matrix from a curved Kähler geometry of the space of WCW spinor fields
15. TGD as it is towards end of 2021
16. Should one replace the notion of unitary matrix with Kaehler metric of fermionic state space?
17. More about the replacement of S-matrix with a generalized Kaehler metric in fermionic degrees of freedom
18. Arnold's conjecture, generalization of Floer's theory, and TGD
19. Homology of "world of classical worlds" in relation to Floer homology and quantum homology
20. Are space-time boundaries possible in the TGD Universe?

2.2 TGD counterpart of Dirac action at space-time level

The identification of the counterpart of Dirac action at the space-time level (there are also Dirac actions at embedding space level and WCW level!) has been the fundamental challenge for TGD [K15, K18] [L18]. Super-symplectic symmetry and super-Kac-Moody symmetries assignable to light-like partonic orbits serve strong guidelines.

The first guess was that Dirac action in H could be what I called Kähler-Dirac action with gamma matrices replaced by contractions of canonical momentum currents of Kähler action with embedding space gamma matrices. This definition is completely general and applies also when the action contains volume term (twistor lift of TGD forces it).

This definition implies supersymmetry in the sense that bosonic action determines modified Dirac action completely and one indeed obtains an infinite number of supersymmetries associated with the modes of the modified Dirac operator. This is not however the ordinary SUSY. These super-charges would give rise to the gamma matrix algebra of WCW.

The quantization of the induced spinor fields would reduce to that for embedding space spinor fields restricted at space-time surface. Modified Dirac action is consistent with the induction since the modes of the embedding space spinor field can be expanded in terms of the modes of modified Dirac action at space-time surface and determined their coefficients as combinations of oscillator operators of embedding space spinor field.

Second guideline is physical. The electromagnetic charge should be well-defined for the spinor modes in H . This condition is satisfied if the modified Dirac action is localized at string world sheets (and with mild additional conditions at light-like 3-surfaces) at which classical W boson fields and perhaps also Z_0 field vanish. These conditions could be satisfied also for special extremals of 4-D Kähler-Dirac action. Also integrability conditions must be satisfied at string world sheets and canonical momentum currents must be tangential to the stringy surfaces. The construction of preferred extremals would rely on holography quite concretely: string world sheets, partonic 2-surfaces, and possibly also their light-like orbits are fixed, and space-time surface is constructed using this data. The vanishing of symplectic conformal charges for sub-algebra of super-symplectic algebra isomorphic with the algebra itself would fix the space-time surface to a high degree.

The simplest option is that bosonic action contains 4-D, 3-D, 2-D, and 1-D parts and corresponding modified Dirac action. The induced spinor fields in all cases would be restrictions of the second quantized spinor field of H [L20, L19] so that no separate second quantization would be needed.

$M^8 - H$ duality provides a different perspective [L17, L15].

1. At the level of M^8 space-time surfaces are identified as co-associative 4-manifolds of M^8 as subspace of complexified octonion [L15]. By holomorphy, minimal surfaces are in question in accordance with the idea that space-time surfaces provide a geometrization of massless fields. Co-associativity allows to map these surfaces to holomorphic minimal 4-surfaces in H : the twistor lift of TGD predicts also minimal surfaces as preferred extremals for which coupling parameters do not appear at all in field equations reducing to mere algebraic conditions expressing holomorphy. Also light-like 3-surfaces and string world sheets in M^8 are predicted and mapped to H .
2. The octonionic Dirac equation at the level of O_c must be purely algebraic rather than being a partial differential equation and thus the analog for the momentum representation of ordinary Dirac equation `citebartM8Hfermion`. This implies that octonionic spinors are restricted on 3-D light-like surfaces in O_c and naturally mapped to light-like partonic orbits in H . At least at the level of O_c fermions would be 3-D or even 1-D and restricted to the intersections of string world sheets with partonic orbits. This would solve the problems associated with the well-definedness of em charge. This however leaves open the question whether the 4-D part of the induced spinor field can be present in H - physical intuition suggests that the modes for which em charge is conserved and W boson field thus vanishes, are possible.

At the level of H , this picture suggests that one should add to the 4-D action also 3-D Chern-Simons-Kähler action associated with the light-like partonic orbits and also stringy action possibly as the ordinary string area. This could bring in the gravitational constant as a fundamental coupling parameter and the ratio $\hbar G/R^2$ (R is CP_2 "radius") would be fixed by quantum criticality. This is however not consistent with the AdS/CFT inspired idea that the strings connecting partonic 2-surfaces are responsible for the formation of gravitational bound states. For ordinary Planck constant only gravitational bound states of order Planck length would be

possible. Even for $h_{eff} = n \times h$ is not enough. For $1/h_{eff}^2$ proportionality of the effective string area predicted by Kähler action, the size of bound states is of order GM/v_0 for $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ applying in planetary system.

1. String world sheets, partonic 2-surfaces and vanishing of induced (classical) weak fields
2. Second quantisation of Kähler-Dirac action
3. About the twistorial description of light-likeness in 8-D sense using octonionic spinors
4. Updated view about the Kähler geometry of "world of classical worlds"
5. Updated view about the Kähler geometry of "world of classical worlds"
6. Holography and Quantum Error Correcting Codes: TGD View
7. Tensor nets and S-matrices
8. ER=EPR in TGD framework
9. Non-commutative space and strong form of holography
10. Is there a duality between associative and co-associative space-time surfaces?
11. Could categories, tensor networks, and Yangians provide the tools for handling the complexity of TGD?
12. Are higher structures needed in the categorification of TGD?
13. Generalization of Riemann zeta to Dedekind zeta and adelic physics
14. Could metaplectic group have some role in TGD framework?
15. Could ZEO provide a new approach to the quantization of fermions?
16. The notion of holography in TGD framework
17. Neutrinos and TGD

2.3 Symmetries of TGD

TGD differs from string models in that there is a gigantic generalization of superconformal symmetries [K5, K19] to isometries of the "world of classical worlds" (WCW).

The first guess would be that conformal symmetries of string models could be extended in a highly non-trivial manner to their 4-D quaternionic counterparts and one could say that complex numbers are replaced with quaternions. The notion of conformal invariance however fails to generalize in a straightforward manner.

There are two complementary approaches to the problem.

1. The geometrization of quantum physics in terms of WCW Kähler geometry provides the first approach. The existence of WCW Riemann connection requires a maximal - and therefore infinite-D - group of isometries as the study of loop spaces demonstrated [?]. These symmetries would decompose to three parts corresponding to super-symplectic symmetries acting at the boundary of light-cone assignable to causal diamond and affecting space-time interior (Kähler action plus volume term), those assignable to the light-like orbits of partonic 2-surfaces (Chern-Simons-Kähler action), and those associated with string world sheets (string world sheet area).
2. The second approach is number theoretic. $M^8 - H$ duality is needed to understand this. M^4 is identifiable as a sub-space of complexified octonions O_c in which the O_c octonion norm is real valued. Space-time surface as image of M^4 by octonionic polynomial P would be co-associative in the sense that the normal space would be associative and thus quaternionic. Space-time surface would contain also co-commutative 2-surfaces identifiable as string world sheets. Co-associative surfaces would be realized as roots for the real part (in quaternionic sense) of a polynomial obtained by algebraic continuation of a real polynomial P .

Co-associativity would allow to map these surfaces to H by $M^8 - H$ duality. Number theoretic holography would be extremely strong: the roots of P alone would dictate the space-time surface! One could speak of octonion analyticity as analog of ordinary complex analyticity. It is clear that number theoretic holography forces the presence of huge internal symmetries having identification as super-symplectic and super-Kac-Moody symmetries at the level of H .

1. About the notion of four-momentum in TGD framework
2. What went wrong with symmetries?
3. The vanishing of super-conformal charges as a gauge conditions selecting preferred extremals of Kähler action
4. Updated view about the Kähler geometry of "world of classical worlds"
5. Field equations as conservation laws, Frobenius integrability conditions, and a connection with quaternion analyticity
6. Are Preferred Extremals Quaternion-Analytic in Some Sense?
7. Some comments about classical conservation laws in Zero Energy Ontology
8. About TGD counterparts of classical field configurations in Maxwell's theory
9. Idea before its time: space-time surfaces as Kähler calibrated surfaces
10. A connection of singularities of minimal surfaces with generation of Higgs vacuum expectation?

11. Minimal surfaces: comparison of the perspectives of mathematician and physicist
12. What could 2-D minimal surfaces teach about TGD?

2.4 Number theoretic vision

Number theoretic vision involves three strands: p-adic physics, classical number fields, and infinite primes.

2.4.1 p-Adic and Adelic Physics

Number theoretic universality states that besides reals and complex numbers also p-adic number fields are involved (they would provide the physical correlates of cognition). Furthermore, scattering amplitudes should be well-defined in all number fields be obtained by a kind of algebraic continuation [K28].

I have introduced the notion of intersection of realities and p-adicities, which corresponds to some algebraic extension of rationals inducing an extension of p-adic numbers for all primes p . Adelic physics is a strong candidate for the realization of fusion of real and p-adic physics, and would mean the replacement of real numbers with adeles. Field equations would hold true for all number fields and the space-time surfaces would relate very closely to each other: one could say that p-adic space-time surfaces are cognitive counterparts of the real ones.

Adelic physics [L8, L9] leads to the notion of cognitive representation. One has a hierarchy of p-adic number fields as extensions induced by extensions of rationals assignable to the polynomials defining space-time surfaces in M^8 picture. This defines a hierarchy of adeles. Cognitive representations a unique discretization of space-time surfaces would consist of points of space-time with almost unique octonionic coordinates of O_c defining M^8 coordinates with values in the extension of rationals considered. They would represent the intersection of realities and p-adicities representing non-deterministic imaginations - non-determinism would be due to the presence of pseudo-constants as integration constants.

The ideas about p-adic space-time sheets as correlates of intentions, imaginations, and cognitions and the idea about cognitive representations as intersection of realities and p-adicities have evolved via several sidetracks.

1. The idea has been that p-adic space-time sheets would be not only “thought bubbles” representing real ones but also correlates for intentions and the transformation of intention to action would correspond to a quantum jump in which p-adic space-time sheet is transformed to a real one. Alternatively, there would be a kind of leakage between p-adic and real sectors. Cognitive act would be the reversal of this process. In “big” (ordinary) state function reductions (BSFRs) p-adic space-time surfaces involving p-adic pseudo constants as integration constants and not realizable as real spacetime surfaces would be replaced with real space-time surfaces for which integration constants are genuine constants.

The latest view about the realization of intention as action [K34] relies on the representation of the space-time surface at the level of M^8 as a root of the real

part of an octonionic polynomial (real part in quaternionic sense) defining a co-associative space-time surface mappable to H by $M^8 - H$ duality. p-Adic sectors would correspond to polynomials, whose coefficients are pseudo constants (vanishing derivative in p-adic sense) and therefore piecewise constant functions, and therefore not making sense as real space-time surfaces. The coefficients would be piecewise constant functions of the light-like coordinate r of the light-like boundary of 8-D CD. In the state function reduction transforming intention to action, the coefficients of P would become constant and the interpretation as a real space-time surface would become possible.

2. This realization allows to clarify the thoughts about what the intersection between p-adicities and realities could be. Intersection would correspond in strong form of holography (SH) to string world sheets and partonic 2-surfaces at which spinor modes are localized for several reasons: the most important reasons are that em charge must be well-defined for the modes and octonionic and real spinor structures can be equivalent at them to make possible twistorization both at the level of embedding space and its tangent space. Cognitive representations would consist of points of these 2-surfaces with M^8 coordinates in the extension of rationals. They would be natural carries of fermion number.

The parameters characterizing space-time surfaces as points of WCW would be discretized - that is belong to an appropriate algebraic extension of rationals so that surfaces are continuous and make sense in real number field and p-adic number fields. By conformal invariance they might be just conformal moduli. Teichmüller parameters, positions of punctures for partonic 2-surfaces, and corners and angles at them for string world sheets. In fact, the recent work related to the construction of the TGD counterpart of S-matrix also leads to Teichmüller spaces [L20].

3. Fermions are correlates for Boolean cognition and anti-commutation relations for them are number theoretically universal, even their quantum variants when algebraic extension allows quantum phase. Fermions and Boolean cognition would reside in the number theoretically universal intersection. Of course they must do so since Boolean thought and cognition in general is behind all mathematics!
4. I have proposed this in p-adic mass calculations for two decades ago. The discretization by cognitive representations would be a wonderful simplification of the theory: by super-symplectic invariance WCW would reduce to finite-dimensional moduli space as far as calculations of scattering amplitudes are considered. The testing of the theory requires classical theory and 4-D space-time. This holography would not mean that one gives up space-time: it is necessary. Only cognitive and as it seems also fundamental sensory representations are 2-dimensional. All that one can mathematically say about reality is by using data at these 2-surfaces. The rest is needed but it requires mathematical thinking and transcendence! This view is totally different from the sloppy and primitive philosophical idea that space-time could somehow emerge from discrete space-time.

This has led also to modify the ideas about the relation of real and p-adic physics.

1. The notion of p-adic manifolds was hoped to provide a possible realization of the correspondence between real and p-adic numbers at space-time level. It relies on the notion canonical identification mapping p-adic numbers to real in continuous manner and realizes finite measurement resolution at space-time level. p-Adic length scale hypothesis emerges from the application of p-adic thermodynamics to the calculation of particle masses but generalizes to all scales [K8].
2. The problem with p-adic manifolds is that the canonical identification map is not a general coordinate invariant notion. The hope was that one could overcome the problem by finding preferred coordinates for the embedding space.
 - (a) Consider first the situation at the level of $M^8 \subset O_c$. In this case of M^8 octonionic structure would fix the coordinate frame apart from translations along the real octonionic coordinate. For co-associative surfaces this coordinate would be zero so that M^4 linear coordinates would be unique. At the level the real-padic correspondence would be therefore essentially unique.
 - (b) What about H ? For M the situation would not change. For CP_2 complex coordinates transforming linearly under $U(2)$ suggest themselves. There would be however many choices corresponding to algebraic sub-group of $U(2)$ with matrix elements in a sub-group defined by the extension of rationals considered. If this group is required to be finite, the number of group elements is finite. The non-uniqueness however persists but one could argue that there is no problem if the breaking of symmetries is below the measurement resolution. The discretization is however non-unique and makes the approach ugly although the idea about p-adic manifold as a correlate of cognition is nice.
3. One could restrict the canonical identification to the points in cognitive representation belonging to the algebraic extension of rationals. These could be mapped to p-adic points as such or using canonical identification or its variant. For instance, a rational number m/n could be mapped to $I(mm)/I(n)$, which is still a rational number and the algebraic numbers defining the units of extension would be mapped as such. That the p-adic space-time surfaces cannot be constructed uniquely from the cognitive representation would reflect the finite measurement resolution.
4. A possible solution of problems came with the discovery of an entirely different approach. First of all, one can realize the discretization at the level of WCW. This discretization is more abstract: the parameters characterizing the objects of WCW are discretized - that is assumed to belong to an appropriate algebraic extension of rationals so that surfaces are continuous and make sense in real number field and p-adic number fields.

Secondly, one can use the strong form of holography (SH) stating that string world sheets and partonic 2-surfaces define the “genes of space-time”. The

only thing needed is to algebraically extend by algebraic continuation these 2-surfaces to 4-surfaces defining preferred extremals of Kähler action - real or p-adic. Space-time surfaces have vanishing Noether charges for a sub-algebra of super-symplectic algebra with conformal weights coming as n -ples of those for the full algebra- hierarchy of quantum criticalities and Planck constants and dark matters!

One does not try to map real space-time surfaces to p-adic ones to get cognitive charts but 2-surfaces defining the space-time genes to both real and p-adic sectors to get adelic space-time! The problem with general coordinate invariance at space-time level disappears totally since one can assume that these 2-surfaces have rational parameters. One has discretization in WCW, rather than at space-time level. As a matter of fact, this discretization selects punctures of partonic surfaces (corners of string world sheets) to be algebraic points in some coordinatization but in a general coordinate invariant manner.

5. A further nice result is that one can understand imagination in terms of p-adic pseudo constants but in a much more refined manner. The possibility of pseudo-constants suggests strongly that almost any collection of string world sheets and partonic 2-surfaces (briefly 2-surfaces) allows a holographic continuation to a p-adic preferred extremals of Kähler action. Preferred extremal property in real case however implies strong correlations between the 2-surfaces involved and in the generic case the continuation to a real space-time surface is not expected to be possible. The 2-surfaces having a continuation to various p-adic space-time surfaces but not real one would represent imaginable but not realizable. The state function reduction to the opposite boundary would give as outcome 2-surfaces, which also allows a continuation to a real space-time surface. This is a killer test in quite concrete sense since the mental image representing intention is transformed to real action. In fact, this option can be equivalent with the one, described above.
6. The vision about evolutionary hierarchy as a hierarchy of algebraic extensions of rationals inducing those of p-adic number fields become clear. The algebraic extension associated with the 2-surfaces in the intersection is in question. The algebraic extension associated with them becomes more and more complex in evolution. Of course, NMP, negentropic entanglement (NE) and hierarchy of Planck constants are involved in an essential manner too. Also the measurement resolution characterized by the number of space-time sheets connecting average partonic 2-surface to others is a measure for “social” evolution since it defines measurement resolution.

There are two questions, which I have tried to answer during these two decades.

1. What makes some p-adic primes preferred so that one can say that they characterizes elementary particles and presumably any system?
2. What is behind p-adic length scale hypothesis emerging from p-adic mass calculations and stating that primes near but slightly below two are favored physically, Mersenne primes in particular. There is support for a generalization

of this hypothesis: also primes near powers of 3 or powers of 3 might be favored as length- and time scales which suggests that powers of prime quite generally are favored.

The adelic view led to possible answers to these questions. The answer to the first question has been staring directly on my eyes for more than a decade.

1. The algebraic extension of rationals allow so called ramified primes. Rational primes decompose to a product of primes of extension but it can happen that some primes of extension appear as higher than first power. In this case one talks about ramification. The product of ramified primes for rationals defines an integer characterizing the ramification. Also extension allows similar characteristic. Ramified primes are a highly natural candidate for preferred primes of an extension (I know that I should talk about prime ideals, sorry for a sloppy language): that preferred primes could follow from number theory itself I had not thought earlier and tried to deduce them from physics. One can assign the characterizing integers to the string world sheets to characterize their evolutionary level. Note that the earlier heuristic idea that space-time surface represents a decomposition of an integer is indeed realized in terms of holography!
2. Also infinite primes seem to finally find the place in the big picture. Infinite primes are constructed as an infinite hierarchy of second quantization of an arithmetic quantum field theory. The infinite primes of the previous level label the single fermion - and boson states of the new level but also bound states appear. Bound states can be mapped to irreducible polynomials of n -variables at n :th level of infinite obeying some restrictions. It seems that they are polynomials of a new variable with coefficients which are infinite integers at the previous level.

At the first level bound state infinite primes correspond to irreducible polynomials: these define irreducible extensions of rationals and as a special case one obtains those satisfying so called Eisenstein criterion: in this case the ramified primes can be read directly from the form of the polynomial. Therefore the hierarchy of infinite primes seems to define algebraic extension of rationals, that of polynomials of one variables, etc.. What this means from the point of physics is a fascinating question. Maybe physicists must eventually start to iterate second quantization to describe systems in many-sheeted space-time! The marvellous thing would be the reduction of the construction of bound states - the really problematic part of quantum field theories - to number theory!

The answer to the second question requires what I call a weak form of NMP.

1. Strong form of NMP states that negentropy gain in quantum jump is maximal: density matrix de-compose into sum of terms proportional to projection operators: choose the sub-space for which number theoretic negentropy is maximal. The projection operator containing the largest power of prime is selected. The problem is that this does not allow free will in the sense as we tend to use: to make wrong choices!

2. Weak NMP allows to choose any projection operator and sub-space which is any sub-space of the sub-space defined by the projection operator. Even 1-dimensional in which case standard state function reduction occurs and the system is isolated from the environment as a prize for sin! The weak form of NMP is not at all so weak as one might think. Suppose that the maximal projector operator has dimension n_{max} which is a product of a large number of different but rather small primes. The negentropy gain is small. If it is possible to choose $n = n_{max} - k$, which is a power of prime, negentropy gain is much larger!

It is largest for powers of prime defining n-ary p-adic length scales. Even more, large primes correspond to more refined p-adic topology: $p = 1$ (one could call it prime) defines discrete topology, $p = 2$ defines the roughest p-adic topology, the limit $p \rightarrow \infty$ is identified by many mathematicians in terms of reals. Hence large primes $p < n_{max}$ are favored. In particular primes near but below powers of prime are favored: this is nothing but a generalization of p-adic length scale hypothesis from $p = 2$ to any prime p .

A further interesting question is what makes ramified primes so special. Here the answer would be that the action of the Galois group at the ends of space-time surfaces for which parameters belong to a prime ideal defined by ramified prime is trivial. n space-time surfaces collapse to a single 3-surface at their ends and one obtains the classical realization of quantum criticality and n additional discrete degrees of freedom.

1. p-Adic length scale hypothesis for twin primes
2. Is evolution 3-adic?
3. Could adelic approach allow to understand the origin of preferred p-adic primes?
4. How preferred p-adic primes could be determined?
5. Updated Negentropy Maximization Principle
6. What could be the origin of p-adic length scale hypothesis?
7. Breakthroughs in the number theoretic vision about TGD
8. More about physical interpretation of algebraic extensions of rationals
9. p-Adic physics as physics of cognition and imagination
10. Gaussian Mersennes in cosmology, biology, nuclear, and particle physics
11. Congruence subgroups of $SL(2, \mathbb{R})$, Monster Moonshine, Gaussian Mersennes, and p-adic physics
12. Could one realize number theoretical universality for functional integral?
13. Algebraic universality and the value of Kähler coupling strength

14. Some applications of Number Theoretical Universality
15. Are the zeros of Riemann zeta number theoretically universal?
16. Does Riemann Zeta Code for Generic Coupling Constant Evolution?
17. Why the non-trivial zeros of Riemann zeta should reside at critical line?
18. Is non-associative physics and language possible only in many-sheeted space-time?
19. Why Mersenne primes are so special?
20. How Ramanujan did it?
21. p-Adicizable discrete variants of classical Lie groups and coset spaces in TGD framework
22. Is the sum of p-adic negentropies equal to real entropy?
23. Langlands program and TGD
24. Comments about Ben Goertzel's ideas related to p-adic physics
25. Boolean algebras, Stone spaces and TGD
26. Mersenne integers and brain
27. p-Adic logic and hierarchy of partition algebras
28. NMP and self
29. Progress in Adelic TGD
30. About some unclear technical issues of TGD
31. What could be the role of complexity theory in TGD?
32. $h_{eff}/h = n$ hypothesis and Galois group
33. Why would primes near powers of two (or small primes) be important?
34. Philosophy of Adelic Physics
35. About McKay and Langlands correspondences in TGD framework
36. Could McKay correspondence generalize in TGD framework?
37. Philosophy of Adelic Physics from Springer
38. About $h_{eff}/h = n$ as the number of sheets of Galois covering
39. General number-theoretical ideas about coupling constant evolution
40. Number theoretic vision about Riemann zeta and evolution of K hler coupling strength

41. Could functional equation and Riemann hypothesis generalize?
42. What perfectoid and its tilt introduced by Fields medalist Peter Scholze are?
43. Two comments about coupling constant evolution
44. Atiyah, fine structure constant, and TGD view based view about coupling constant evolution
45. Reduction of coupling constant evolution to that for cosmological constant
46. Solution of renormalization group equation for flux tubes having minimum string tension and RG evolution in terms of Riemann zeta
47. Generalized conformal symmetry, quantum criticality, catastrophe theory, and coupling constant evolution
48. About the physical interpretation of ramified primes in TGD framework
49. Shnoll effect decade later
50. Secret Link Uncovered Between Pure Math and Physics
51. About the mathematics needed in TGD
52. What extensions of rationals could be winners in the fight for survival?
53. Trying to understand why ramified primes are so special physically
54. Some comments about number theoretic discretisation
55. When do partonic 2-surfaces and string world sheets define large cognitive representations?
56. Comparing Gisin's intuitionistic mathematics with adelic physics
57. Mathematical bridge connecting Diophantine equations and spectrum of automorphic functions
58. Wolfram's proposal for discrete space-time dynamics
59. About p-adic length scale hypothesis and dark matter hierarchy
60. $MIP^*=RE$: What it could possibly mean?
61. What $MIP^*=RE$ could mean in TGD Universe?
62. Does Goedel's incompleteness theorem hold true for reals?
63. Questions related to coupling constant evolution
64. About the role of Galois groups in TGD framework
65. Minimal value of h_{eff} from the ratio of Planck mass and CP2 mass?

66. Evolution of Kähler coupling strength
67. The conjectured duality between number theory and geometry from TGD point of view
68. Could the notion of a polynomial of infinite degree make sense?
69. Adelic physics and quantum measurement theory
70. Galois confinement
71. Braids, anyons, and Galois groups
72. Could computable reals (p-adics) replace reals (p-adics) in physics?
73. p-Adic particle massivation and entanglement: are all physical states massless?!
74. Some comments of the notion of mass
75. About the TGD based notions of mass, of twistors and hyperbolic counterpart of Fermi torus

2.4.2 Quaternions and octonions

The dimensions of the basic geometric objects in TGD suggest strongly that classical number fields should be crucial for understanding of TGD [K29]. The basic dynamical principle would be requirement of associativity for the tangent space or normal space space-time surface in embedding space with octonionic tangent space. This would give space-time surfaces as quaternionic or co-quaternionic surfaces or possibly both. String world sheets would in turn be commutative or co-commutative 2-surfaces with spinor connection which should be also consistent with associativity/co-associativity. The light-like boundaries would correspond to real or co-real sub-manifolds so that the hierarchy well-orderedness-commutativity-associativity might characterize physics.

It turns out that only co-associativity, co-commutativity, and co-reality allow M^8H duality. The normal space of space-time surface would be associative and contain co-commutative sub-space most probably as preferred octonionic plane containing octonionic real axis in turn containing co-real sub-space as octonionic real axis.

1. Quaternions octonions and TGD
2. Could the lines of generalised Feynman diagrams correspond to quaternion-Kähler manifolds?
3. Could quaternion analyticity make sense for the preferred extremals?
4. Classical number fields and associativity and commutativity as fundamental law of physics

5. Field equations as conservation laws, Frobenius integrability conditions, and a connection with quaternion analyticity
6. Geometrization of fermions using super version of the octonionic algebraic geometry
7. About enumerative algebraic geometry in TGD framework
8. Do Riemann-Roch theorem and Atiyah-Singer index theorem have applications to TGD?
9. What the properties of octonionic product can tell about fundamental physics?
10. Is the quantum leakage between different signatures of the real sectors of the complexified M^8 possible?
11. Physics as number theory and number theory as physics

2.4.3 $M^8 - H$ duality

A brief summary about the development of the idea is in order.

1. The original version of $M^8 - H$ duality assumed that space-time surfaces in M^8 can be identified as associative or co-associative surfaces. If the surface has associative tangent/normal space and contains a complex co-complex surface, it can be mapped to a 4-surface in $M^4 \times CP_2$.
2. Later emerged the idea that octonionic analyticity realized in terms of real polynomials P algebraically continued to polynomials of complexified octonion might realize the dream [L5, L6, L7]. The original idea was that the vanishing condition for the real/imaginary part of P in quaternion sense could give rise to co-associative/associative sense.

$M^8 - H$ duality concretizes number theoretic vision [L9, L8] summarized as adelic physics fusing ordinary real number based physics for the correlates of sensory experience and various p-adic physics ($p = 2, 3, \dots$) as physics for the correlates of cognition. The polynomials of real variable restricted to be rational valued defines an extension or rationals via the roots of the polynomials and one obtains an evolutionary hierarchy associated with these extensions increasing in algebraic complexity. These extensions induce extensions of p-adic numbers and the points of space-time surface in M^8 with coordinates in the extension of rationals define cognitive representations as unique discretizations of the space-time surface.

3. The realization of the general coordinate invariance in TGD framework [K7, K5, K18, L18, L20] motivated the idea that strong form of holography (SH) in H could allow realizing $M^8 - H$ duality by assuming associativity/co-associativity conditions only at 2-D string world sheet and partonic 2-surfaces and possibly also at their light-like 3-orbits at which the signature of the induced metric changes from Minkowskian to Euclidian.

4. The latest progress [L15] involved the realization that only co-associativity is possible and is so for any distribution of associative normal spaces of the space-time surface. Also co-commutativity is possible. This makes possible $M^8 - H$ -duality allowing to map the entire space-time surface in O_c to H so that the original idea would be realized almost as such. This option allows both Euclidian and Minkowskian signature for the regions of the space-time surface. One can say that the situation is finally settled.
1. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry?
2. $M^8 - H$ duality: summary and future prospects
3. M^8H Duality and Consciousness
4. M^8H duality and the two manners to describe particles
5. New Aspects of M^8H Duality
6. Breakthrough in the understanding of M8-H duality
7. New results on $M^8 - H$ duality
8. $M^8 - H$ duality for fermions
9. Breakthrough in understanding of $M^8 - H$ duality
10. About the implications of the revised form of $M^8 - H$ duality
11. Is $M^8 - H$ duality consistent with Fourier analysis at the level of $M^4 \times CP_2$?
12. Still some questions about $M^8 - H$ duality
13. The emergence of twistor spaces from M8-H duality
14. Uncertainty Principle and $M^8 - H$ duality
15. Fundamental quark dynamics as recombinatorics for Galois singlets
16. Critical questions related to the number theoretical view about fundamental dynamics
17. A possible generalization of number theoretic approach to analytic functions
18. $M^8 - H$ duality at the level of "world of classical worlds"
19. Riemann zeta and the number theoretical vision of TGD
20. Some comments of the physical interpretation of Riemann zeta in TGD

2.5 Development of ideas about SUSY and TGD

It became very early clear that TGD does not allow $\mathcal{N} = 1$ SUSY and LHC has excluded it experimentally at the predicted energies. Whether right-handed neutrino could generate $\mathcal{N} = 2$ SUSY was an open question for a long time. For a couple of years I thought that allowing local composites of fermions in the discretized version of TGD could allow analog of SUSY in which polynomials of quark and antiquark oscillator operator could replaced the usual expansion in terms of Grassmann parameters. In this framework right-handed neutrino disappears as a fundamental fermion from the spectrum but leptons would appear as local 3-quark composites [L14].

It turned out that this option does not work at continuum limit but that an approximate version of this SUSY is possible. Leptons can be regarded as 3-quark components with quarks at the same wormhole throat. Quite generally, quarks and antiquarks must be at opposite boundaries of wormhole contacts to avoid normal ordering divergences. In the bilocal version of modified Dirac action allowing to avoid normal ordering divergences, this condition is implied by the modified Dirac action.

I learned however very early that TGD realizes SUSY in the sense that the bosonic action - Kähler action plus volume term having interpretation in terms of cosmological constant implied by the twistor lift of TGD - determines a unique modified Dirac action from the condition of hermiticity. This gives rise to an infinite number of super-currents associated with the modes of the modified Dirac action. This form of SUSY is also behind the super-symplectic symmetries crucial in the construction of the Kähler metric and gamma matrices of WCW.

The recent view about quantum TGD relies on 3 basic pillars: zero energy ontology (ZEO), hierarchy of Planck constants labelling phases of ordinary matter identifiable as dark matter and implied by adelic physics, and the identification of the counterpart in terms of the Kähler metric of Hilbert bundle defined by WCW spinor fields. The following postings reflect the tortuous path to the final picture.

1. Super-number fields: does physics emerge from the notion of number?
2. SUSY in TGD Universe
3. Super-octonions, super-twistors, and twistorial construction of scattering amplitudes
4. Neutrinos and TGD

2.6 Hierarchy of Planck constants and dark matter

The idea about hierarchy of Planck constants labeling phases of ordinary matter identified as dark matter emerged around 2005 [K22]. The hypothesis about hierarchy of Planck constants emerged as two variants, which seem to be equivalent: the gravitational Planck constant h_{gr} emerging from the work of Nottale on astrophysics is equal to Planck constant $h_{eff} = n \times h$ emerging from neuroscience and biology (one can also introduce electromagnetic Planck constant h_{em}). This hypothesis has powerful consequences in TGD inspired quantum biology and theory of consciousness.

How to create dark matter? I have proposed several answers to this question. The most general proposal is that dark phases emerge automatically at quantum

criticality and perhaps even at ordinary criticality [K21]. The long range quantum correlations/fluctuations associated with large value of Planck constant would correspond to long range correlations associated with criticality.

Super-symplectic conformal invariance [K5, K18, L18] is an essential aspect of criticality for 2-D systems and generalizes in TGD framework to all systems by effective 2-dimensionality implied by strong form of holography in turn implied by strong form of general coordinate invariance. Also a hierarchy of breakings of conformal invariance defined by sub-algebras of conformal algebra is predicted and corresponds to the hierarchy of Planck constants. What is surprising that the increase of $h_{eff} = n \times h$ corresponds to a reduction of criticality since super-conformal generators generating gauge symmetries begin to generate physical symmetries. Since it happens spontaneously, the generation of dark matter occurs spontaneously. In biology this means that the reduction of h_{eff} is what requires metabolic energy.

1. Are dark photons behind biophotons?
2. Could photosensitive emulsions make dark matter visible?
3. Is $h_{eff} = h_{gr}$ hypothesis really consistent with TGD inspired quantum biology?
4. The behavior of superfluids in gravitational field
5. Does a phase transition generating dark matter occur accompany criticality
6. Criticality and dark matter
7. Could the magnetic flux quanta assigned with criticality carry monopole flux?
8. Mathematical approach to criticality
9. Is the formation of gravitational bound states impossible in superstring models?
10. Transition from flat to hyperbolic geometry and q-deformation
11. Macroscopically quantum coherent fluid dynamics at criticality?
12. Invisible magnetic fields as dark magnetic fields?
13. Dark matter is absorbed by blackhole slower than ordinary matter
14. The new findings about the structure of Milky Way from TGD viewpoint
15. Did Dragonfly 44 fail as a galaxy?
16. Nothing new at LHC?
17. Is the new physics really so elementary as believed?
18. What does one mean with quantum fluctuations in TGD framework?
19. More precise interpretation of gravitational Planck constant

20. Dark Matter Day and my wish for Christmas present
21. Long range magnetic fields at distance of 5 billion light years and death blow to dark matter disks
22. Dark matter explanation for the cosmic ray positron excess favoured
23. Misbehaving Ru atoms and valence electrons as dark electrons
24. "Invisible visible" matter identified
25. The prediction of quantum theory for heat transfer rate fails: evidence for the hierarchy of Planck constants
26. What does one really mean with gravitational Planck constant?
27. Solar surprise
28. Three alternative generalizations of Nottale's hypothesis in TGD framework
29. The newest anomaly of the cold dark matter scenario supports the TGD view of galactic dark matter

2.7 Hyperfinite factors and TGD

The notion of finite measurement resolution is central in TGD.

1. The inclusions of hyper-finite factors (HFFs) provide an attractive realization of the finite measurement resolution: the action of the included factor generates states not distinguishable from the original one and is analog of gauge group action.

This picture can be now formulated more precisely and makes a lot of very general predictions. In particular, the representations of quantum group should be obtained as one decomposes the representations of group with respect to discrete algebraic subgroup. This insight would explain explain and generalize some key observations about quantum group representations (finite number of spins for $SU(2)_q$).

R-matrix defining the action of braid group defines quantum group. A connection with p-adic physics emerges: in p-adic sectors the discretisation is always necessary since only discrete phases (rather than continuous angles) definable as roots of unity and their hyperbolic counterparts exist in the extensions of p-adic numbers. An infinite hierarchy of quantum groups associated with the algebraic extensions of rationals emerges if the interpretation is correct.

2. Discretization is the natural counterpart of the classical realization of finite measurement resolutions. Discretization is however realized for the parameters characterizing string world sheets and partonic 2-surfaces which provide dynamical discretization of space-time surface - not as discrete point set but a collection of 2-surfaces. 2-surfaces make possible braids and quantum group concept closely related to inclusions of HFFs.

Adelic physics led to the identification of discretizations as a unique cognitive representations defined by the points common to the real and various p-adic space-time sheets associated with the extensions of p-adic numbers induced by extensions of rationals. The points of cognitive representation associated with a given extension would have coordinates in the extension. This extension would be characterized in the approach based on $M^8 - H$ duality by the real polynomial with rational coefficients defining the space-time surface in M^8 via its octonionic continuation. Octonionic coordinates would be almost unique.

1. Hierarchies of conformal symmetry breakings, Planck constants, and inclusions of hyperfinite factors of type II_1
2. TGD view about McKay Correspondence, ADE Hierarchy, Inclusions of Hyperfinite Factors, M^8 -H Duality, SUSY, and Twistors
3. Hierarchies of conformal symmetry breakings, Planck constants, and inclusions of hyperfinite factors of type II_1
4. The idea of Connes about inherent time evolution of certain algebraic structures from TGD point of view
5. McKay Correspondence from Quantum Arithmetics Replacing Sum and Product with Direct Sum and Tensor Product?
6. Wheels and quantum arithmetics
7. Antipodal duality and TGD
8. Do the inclusion hierarchies of extensions of rationals correspond to inclusion hierarchies of hyperfinite factors?
9. Some TGD inspired questions and thoughts about hyperfinite factors of type II_1
10. Trying to fuse the basic mathematical ideas of quantum TGD to a single coherent whole

2.8 Twistors and TGD

8-dimensional generalization of ordinary twistors is highly attractive approach to TGD [K30]. 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. The twistor space of $M^4 \times CP_2$ is Cartesian product of those of M^4 and CP_2 . The obvious idea is that space-time surfaces allowing twistor structure if they are orientable are representable as surfaces in H such that the properly induced twistor structure co-incides with the twistor structure defined by the induced metric. This condition would define the dynamics, and the conjecture is 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.

The condition that the basic formulas for the twistors in M^8 serving as tangent space of embedding space generalize. This is the case if one introduces octonionic sigma matrices allowing twistor representation of 8-momentum serving as dual for four-momentum and color quantum numbers. The conditions that octonionic spinors are equivalent with ordinary requires that the induced gamma matrices generate quaternionic sub-algebra at given point of string world sheet. This is however not enough: the charge matrices defined by sigma matrices can also break associativity and induced gauge fields must vanish: the CP_2 projection of string world sheet would be one-dimensional at most. This condition is symplectically invariant. Note however that for the interior dynamics of induced spinor fields octonionic representations of Clifford algebra cannot be equivalent with the ordinary one.

One can assign 4-momentum both to the spinor harmonics of the embedding space representing ground states of superconformal 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 is nothing but a concretization of Equivalence Principle. Also a connection with string model emerges.

Twistor approach developed rapidly during years. Witten's twistor string theory generalizes: the most natural counterpart of Witten's twistor strings is partonic 2-surface. The notion of positive Grassmannian has emerged and TGD provides a possible generalization and number theoretic interpretation of this notion. TGD generalizes the observation that scattering amplitudes in twistor Grassmann approach correspond to representations for permutations. Since 2-vertex is the only fermionic vertex in TGD, OZI rules for fermions generalizes, and scattering amplitudes are representations for braidings. Braid interpretation gives further support for 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).

Twistor approach has hitherto left open the explicit construction of geometric 3-vertices of the scattering amplitudes and the question how 3-vertices and fermionic dynamics relate. A concrete realization of super-symplectic Yangian leads in terms of multi-stringy generators leads to a very concrete proposal for the 3-vertices of the twistorial scattering amplitudes in terms of commutators and co-commutators. The old idea is that Universe could be performing arithmetics in an algebra involving besides product also co-product which is in well-defined sense "time-inverse" of the product. The natural identification of this algebra is as a super-symplectic Yangian and the product and co-product have interpretation in terms of basic 3-vertices.

It is easy to hear the comments of the skeptic listener in the back row.

1. The attribute "minimal" - , which could translate to minimal value of Kähler function - is dangerous. It might be very difficult to determine what the minimal diagram is - consider only travelling salesman problem or the task of finding the shortest proof of theorem. It would be much nicer to have simple calculational rules.

The original proposal might help here. The generalization of string model duality was in question. It stated that that it is possible to move the positions of the vertices of the diagrams just as one does to transform s-channel

resonances to t-channel exchange. All loops of generalized diagrams could be eliminated by transforming them to tadpoles and snipped away so that only tree diagrams would be left. The variants of the diagram were identified as different continuation paths between different paths connecting sectors of WCW corresponding to different 3-topologies. Each step in the continuation procedure would involve product or co-product defining what continuation between two sectors means for WCW spinors. The continuations between two states require some minimal number of steps. If this is true, all computations connecting identical states are also physically equivalent. The value of the vacuum functional be same for all of them. This looks very natural.

That the Kähler action should be same for all computational sequences connecting the same initial and final states looks strange but might be understood in terms of the vacuum degeneracy of Kähler action closed related to quantum criticality, which means infinite gauge degeneracy associated with the Yangian of a sub-algebra of super-symplectic algebra.

2. QFT perturbation theory requires that should have superposition of computations/continuations. What could the superposition of QFT diagrams correspond to in TGD framework?

Could it correspond to a superposition of generators of the Yangian creating the physical state? After all, already quantum computer performs superpositions of computations. The fermionic state would not be the simplest one that one can imagine. Could AdS/CFT analogy allow to identify the vacuum state as a superposition of multi-string states so that single super-symplectic generator would be replaced with a superposition of its Yangian counterparts with same total quantum numbers but with a varying number of strings? The weight of a given superposition would be given by the total effective string world sheet area. The sum of diagrams would emerge from this superposition and would basically correspond to functional integration in WCW using exponent of Kähler action as weight. The stringy functional integral (“functional” if also wormhole contacts contain string portion, otherwise path integral) would give the perturbation theory around given string world sheet. One would have effective reduction of string theory.

1. Classical TGD and embedding space twistors
2. Twistor spaces as TGD counterparts of Calabi-Yau spaces of string models
3. The classical part of the twistor story
4. Witten’s twistor string approach and TGD
5. About the twistorial description of light-likeness in 8-D sense using octonionic spinors
6. Twistorial questions to ponder
7. Does number theoretical universality require the positivity of twistor Grassmann amplitudes?

8. What about non-planar-Feynman diagrams?
9. Permutations, braidings, and amplitudes
10. About the twistorial description of light-likeness in 8-D sense using octonionic spinors
11. More detailed view about scattering amplitudes
12. Could the Universe be doing Yangian quantum arithmetics?
13. From Principles to Diagrams
14. Twistors and the relationship of TGD to GRT
15. Cosmic evolution of the radius of the fiber of the twistor space of space-time surface
16. Does M^4 Kähler form imply new physics?
17. Twistor googly problem transforms from a curse to blessing in TGD framework
18. How the hierarchy of Planck constants might relate to the almost vacuum degeneracy for twistor lift
19. Some questions related to the twistor lift of TGD
20. Generalized Kähler structure for Minkowski space and CP breaking and matter antimatter asymmetry
21. Symplectic structure for M^4 , CP breaking, matter-antimatter asymmetry, and electroweak symmetry breaking
22. Further details related to the induction of twistor structure
23. Twistor lift and the reduction of field equations by SH to holomorphy
24. How does the twistorialization at embedding space level emerge?
25. A new view about color, color confinement, and twistors
26. Questions related to the quantum aspects of twistorialization
27. Questions related to the twistor lift of Kähler action
28. Criticizing the TGD based construction of twistor amplitudes
29. What causes CP violation?
30. Issues related to the precise formulation of twistor lift of TGD
31. Key ideas related to the twistor lift of TGD
32. Kerr effect, breaking of T symmetry, and Kähler form of M^4

33. About unitarity of twistor amplitudes
34. About the generalization of dual conformal symmetry and Yangian in TGD
35. Getting quantitative about violations of CP, T, and P
36. Getting even more quantitative about CP violation
37. From amplituhedron to associahedron
38. Questions inspired by quantum associations
39. From amplituhedron to associahedron
40. The Recent View about Twistorialization in TGD Framework
41. Summary about twistorialization in TGD framework
42. Complex 8-momenta are necessary for the realization of massless many-particle states implying unitary without loops
43. New insights about quantum criticality for twistor lift inspired by analogy with ordinary criticality
44. Three dualities of the field equations of TGD
45. Are space-time surfaces minimal surfaces everywhere except at 2-D interaction vertices?
46. How could Planck length be actually equal to much larger CP² radius?!
47. Twistor lift for 2-D objects
48. Still about twistor lift of TGD
49. More about the construction of scattering amplitudes in TGD framework
50. About gauge bosons and their decay vertices in TGD framework
51. Twistors in TGD and unexpected connection with Veneziano duality
52. Number theoretical view about unitarity conditions for twistor lift
53. Scattering amplitudes and orbits of cognitive representations under subgroup of symplectic group respecting the extension of rationals
54. Secret Link Uncovered Between Pure Math and Physics*
55. How to construct scattering amplitudes?
56. Twistor lift of TGD and WCW geometry
57. Twistors in TGD
58. M8-H duality and twistor space counterparts of space-time surfaces

59. Getting critical about twistor lift of TGD
60. Twistors in TGD Universe
61. What could 2-D minimal surfaces teach about TGD?
62. The emergence of twistor spaces from $M^8 - H$ duality
63. About TGD counterparts of twistor amplitudes
64. Should one replace the notion of unitary matrix with Kähler metric of fermionic state space?
65. More about the replacement of S-matrix with a generalized Kaehler metric in fermionic degrees of freedom
66. Objection against generalized OZI rule
67. Is pair creation really understood in the twistorial picture?
68. About the TGD based notions of mass, of twistors and hyperbolic counterpart of Fermi torus

2.9 Zero energy ontology (ZEO)

The TGD based explanation would be based on zero energy ontology (ZEO) allowing to solve the basic paradox of quantum measurement theory. First a brief summary of ZEO [L13].

1. In ZEO quantum states are not 3-dimensional but superpositions of 4-dimensional deterministic time evolutions connecting ordinary initial 3-dimensional states. By holography they are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution.

Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced with a new superposition. Classical determinism of individual time evolution is not violated and this solves the basic paradox of quantum measurement theory. There are two kinds of quantum jumps: ordinary ("big") state function reductions (BSFRs) changing the arrow of time and "small" state function reductions (SSFRs) (weak measurements) preserving it and giving rise to the analog of Zeno effect [L13].

2. To avoid getting totally confused it is good to emphasize some aspects of ZEO.
 - (a) ZEO does not mean that physical states in the usual 3-D sense as snapshots of time evolution would have zero energy state pairs defining zero energy states as initial and final states have same conserved quantities such as energy. Conservation implies that one can adopt the conventions that the values of conserved quantities are opposite for these states so that their sum vanishes: one can think that incoming and outgoing particles come from geometric past and future is the picture used in quantum field theories.

- (b) ZEO means two times: subjective time as sequence of quantum jumps and geometric time as space-time coordinate. These times are identifiable but are strongly correlated.
3. In BSFRs the arrow of time is changed and the time evolution in the final state occurs backwards with respect to the time of the external observer. BSFRs can occur in all scales since TGD predicts a hierarchy of effective Planck constants with arbitrarily large values. There is empirical support for BSFRs.
- (a) The findings of Mineev et al [L10] in atomic scale can be explained by the same mechanism [L10]. In BSFR a final zero energy state as a superposition of classical deterministic time evolutions emerges and for an observer with a standard arrow of time looks like a superposition of deterministic smooth time evolutions leading to the final state. Interestingly, once this evolution has started, it cannot be stopped unless one changes the stimulus signal inducing the evolution in which case the process does not lead to anywhere: the interpretation would be that BSFR back to the initial state occurs!
- (b) Libets' experiments about active aspects of consciousness [?] can be understood. Subject person raises his finger and neural activity starts before the conscious decision to do so. In the physicalistic framework it is thought to lead to raising of the finger. The problem with the explanation is that the activity beginning .5 seconds earlier seems to be dissipation with a reversed arrow of time: from chaotic and disordered to ordered at around .15 seconds. ZEO explanation is that macroscopic quantum jump occurred and generated a signal proceeding backwards in time and generated neural activity and dissipated to randomness.
- (c) Earthquakes involve a strange anomaly: they are preceded by ELF radiation. One would expect that they generate ELF radiation. The identification as BSFR would explain the anomaly [L11]. In biology the reversal of the arrow of time would occur routinely and be a central element of biological self-organization, in particular self-organized quantum criticality (see [L12, L21]).

ZEO has profound implications for understanding self-organization and self-organized quantum criticality in terms of dissipation with non-standard arrow of time looking like generation of structures [L12, L21]. ZEO could also allow understanding of what planned actions - like realizing the experiment under consideration - could be.

1. Second law in the standard sense does not favor - perhaps even not allow - realization of planned actions. ZEO forces a generalization of thermodynamics: dissipation with a non-standard arrow of time for a subsystem would look like self-organization and planned action and its realization.

Could most if not all planned action be like this - induced by BSFR in the geometric future and only apparently planned? There would be however the experience of planning and realizing induced by the signals from geometric

future by a higher level in the hierarchy of conscious entities predicted by TGD! In long time scales we would be realizing our fates or wishes of higher level conscious entities rather than agents with completely free will.

2. The notion of magnetic body (MB) serving as a boss of ordinary matter would be central. MB carries dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n serving as a measure for algebraic complexity of extension of rationals as its dimension and defining a kind of universal IQ. There is a hierarchy of these phases and MBs labelled by extension of rationals and the value of n .

MBs would form a hierarchy of bosses - a realization for master slave hierarchy. Ordinary matter would be at the bottom and its coherent behavior would be induced from quantum coherence at higher levels. BSFR for higher level MB would give rise to what looks like planned actions and experienced as planned action at the lower levels of hierarchy. One could speak of planned actions inducing a cascade of planned actions in shorter time scales and eventually proceeding to atomic level.

1. What ZEO can give to the description of criticality?
2. Emergence of Zero Energy Ontology and Causal Diamonds from octonionic algebraic surface dynamics
3. Some comments related to Zero Energy Ontology (ZEO)
4. Self-organization and metabolism as dissipation with reversed arrow of time
5. About the description of rotating magnetic systems in zero energy ontology (ZEO)
6. Rejuvenation and zero energy ontology
7. How the life cycle of self could corresponds to a transition to chaos as iteration of polynomial?
8. Collapsing soap bubbles, collapsing stars, and zero energy ontology
9. How are the space-time surfaces assignable to the opposite boundaries of CD glued together?
10. More Reasons Why for Zero Energy Ontology
11. DNA and time reversal
12. A possible paradox related to zero energy ontology
13. Some comments about classical conservation laws in Zero Energy Ontology
14. Time reversal and the anomalies of rotating magnetic systems
15. New evidence for zero energy ontology

16. Zero energy states as scattering amplitudes and subjective time evolution as sequence of SSFRs
17. Still about the notion of causal indefiniteness in TGD framework
18. Some questions concerning zero energy ontology
19. About the number theoretic aspects of zero energy ontology
20. Self-organized quantum criticality and $1/f$ noise as a possible signature for the reversal of the arrow of time

3 Applications to astrophysics, cosmology and galactic physics

TGD Universe is fractal so that TGD predicts new physics in all scales. In practice this means, that TGD can say something non-trivial about practically any anomaly of standard physics. This fact of course gives an effective weapon for the irritated skeptics: TGD solves all possible problems!

3.1 TGD, GRT, and astrophysics

Is Equivalence Principle (EP) true in TGD and what is its detailed form? This is one of the key questions, which found a partial answer only after I understood how the many-sheeted space-time of TGD gives rise to GRT space-time and gauge theory picture as an approximation [K32].

I took a long time to realization that QFT limit based on Einstein-YM action follows from the many-sheeted space-time of TGD by replacing sheets with a single region of M^4 which becomes slightly curved. Since the effects of induced fields at various sheets on test particle touching them sum up, the sum of induced gauge potentials defines standard model gauge potential. Same applies to the deviations of the induced metric from M^4 metric. Effects superpose and the approximate description is as a summation of induced gauge potentials (components of spinor connection of H). At the fundamental level superposition of fields corresponds to a disjoint union of space-time sheets with same M^4 projection.

The question how geometrical description of gravitation can be consistent with particle physics description remained for a long time poorly understood. Gravitational red-shift is not easy to understand solely in terms of gravitons whereas Poincare invariance natural in particle approach is difficult to understand in GRT approach. The solution of both problems emerges in TGD framework.

1. Further progress concerning the relationship between TGD and GRT and Kähler-Dirac action
2. SN1987A and many-sheeted space-time
3. Neutrinos from the galactic center as a further piece of evidence for many-sheeted space-time?

4. Variation of Newton's constant and of length of day
5. Is cosmic expansion a mere coordinate effect?
6. Cosmic redshift as purely kinematic effect
7. Is Planck length really fundamental length?
8. How the QFT-GRT limit of TGD differs from QFT and GRT?

3.1.1 Black holes and TGD

Einstein himself thought that black holes are not physical objects. This is of course obvious since a concentration of a stellar mass at single point does not make sense. Schwarzschild metric allows imbedding only down to certain critical radius as 4-surface in H so that something must happen.

A work of decades was required to realize that cosmic strings (4-D but with cross section being geodesic sphere of CP_2 thickened to magnetic flux tubes can be seen as the stuff from which galaxies stars, planets, and even smaller structures down to the level of hadrons could be build as flux tube tangles. The thickening of flux tube would transform its energy - essentially dark energy and dark matter - to ordinary matter and give rise to visible matter. In particular, blackhole like objects would be volume filling flux tube spaghettis and the asymptotic states of stars would correspond to this kind of objects with the discrete thickness of the flux tube characterized by a p-adic length scale.

1. Manifest unitarity and information loss in gravitational collapse
2. TGD view about blackholes and Hawking radiation: part I
3. TGD view about blackholes and Hawking radiation: part II
4. Sharpening of Hawking's argument
5. Where they are - the gravitational waves?
6. About Fermi-Dirac and Bose-Einstein statistics, negentropic entanglement, Hawking radiation, and firewall paradox in TGD framework
7. About the new proposal of Hawking, Perry, and Strominger to solve the black-hole information loss problem
8. What Fermilab's Holometer experiment has to do with Quantum Gravity?
9. Manifest unitarity and information loss in gravitational collapse
10. LIGO and TGD
11. What could the gamma ray pulse detected .4 seconds after the LIGO merger mean?
12. Gravitational Waves from Black Hole Megamergers Are Weaker Than Predicted

13. The problem of two Hubble constants
14. Dark matter is absorbed by blackhole slower than ordinary matter
15. Cosmic redshift but no expansion of receding objects: one further piece of evidence for TGD cosmology
16. Does GRT really allow gravitational radiation?
17. Does GW150914 force to modify the views about formation of binary blackhole systems?
18. What happens to the extremals of Kähler action when volume term is introduced?
19. Emergent gravity and dark Universe
20. Does the presence of cosmological constant term make Kähler coupling strength a genuine coupling constant classically?
21. About minimal surface extremals of Kähler action
22. Do you already believe in emergent gravity?
23. Space-time engineering from space-time legos
24. Minimal surface analog of Schwarzschild solution: two horizons and possible connection LIGO anomaly
25. LIGO blackhole anomaly and minimal surface model for star
26. Minimal surface cosmology
27. Is Lorentz invariant synchronization of clocks possible?
28. What about actual realization of Lorentz invariant synchronization?
29. How the QFT-GRT limit of TGD differs from QFT and GRT?
30. How the QFT-GRT limit of TGD differs from QFT and GRT?
31. Third gravitational wave detection by LIGO collaboration
32. Why should stars be borne in pairs?
33. How to demonstrate quantum superposition of classical gravitational fields?
34. Some comments about GW170817
35. What is the IQ of neutron star?
36. LIGO: no gravitational radiation from cosmic strings
37. CMB cold spot as problem of the inflationary cosmology

38. New evidence for blackhole echoes
39. Two problems with a common solution: the problem of two Hubble constants and enormous value of cosmological constant
40. Is the hierarchy of Planck constants behind the reported variation of Newton's constant?
41. Did LIGO observe non-standard value of G and are galactic blackholes really supermassive?
42. Is it possible to determine experimentally whether gravitation is quantal interaction?
43. Intelligent blackholes
44. Cosmological Axis of Evil as a memory from primordial cosmology
45. Has LIGO observed gravitational echoes in 21 minute time scale?
46. Badly behaving blackholes
47. Some aspects of the TGD inspired model of blackhole like objects
48. Blackholes, quasars, and galactic blackholes
49. Too heavy blackhole in Milky Way
50. Time reversal of blackhole like object observed?
51. Blackhole information paradox solved!: Really?
52. A test for the quantum character of gravity as a test for quantum TGD
53. Do galactic rotational spectra show a violation of Strong Equivalence Principle?

3.1.2 Astrophysics and TGD

TGD view about dark matter and dark energy differs from the standard view [K27, K26, ?]. For instance, the model for galactic dark matter assumes the dark matter to be condensed around cosmic string containing galaxies like pearls in necklace. The magnetic energy of the cosmic string could be in good approximation responsible for the gravitational field which is automatically such that constant velocity spectrum for distant stars is predicted. The deviation from a typical model of galactic dark matter is that there is no halo. The motion in the direction of the cosmic string is predicted to be free apart from the gravitational force created by galaxy itself. Galaxies would have emerged in the decay of cosmic strings to ordinary particle in a manner analogous to its emergence from the energy of inflaton field. Stars would be flux tube tangles.

A rather spectacular support for the model comes from Pioneer and Flyby anomalies [K26] allowing to estimate the density of the needed dark matter sphere.

Estimate is consistent with the estimate for the effective surface density assignable to galactic dark matter and also with constraints from the model identifying biophotons as decay products of dark photons [K25].

1. Variation of Newton's constant and of length of day
2. Pioneer and Flyby anomalies as demonstrations of dark matter spheres associated with orbits of planets
3. Evidence for astrophysical phase transitions of ordinary matter to dark matter?
4. BICEP2 might have detected gravitational waves
5. Further progress in the understanding of dark matter and energy in TGD framework
6. Do we really understand neutron star pairs or even neutron stars?
7. Could solar system be modelled as a miniature version of spiral galaxy?

3.1.3 New physics and planetary system

It is known that astrophysical objects comove but do not expand themselves during cosmic expansion. TGD suggests that the expansion occurs but in quantum jerks as the p-adic length scale associated with the space-time sheet associated with the astrophysical object increases.

In the case of Earth this jerk-wise expansion could provide a physical justification for Expanding Earth model inspired by the observation that the continents fit nicely to cover entire surface of Earth if the radius is one half of its recent value [K6]. This leads to a profound modification of the views about the history of geology, climate, and biological evolution. The emergence of highly developed species during Cambrian explosion could be seen as the burst of life developed in underground oceans caused by the rapid expansion of the radius of Earth. This could also explain the emergence of oceans.

Also the dynamics of the magnetic field of Earth could be understood as being controlled by dark magnetic body of Earth [K2].

1. Maintenance problem for the Earth's magnetic field
2. Where did oceans come from?
3. New Horizons about Pluto
4. How did life evolve during pre-Cambrian period?
5. Mystery: How Was Ancient Mars Warm Enough for Liquid Water?
6. Expanding Earth hypothesis, Platonic solids, and plate tectonics as symplectic flow
7. New support for the view about Cambrian explosion being caused by rapid increase of Earth radius

8. Could Mars have intraplanetary life?
9. Earthquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology
10. New surprises about the physics at the boundary of heliosphere
11. What smoothed out Earth's surface for 600 million years ago - or was it already smooth?
12. What created the craters of Moon and other celestial bodies?
13. Earthquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology
14. New surprises from Mars
15. North Pole is moving
16. Correlation between earthquakes and volcanic eruptions with the spin dynamics of Earth
17. No continents before Cambrian Explosion
18. Has Pluto experienced a period of fast expansion?
19. Planning to move to Mars?: have you asked the opinion of your magnetic body?
20. Life in Venus? What says TGD?
21. Expanding Earth model, Cambrian Explosion, and Pangaea supercontinent
22. Earth's pulsation rhythm of 26 seconds as an analog of EEG rhythm?
23. Moon has possessed a magnetic field?
24. The mysterious precession of the Earth's spin axis from the TGD point of view

3.2 TGD and galactic dark matter

Cosmic strings (4-D but with cross section being geodesic sphere of CP_2 thickened to magnetic flux tubes can be seen as the stuff from which galaxies stars, planets, and even smaller structures down to the level of hadrons could be build as flux tube tangles. The thickening of flux tube would transform its energy - essentially dark energy and dark matter - to ordinary matter and give rise to visible matter. The assumption that galaxies are tangles in long flux tubes predicts automatically flat velocity spectrum for distant stars and explains also stars apparently without dark matter in terms of closed flux tubes.

1. TGD interpretation for the new discovery about galactic dark matter

2. Antimatter as dark matter
3. Bullet cluster and TGD based model of dark matter
4. Velocity curves of galaxies flatten for large redshifts
5. Early galactic collision gives support for TGD based model of galactic dark matter
6. Zwicky paradox and models of galactic dark matter
7. Missing dark matter
8. Breaking of CP, P, and T in cosmological scales in TGD Universe
9. Galactic blackholes as a test for TGD view about formation of galaxies?
10. TGD view about universal galactic rotation curves for spiral galaxies
11. New view about galaxies and galactic blackholes
12. Dark matter explanation for the cosmic ray positron excess favoured
13. Does instability of Einstein's equations explain accelerated expansion?
14. Have galactic cosmic strings been observed?
15. Knotty inflation and dimensionality of space-time
16. A further lethal blow to the dark matter halo paradigm
17. Low surface brightness galaxies as additional support for pearls-in-necklace model for galaxies
18. Did you think that star formation is understood?
19. TGD view about quasars
20. Does 160 minute period define a universal "alpha rhythm"?
21. Cosmic strings and magnetic flux tubes as basic building bricks of TGD Universe
22. Some remarks about cosmic string model for the formation of galaxies and stars
23. Too fast
24. Two new findings supporting the cosmic string model of galaxy formation
25. Local supercluster Laniakea from TGD point of view
26. Why the interstellar gas is ionized?

27. Fluctuations of Newton's constant in sub-millimeter scales as evidence for TGD
28. Lense effect as support for TGD view about galaxies
29. New findings challenging the notion of galactic dark matter halo and its identification as exotic particles
30. Halo model of dark matter meets further difficulties
31. A model for the formation of galaxies
32. Direct astrophysical evidence for monopole flux tubes
33. Evidence for 3 different temperatures at Milky Way halo
34. Cosmic spinning filaments that are too long
35. TGD view of the engine powering jets from active galactic nuclei
36. Central engine of galactic nuclei as a time reversed blackhole-like object
37. Do we really understand how galaxies are formed?
38. Can the initial stellar mass distribution of galaxy really depend on its distance from Earth?
39. The first findings of the James Webb telescope might revolutionize the views of the formation of galaxies
40. Quantization of cosmic redshifts in the TGD framework

3.3 TGD and cosmology

Cosmic strings [K27, K20] are key players of primordial TGD inspired cosmology and correspond to a phase in which space-time as we understand it, had not yet emerged. Gas of cosmic strings (having nothing to do with cosmic strings in the standard sense of the word) is the appropriate term.

BICEP2 collaboration claimed to have detected polarization of CMB, which could be due to interaction with gravitons during inflationary period. It turned out that dust is a more plausible explanation. This claim however inspired more detailed development of the model for the TGD counterpart of the inflationary period.

During this period a phase transition from string gas phase to a radiation dominated cosmology took place. If one assumes that single sheeted space-time identified as vacuum extremal with Robertson-Walker type metric allows to model this period, one obtains a highly predictive model involving only single parameter identifiable as the duration of the transition period.

After primordial period the M^4 projection of cosmic strings thickened from string world sheets to 4-D regions of Minkowski space and the outcome was magnetic flux tubes carrying monopole flux. Monopole flux does not need any currents to generate it unlike ordinary magnetic flux, and this could explain why magnetic fields

appear in all length scales although the required currents coherent in long scales have not been possible. The magnetic energy of the flux tubes can be identified as dark energy and the dark matter at the flux tubes would correspond to large h_{eff} phases. The magnetic tension would correspond to the apparent "negative pressure" in the models assuming vacuum energy density due to inflaton field rather than cosmological constant.

3.3.1 Basic problems of cosmology

Standard cosmology is plagued by numerous problems. Primordial cosmology should be able to explain the extreme constancy of the temperatures of the microwave background. One should find the TGD counterpart of inflationary cosmology plagued by many problems. Dark matter and dark energy, in particular the extremely small value of the cosmological constant are still mysteries. There is also the puzzle of two Hubble constants. TGD provides a possible solution to all these problems.

1. Could TGD allow inflationary cosmology
2. Quantum critical cosmology of TGD predicts also very fast expansion
3. Still about TGD and inflation
4. Planck 2013 estimates for string tension of various strings
5. Cyclic cosmology from TGD perspective
6. Correlated Polygons in Standard Cosmology and in TGD
7. Is inflation theory simply wrong?
8. Conformal cyclic cosmology of Penrose and zero energy ontology based cosmology
9. Large scale fluctuations in metagalactic ionizing background for redshift six
10. Cosmological constant in TGD and in superstring models
11. Evidence for the anisotropy of the acceleration of cosmic expansion
12. Did cosmology have Dark Ages at all?
13. The puzzle of two different values of Hubble constants
14. About the problem of two Hubble constants
15. About the notion of length scale dependent cosmological constant
16. Cosmology is in crisis again
17. Could Universe could have North-South direction: How?
18. Fast Radiowave bursts in TGD framework

19. New evidence for two values of Hubble constant
20. A solution of the Hubble constant discrepancy?
21. Cosmological time anomalies and zero energy ontology
22. Cosmic strings and angular momentum problem of general relativity
23. Too heavy too early
24. Magnetars as additional support for monopole flux tubes
25. About detection of gravitation radiation from TGD cosmic strings
26. Helium problem and CNO problem: two anomalies explained by dark fusion
27. Can TGD predict the value of Newton's constant?
28. Has Pluto experienced a period of fast expansion?
29. Planning to move to Mars?: have you asked the opinion of your magnetic body?
30. Life in Venus? What says TGD?
31. Expanding Earth model, Cambrian Explosion, and Pangaea supercontinent
32. Earth's pulsation rhythm of 26 seconds as an analog of EEG rhythm?
33. Updated version of Expanding Earth Model
34. Huge fluctuations in oxygen concentration during Cambrian Explosion and Expanding Earth model
35. Expanding Venus model
36. Empirical support for the Expanding Earth Model and TGD view about classical gauge fields
37. Bubble-like structures in TGD Universe
38. The honeycomb of large voids as a tessellation of hyperbolic space by membrane like structures?
39. Quantum friction in the flow of water through nanotube
40. The effects of Cambrian Explosion in deep mantle: TGD point of view
41. Universe as a dodecahedron?: two decades later

3.3.2 Dark energy, dark matter and cosmology

Dark matter and dark energy are mysteries of recent cosmology. Cold dark matter model involves a halo of dark particles assumed to have very weak interactions with ordinary matter. The search of dark particle candidates has failed and the halo model has grave difficulties. Twistor lift of TGD predicts that dark matter and energy are associated with cosmic strings which have thickened to flux tubes and emitted part of dark dark energy and matter as ordinary particles.

This phase transition involves a reduction of length scale dependent cosmological constant characterizing the space-time sheet. This has led to its recent extremely small value. Therefore the problems associated with cosmological constant are solved. Long cosmic strings create a transversal gravitational field explaining the flat velocity spectrum of galaxies without further assumptions needed in the models based on dark matter halo.

The model explains the inflationary period and also later accelerating periods in terms of this mechanism.

1. Anomalously strong 21-cm absorption line of hydrogen in cosmology as indication for TGD based view about dark matter
2. Dark matter nightmare is not due to wrong equations but wrong philosophy
3. Has the decay of dark photons to visible photons been observed in cosmological scales?
4. Long range correlations between spins of quasars
5. Surprising finding about gamma ray bursts
6. Findings challenging the notion of dark energy
7. Does dark matter induce formation of more dark matter? MOND and TGD view of dark matter
8. Can the initial stellar mass distribution of galaxy really depend on its distance from Earth?
9. The first findings of the James Webb telescope might revolutionize the views of the formation of galaxies
10. Quantization of cosmic redshifts in the TGD framework
11. Ultradiffuse galaxies as a problem of cold dark matter and MOND scenarios

4 Applications to particle physics, nuclear physics and condensed matter

The number theoretically and twistorially unique choice $H = M^4 \times CP_2$ predicts standard model symmetries and family replication can be understood in terms of

topology of partonic 2-surfaces. A lot of new physics is however predicted. p-Adic length scale hierarchy allows to understand particle massivation and predicts the possibility of scaled copies of hadron physics and electroweak physics. TGD color also differs from QCD color and predicts new particles as color excitations of ordinary ones (CP_2 spinor harmonics). The most important recent breakthrough already discussed is the understanding of the origin of preferred p-adic primes as ramified primes and of the generalization of p-adic length scale hypothesis stating that primes near but below powers of primes are favoured by NMP.

4.1 Particle physics

The view about fundamental fermions have developed considerably from the original one. The original postulate was that both chiralities of H fermions are present. The construction of WCW geometry is however possible using only single chirality.

The final picture is astonishingly simple: leptons correspond to almost local composites of 3 quarks located at single partonic 2-surface and baryons to composites of 3 quarks at separate partonic 2-surfaces. One obtains just the correct number of lepton states with correct electroweak quantum numbers [L19]. Quarks do not have color as spin-like quantum number but corresponds to color partial waves is essential prerequisite of this picture. Therefore fundamental fermions correspond to single quark generation without color as spin-like quantum number. One could hardly think anything simpler.

1. What particles are in TGD Universe?
2. Still about the topology of elementary particles and hadrons
3. Neutrinos and TGD
4. Could inert neutrinos be dark neutrinos in the TGD sense?

4.1.1 Comments about experimental findings

The articles in this section discuss various experimental findings from TGD point of view.

1. Has IceCube detected neutrinos coming from decays of p-adically scaled up copies of weak bosons?
2. New results from PHENIX concerning quark gluon plasma
3. Experimental evidence for sterile neutrino?
4. Misbehaving b-quarks and proton's magnetic body
5. Leptonic CKM mixing and CP breaking?
6. Toponium at 30.4 GeV?
7. Critizing the view about elementary particles

8. Muon surplus in high energy cosmic ray showers as an indication for new hadron physics
9. Anomaly in neutron lifetime as evidence for the transformation of protons to dark protons
10. Neutron production from an arc current in gaseous hydrogen: 66 year old nuclear physics anomaly
11. Encountering the puzzle of inert neutrinos once again
12. New indications for the third generation weak bosons
13. TGD view about ANITA anomalous events
14. Evidence for 96 GeV pseudoscalar predicted by TGD
15. TGD based explanation for the asymmetry between anti-u and anti-d sea quarks in proton
16. Pomeron and Odderon as direct support for the notion of color magnetic body
17. Does muon's anomalous anomalous magnetic moment imply new physics?

4.1.2 Higgs and TGD

TGD predicts Higgs but the description of particle massivation in terms of Higgs vacuum expectation value emerges only in the QFT approximation [K16]. It is however important to understand the counterpart of Higgs vacuum expectation and it is now clear how it emerges from fermionic 2-vertex as discontinuity of Dirac operator at the partonic 2-surface defining vertex for generalized Feynman diagram.

CKM mixing for quarks reduces to different topological mixings for U and D type quarks [K11, K12]. CKM mixing occurs also for leptons and the observed decay of Higgs to $\tau\mu$ pair provides first evidence for this mixing.

The newest twist in the development is the realization that Higgs in standard model framework is metastable: the sign of the quartic coupling λ at energy range $10^{10} - 10^{12}$ GeV changes sign if standard model is correct and a new energy minimum emerges making the standard minimum meta-stable. This supports the view that coupling might vanish at CP_2 scale in the dynamics provided by TGD.

1. Could vacuum expectation value of Higgs have TGD counterpart?
2. TGD explanations of the anomalous decay of Higgs to $\tau - \mu$ pair and anomalies of B meson decays
3. Criticality of Higgs: is Planck length dogmatics physically feasible?
4. Still about induced spinor fields and TGD counterpart for Higgs
5. Could the two photon emissions of dark particles reveal the value of h_{eff} ?
6. New pseudoscalar meson at LHC?
7. Strange spin asymmetry at RHIC

4.1.3 M_{89} hadron physics and new particles

M_{89} physics is scaled up counterpart of ordinary hadron physics assignable to Mersenne prime M_{107} with 512 times higher mass scale so that it could become visible at LHC [K10]. TGD view about elementary particles allows also several exotic states: for instance, leptoquarks having lepton and quark at opposite boundaries of worm-hole contact.

1. W boson excess at LHC and ATLAS: explanations?
2. Have leptoquarks been observed in the decays of B meson?
3. Does color deconfinement really occur?
4. Could leptoquarks be squarks in TGD sense?
5. Do I here M_{89} bells ringing?
6. Evidence for the η meson of M_{89} hadron physics

4.1.4 Hierarchy of Planck constants and particle physics

Hierarchy of Planck constants has the most interesting applications in TGD inspired quantum biology. I have however considered also particle physics applications. First application proposed long time ago is to the model of the anomalous electron pair production in heavy ion collisions in terms of leptopions which are pion-like bound states of colored excitations of leptons. The decay rates of weak bosons do not allow new light particles and a possible manner to understand this is to assume that the colored excitations are dark in TGD sense [K31]. If one identifies dark particles with $N = 2$ sparticles, these states are selectrons.

A further possible application relates to the reported large parity breaking effects in proton-proton collisions. Could it be that M_{89} hadrons with large Planck constant $h_{eff} = 2^9 \times h$ are created so that their size is same as that of ordinary hadrons? [K10]

1. Large parity breaking in heavy ion collisions
2. Has dark matter particle been observed
3. Gaussian Mersennes in cosmology, biology, nuclear, and particle physics
4. Pion of $M_{G,79}$ hadron physics at LHC?
5. Further evidence that 2 TeV bump could be MG,79 pion
6. 5 TeV bump at CMS?
7. New indication for leptonic CKM mixing
8. Indication for a scaled up variant of Z boson
9. First indications for the breaking of lepton universality due to the higher weak boson generations

10. The latest CMS results concerning narrow dijet resonances
11. Do I here M_{89} bells ringing?
12. Newest LHC Run 2 rumours
13. Indications for the new physics predicted by TGD
14. M_{89} hadron physics is there and maybe also $M_{G,79}$ hadron physics!
15. Evidence for the eta meson of M_{89} hadron physics
16. New evidence for second generation weak bosons predicted by TGD
17. Direct evidence for Z' a la TGD and M_{89} J/Psi
18. Evidence for rho or omega meson of M_{89} hadron physics
19. Lightnings, dark matter, and lepto-pion hypothesis again
20. What if 750 GeV bump disappears?
21. CMS provides evidence for two new spin 2 mesons of M_{89} hadron physics
22. Could second generation of weak bosons explain the reduction of proton charge radius?
23. About parity violation in hadron physics
24. Getting even more quantitative about CP violation
25. Phase transition from M_{107} hadron physics to M_{89} hadron physics as TGD counterpart for de-confinement phase transition?
26. Anomalous J/Ψ production and TGD
27. Breaking of lepton universality seems to be real
28. Excess of cosmic ray antiprotons as a further support for M_{89} hadron physics?
29. Chinese satellite provides evidence for second generation Z boson predicted by TGD
30. Further evidence for the third generation of weak bosons
31. How to describe family replication phenomenon gauge theoretically?
32. Still about quark gluon plasma and M_{89} physics
33. Aleph anomaly just refuses to disappear
34. A new twist in the spin puzzle of proton
35. The masses of hadrons, weak bosons, and Higgs in p-adic mass calculations

36. Evidence for omega meson of M_{89} hadron physics from CMS?
37. Indications for an axionlike state in mass range 1-7 keV from XENON
38. Is Standard Model tumbling down?: W boson mass is .1 per cent higher than predicted!

4.1.5 SUSY and TGD

TGD predicts huge super-symplectic and super-Kac-Moody symmetries. In particular, the bosonic action determines the modified Dirac action completely. The prediction is the existence of an infinite number of fermionic super-charges as Noether charges for the modified Dirac action: these charges define the gamma matrices of WCW.

Whether TGD predicts also some variant of space-time SUSY has remained unclear for a long time [K17] [L14, L20]. The answer turned out to be negative.

1. The addition of a right-handed neutrino to the wormhole throat carrying fermion would generate sfermion. Another possibility considered earlier is that right-handed neutrino is associated with the space-time interior. This option looks equally attractive and generalizes to all fermions in the sense that dynamical super-symmetries would correspond to the addition of interior fermions to the state defined by ordinary fermions at partonic 2-surfaces.

The outcome would be broken $N = 2$ SUSY. The fermionic oscillator algebra at partonic 2-surface would generate larger SUSY with bigger breaking. It is quite possible that spartners for $N = 2$ SUSY have the same p-adic mass scale as particles. Hence one can ask whether these states have non-standard value of Planck constant so that they are dark and not observed in ordinary particle physics experiments.

2. The recent view [L19] assumes only quarks as fundamental fermions and leptons are composites of 3 quarks. This discovery was preceded by the idea [L14] that leptons could be purely local 3-quark composites, and that there would be an analog of SUSY in which polynomials of theta parameters as super fields would be replaced by polynomials of quark and antiquark oscillator operators with well-defined quark number so that strictly speaking leptons would not correspond component of quark superfield.

It turned out this picture leads to normal ordering divergences if the quark field at space-time surface is induced from the second quantized quark field in H . To avoid divergences, quarks and antiquarks must reside at opposite throats of wormhole contacts defining a pair of partonic 2-surfaces. Strictly local composites are not possible but leptons can be composites of 3 quarks located at the same partonic 2-surface. This is possible because quark color is not a spin-like quantum number.

This implies $\mathcal{N} = 2$ can be only an approximate SUSY - as also the proposed modification of SUSY.

1. Standard SUSY or M_{89} hadron physics?

2. Could sparticles have same p-adic mass scale as particles and be dark matter in TGD sense?
3. About sterile neutrinos, SUSY partners, antimatter, and dark matter
4. LSND anomaly is here again
5. What went wrong with SUSY?
6. The recent view about SUSY in TGD Universe
7. S-matrix and SUSY in TGD sense
8. Finiteness for the number of non-vanishing Wick contractions, quantum criticality, and coupling constant evolution
9. SUSY in TGD Universe
10. Super-symmetry in TGD Universe
11. Can one regard leptons as effectively local 3-quark composites?

4.2 Nuclear physics

In nuclear string model nucleons form strings connected by color flux tubes with quark and antiquark at ends [K24]. This model predicts new nuclear physics 1-10 keV scale for which there is some evidence. This would also mean interaction with atoms since the wavelengths of photons are in the range 1-10 Angstrom. Dark variants of nuclei with sizes scaled up by $h = h_{eff}/h_0$ is second prediction [L4, L3]. They would be quantum coherent entities. Nuclear binding energy would be scaled down by a factor $1/n$ and dark nuclei could be formed at room temperatures from dark protons generated by Pollack effect.

Dark nuclei could explain "cold fusion" and play a crucial role also in ordinary nuclear physics leading to a new view about the pre-stellar evolution by serving as a "warm-up band" by transforming to ordinary nuclei and liberating almost all nuclear binding energy and raising the temperature so high that ordinary nuclear fusion becomes possible. This would also make possible nuclear fusion outside stellar cores at rather low temperatures. The technological implications are rather obvious [L16].

1. Individual nucleons inside nuclei do not behave according to predictions
2. Tewari's space-energy generator for two decades later
3. Cold Fusion Again
4. Does electrolysis involve dark matter and new physics?
5. Solution of the Ni62 mystery associated with Rossi's E-Cat
6. Could cold fusion solve some problems of the standard view about nucleosynthesis?

7. Reactor antineutrino anomaly as indication for new nuclear physics predicted by TGD
8. Very strong support for TGD based model of cold fusion from the recent article of Holmlid and Kotzias
9. The discovery of X boson as a further evidence for nuclear string model
10. Pear-shaped Barium nucleus as evidence for large parity breaking effects in nuclear scales?
11. Is cold fusion taking place in 175 year battery still working?
12. 175 year old battery still working, Pollack's EZs, cold fusion, self-loading batteries, membrane potential, and nerve pulse
13. Hydrinos again
14. Three books about cold fusion/LENR
15. Comparison of Widom-Larsen model with TGD inspired models of CF/LENR or whatever it is
16. More about dark nucleosynthesis
17. The lost history from TGD perspective
18. Summary of the model of dark nucleosynthesis
19. Dark nucleosynthesis and stellar evolution
20. Two different values for the metallicity of Sun and heating of solar corona: two puzzles with a common solution?
21. Unexpected support for the nuclear string model
22. Confession
23. Solar surprise
24. Heavy element surprise
25. Solar metallicity problem from TGD perspective
26. New predictions from the flux tube model of galaxies
27. New surprises about the physics at the boundary of heliosphere
28. The findings of SAFIRE team as support for dark nucleosynthesis
29. Comparing Electric Universe hypothesis and TGD
30. Hot nuclear fusion is again almost here
31. Modern oldies

32. X boson makes a comeback!
33. EMC effect in nuclear string model
34. New pseudoscalar particle having no explanation in standard model detected?
35. Could TGD provide new solutions to the energy problem?
36. Skyrmions in TGD
37. Support for the quantization of Planck constant from the decays of heavy nuclei
38. TGD based interpretation for the strange findings of Eric Reiter
39. Three unexpected findings in hadron and nuclear physics from TGD point of view
40. Quantum hydrodynamics in nuclear physics and hadron physics
41. 10 times too high amount of He-4 in atmosphere as evidence for cold fusion
42. TGD solution of 12 year old puzzle related to nuclear reactors

4.3 Condensed matter physics

p-Adic length scale hierarchy and dark matter hierarchy predict new physics also in condensed matter scales. Dark matter as $h_{eff} = nh_0$ phases of ordinary matter located at the flux tubes of magnetic bodies (MBs) predicts further new physics. MB would naturally serve as a "boss" of ordinary matter since n as a measure of algebraic complexity (dimension of extension of rationals) would give it higher universal IQ and make it quantum coherent in arbitrarily long scales. The master-slave hierarchy of MBs and the tensor network formed by them would be crucial for understanding condensed matter but especially important in living matter. Essentially an extension of the standard physics picture involving only particles to a network having particles at nodes connected by flux tubes is in question.

Zero energy ontology would be a further new element and would predict a theory of self-organization involving in an essential manner dissipation in non-standard time direction looking like self-organization in the standard time direction. Also self-organized quantum criticality is predicted and would be crucial in living matter.

TGD predicts a mechanism of super-conductivity based on Cooper pairs at parallel magnetic flux tubes with either opposite or parallel magnetic fields [K3, K4]. Large value of Planck constant makes in principle possible to raise the cyclotron energy scale above thermal energy. One can understand the basic aspects of high Tc superconductivity in this model. How the gap energy emerges from cyclotron binding energy which for the values of h_{eff} considered would be much higher than thermal energy, is not yet well-understood.

The conjecture $h_{eff} = h_{gr}$ [K25] leads to a model for the fountain effect of superfluidity in terms of macroscopic gravitational quantum coherence. Also Podkletnov effect [K25] might be understood along same lines. Quite generally, critical systems

could exhibit dark matter with large h_{eff} which would be responsible for long range quantum fluctuations. A possible interpretation would be in terms of interior modes of induced spinor field.

The recent finding that SmB₆ behaves very paradoxically at low temperatures in presence of magnetic field being conductor and insulator simultaneously has a trivial explanation in TGD framework - magnetic flux tubes as current wires. If so, this finding would be one further direct evidence for several new physics notions predicted by TGD: many-sheeted space-time and topological field quantization, strong form of holography and the generalization of AdS/CFT correspondence predicted by it, TGD as almost topological QFT at the level of single space-time sheet, and hierarchy of Planck constants predicted by quantum criticality of TGD and identified as dark matter hierarchy.

1. New finding about pseudo gap in high temperature super-conductivity
2. More precise view about high T_c superconductivity taking into account recent experimental results
3. The behavior of superfluids in gravitational field
4. Could Podkletnov effect be understood using $h_{eff} = h_{gr}$ hypothesis?
5. Quantitative model of high T_c super-conductivity and bio-super-conductivity
6. Does the physics of SmB₆ make the fundamental dynamics of TGD directly visible?
7. Strange behavior of SmB₆ and new mechanism of quantum bio-control
8. Topological order and Quantum TGD
9. Flux tube description seems to apply also to low T_c superconductivity
10. Hydrogen sulfide superconducts at -70 degrees Celsius!
11. Quantal heat conduction in scale of one meter!
12. Nematicity and high T_c superconductivity
13. Indications for high T_c superconductivity at 373 K with $h_{eff}/h = 2$
14. Teslaphoresis and TGD
15. Badly behaving photons and space-time as 4-surface
16. Have magnetic monopoles been detected?
17. New findings about high-temperature super-conductors
18. Topological condensed matter physics and TGD
19. Induction coils in many-sheeted space-time

20. The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis?
21. Could the presence of light affect weight?
22. Weight change for electrets and "weight of soul"
23. High Tc superconductivity in n-alkanes above 231 C
24. High Tc superconductivity in n-alkanes above 231 C
25. TGD and hydrogen atom as anomaly of QED
26. Anomalies of water as evidence for dark matter in TGD sense
27. Time crystals, macroscopic quantum coherence, and adelic physics
28. Mysteriously disappearing valence electrons of rare Earth metals and hierarchy of Planck constants
29. Valence bond theory from the hierarchy of Planck constants
30. About the biological role of low valence ions
31. How the ionization is possible in living matter?
32. Exciton-polariton Bose-Einstein condensate at room temperature and h_{eff} hierarchy
33. Condensed matter simulation of 4-D quantum Hall effect from TGD point of view
34. Superfluids dissipate!
35. TGD based model for graphene superconductivity
36. Rydberg polarons as a support for TGD view about space-time
37. Too thin em waves in graphene

Maxwell's lever rule and expansion of water in freezing: two poorly understood phenomena

Dark valence electrons and color vision

Two new findings related to high Tc super-conductivity

More about badly behaving photons

TGD explanation for the finding challenging the reported high Tc superconductivity

Dark valence electrons, dark photons, bio-photons, and carcinogens

The prediction of quantum theory for heat transfer rate fails: evidence for the hierarchy of Planck constants

BCS super conductivity at almost room temperature

Tesla inspires still

Quantum scarring from TGD point of view

The implications of TGD view about magnetic fields for superconductivity

Snow flakes and macroscopic quantum criticality

Three condensed matter surprises

New ideas about the transition to ferromagnetic phase

New support for TGD view about quantum tunnelling

Ballistic resonance as breaking of second law: TGD view point

Comparing the Berry phase model of superconductivity with the TGD based model

Beltrami flow as space-time correlate for non-dissipative flow

The 4 anomalies of BCS model of superconductivity in TGD framework

Possible implications of the TGD based model of superconductivity

Connection with parity breaking, massivation, and PCAC hypothesis

Non-dissipative waves in excitonic insulators: a connection with superconductivity?

Hyperon problem of stellar cores in TGD framework

Time crystals in TGD framework

Fractons and TGD

TGD and Condensed Matter

TGD as it is towards end of 2021

Breakthrough prediction for quantum hydrodynamics and quantum gravity according to TGD

TGD and Quantum Hydrodynamics

Condensate of electron quadruplets as a new phase of condensed matter

Bird's Eye of View about the Topics of the Book "TGD and Condensed Matter"

Breakthrough prediction for quantum hydrodynamics and quantum gravity according to TGD

TGD and Quantum Hydrodynamics

Mott insulators learn like living matter

Superionic ice, possibly existing inside some planets, discovered

Spin Glasses, Complexity, and TGD

How bubbles in coffee cup, hyperbolic geometry, and magnetic body could relate?

About systems that apparently defy Newton's third law

Why the resistance of strange metals is linear in temperature?

Bosonic strange metals and oscillatory behavior of magnetoresistance

Why airplanes do not fall down?

TGD inspired model for freezing in nano scales

Are space-time boundaries possible in the TGD Universe?

Invisible magnetic fields as a support for the notion of monopole flux tube

A strange behavior of hybrid matter-antimatter atoms in superfluid Helium

Strange glass spheres in the Moon

5 TGD inspired quantum biology

TGD inspired quantum biology involves several new physics elements. Zero energy ontology (ZEO) allows to see living systems as essentially 4-D objects and provides a new view about self-organization. Dark matter assumed to reside at large h_{eff} phase at the flux tubes of the magnetic body is another key element.

ZEO predicts a mechanism of self-organization based on dissipation in non-standard time direction looking like self-organization in the standard time direction. Critical state is by definition a repeller. For an observed with the standard time direction the critical state with a reversed arrow of time looks like an attractor: this makes possible self-organized quantum criticality crucial for living matter.

The hierarchy of Planck constants defines a hierarchy of criticalities. The generation of h_{eff} phases requires energy feed because the energies of states quite generally increase with h_{eff} .

In biology this means that metabolic energy is needed to increase h_{eff} . For instance, the reduction of the length of magnetic flux tubes connecting two biomolecules would occur spontaneously so that chemical reaction becomes possible as the molecules find each other. The energy liberated in the reduction could kick the reactants over the potential wall preventing the reaction from occurring.

5.1 General ideas

Dark matter at magnetic flux tubes would make the magnetic body (MB) the boss of ordinary living matter. Large h_{eff} makes possible parity breaking effects in long scales and could explain chiral selection. Many-sheeted space-time and the notion of MB combined with ZEO in which basic entities are time evolutions (analogous to biological function and computer programs) suggests a new view about morphogenesis. The explanation of Pollack effect in terms of dark protons at flux tubes of MB leads to ideas about water memory and evolution of immune systems. Dark proton triplets could also define a fundamental realization of genetic code and both DNA, RNA, tRNA and amino-acids could have dark proton variants and biochemical level of life would be mimicry in accordance with the idea that MB is the boss.

Large values of h_{eff} suggest also the possibility of remote replication and transcription, remote control, and remote metabolism by sending negative energy signal to a target able to receive it.

Dark photons would be responsible for communications and control by resonance mechanism. The mechanism would generalize to bound states of dark photons which are Galois singlets as analogs of color singlets formed by 3 quarks. Genetic codons formed both by 3 dark protons and 3 dark photons could be Galois singlets and even genes could be so. This would make possible resonant communications with

the cyclotron frequency pattern of dark gene serving as an address. Information would be coded to frequency modulation of Josephson radiation induced by the variations of membrane potential and inducing a sequence of ticks as the receiving cyclotron Bose-Einstein condensates associated with the basic biomolecules get into resonance.

1. Seth Lloyd on quantum life
2. More precise view about remote replication
3. New experimental information about chiral selection
4. Morphogenesis, morphostasis, and learning in TGD framework
5. TGD view about homeopathy, water memory, and evolution of immune system
6. More Precise TGD Based View about Quantum Biology and Prebiotic Evolution
7. Is the view about evolution as approach away from criticality consistent with biology?
8. Are lithium, phosphate, and Posner molecule fundamental for quantum biology?
9. Could Chladni mechanism allow to realize morphogenesis?
10. Bio-catalysis, morphogenesis by generalized Chladni mechanism, and bio-harmonies
11. Can quantum biology really do without new physics?
12. What's new in TGD inspired view about phase transitions?
13. Quantum phase transitions and 4-D spin glass energy landscape
14. About a model for the control of biological body by magnetic body
15. How molecules in cells "find" one another and organize into structures?
16. The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis?
17. Life-like properties observed in a very simple system
18. More about life-like properties found in very simple system
19. System of particles able to self-assemble and self-heal in presence of acoustic waves
20. Why metabolism and what happens in bio-catalysis?
21. More about Posner molecule
22. Could Posner molecules and cortex realize a representation of genetic code?

23. Galois groups and genes
24. Getting philosophical: some comments about the problems of physics, neuroscience, and biology
25. Morphogenesis in TGD Universe
26. Morphogenesis and metabolism in astrophysical scales?
27. Which came first: genes or metabolism?
28. Homeostasis and zero energy ontology
29. TGD approach to the hen-or-egg problems of biology
30. How life began?
31. Libet's paradoxical findings and strange findings about state function reduction in atomic scales
32. Minimization of Gibbs free energy as thermodynamical variational principle in TGD framework
33. Quantum self-organization by h_{eff} changing phase transitions
34. Darwinian or neutral theory evolution or something else?
35. TGD based view about dark matter at the level of molecular biology
36. TGD view about water memory and the notion of morphogenetic field
37. Dark meiosis and the mystery of why different cells express the chromosomes of father and mother in different manner

5.2 Dark matter, quantum gravitation, and life: $h_{eff}=h_{gr}$ hypothesis

MB would serve as a "boss" of ordinary matter since $n = h_{eff}/h_0$ as a measure of algebraic complexity (dimension of extension of rationals) would give it higher universal IQ and make it quantum coherent in arbitrarily long scales. The master-slave hierarchy of MBs and the tensor network formed by them would be crucial for understanding living matter.

Zero energy ontology predicts a theory of self-organization [L12] involving in an essential manner dissipation in non-standard time direction looking like self-organization in the standard time direction. Also self-organized quantum criticality is predicted and would be crucial in living matter.

5.2.1 Quantum gravitation and life

The emergence of life could be seen as emergence of large h_{eff} phases at magnetic flux quanta assignable to quantum criticality. $h_{eff} = h_{gr}$ hypothesis strengthens the predictions and gives a connection between dark photons and bio-photons [K25].

1. Implications of strong gravimagnetism for TGD inspired quantum biology
2. Gravitational Mother Gaia and life
3. Quantum gravity, dark matter, and prebiotic evolution
4. Is $h_{eff} = h_{gr}$ hypothesis really consistent with TGD inspired quantum biology?

5.2.2 Dark realization of genetic code and basic information molecules

TGD inspired comments on Mae-Wan Ho's talk about protons in water

Direct evidence for dark DNA?!

Could protein dynamics be dictated by the magnetic body of the protein with the mediation of water?

Quantum critical dark matter and tunneling in quantum chemistry

Brain metabolic DNA as an indication for genomic R&D based on dark DNA

Gut cells having no mitochondria survive: evidence for quantum credit card mechanism

About dark variants of DNA, RNA, and amino-acids

Hachimoji DNA from TGD perspective

New results about dark DNA inspired by the model for remote DNA replication

Three variants of dark genetic code and an objection against bio-harmony

About the role of possible longitudinal electric field of DNA

Quantum gravitation in TGD inspired quantum biology

Could the metabolism of cilia and flagella rely on gravitationally dark electrons?

How animals without brain can behave as if they had brain?

Connection between dark nucleon code and bioharmony

Implications of the model of pre-nervous system to the basic biochemistry and model nerve pulse

The language of fungi

Objection against the quantum gravitational metabolism

Quantum gravitational metabolism in contrast to the standard view about metabolism

Could quantum gravitation play a key role in the DNA metabolism and DNA replication and transcription?

Quantum gravitation as an explanation for the different chemistries of living and inanimate matter

Metabolism involves also the gravitational field of Sun

Jupiter's Moon Europa as a candidate for a seat of life

Quantum Gravitation and Topological Quantum Computation

Comparison of Orch-OR hypothesis with the TGD point of view

Snow flakes, Emoto effect, and Pollack effect: life at quantum criticality?

TGD view of Krebs cycle

The Possible Role of Spin Glass Phase and P-Adic Thermodynamics in Topological Quantum Computation: the TGD View

5.2.3 Prebiotic life

TGD provides new insights about prebiotic life. One key ingredient is $h_{gr} = h_{eff}$ phases at gravitational flux tubes. Also flux tubes with much smaller value $h_{eff} \ll h_{em}$ are predicted and could play a key role in the understanding of molecular bonds. The bond energies are predicted to increase as one moves to the right along the row of the periodic table. This could be crucial for the understanding why the molecules carrying metabolic energy contains atoms near the right end of the row,

Magnetic body would serve as the "boss" of ordinary matter. Bio-chemistry would be shadow dynamics, mimicry of a much simpler dark dynamics. Dark proton triplets at the flux tubes could already realize genetic code. Dark photon triplets would make possible communications based on resonance. This suggests that primordial life was associated with the magnetic body of water and that chemical life emerged only later.

This picture would solve several hen-egg problems such as the question whether metabolism of genetic code emerged first and whether DNA, RNA or proteins emerged first. All them could have emerged simultaneously as the mimicry of their dark analogs. Even cell membrane could be seen as a realization of a higher level 2-D representation of genetic code. Replication, transcription, and translation could have dark variants. In accordance with the basic idea about MB as boss, these processes could actually induce the corresponding processes at chemical level.

1. Evidence of ancient life discovered in mantle rocks deep below the seafloor
2. One step further in understanding the origins of life
3. Could the replication of mirror DNA teach something about chiral selection?
4. One step further in understanding the origins of life
5. From RNA world to RNA-tRNA world to DNA-RNA-protein world: how it went?
6. Model for RNA life
7. Two steps towards understanding of the origins of life
8. A potential missing link in prebiotic chemistry

9. System of particles able to self-assemble and self-heal in presence of acoustic waves
10. Did animals emerge only 100,000-200,000 y ago or did the mitochondrial mutation rate increase dramatically at that time?
11. Some applications of TGD inspired quantum biology: bio-catalysis, selection of bio-molecules, and remote metabolism
12. Do hydrogels learn in presence of irradiation and heating?
13. The mysterious dichloromethane droplet, which refuses to sink in water and begins to spin
14. Epigenesis, inherited memories and moods lasting over several generations
15. Very simple system showing brain like behaviours
16. Basic organic molecules appear much before they should
17. Chemistry revolution
18. Water oxidation and photosynthesis in TGD framework
19. Molecular Signalling from the TGD Point of View
20. Hen-egg problem: did RNA or proteins come first?
21. About prebiotic counterparts of tRNA and metabolic machinery

5.3 Pollack's findings about fourth phase of water

Pollack's findings about four phase of water allow a description in terms of emergence of dark phase of protons and provide support for the vision that genetic code is realized as sequences of dark protons with states of proton allowing grouping to multiplets in one-one correspondence with the basic bio-molecules [K23].

1. Pollack's findings about fourth phase of water
2. Possible implications of Pollack's findings for pre-biotic life in TGD Universe
3. Pollack's findings and quantum model of cell membrane using square root of thermodynamics
4. Biochemical communications as a prerequisite for dark photon communications?
5. How transition from dark life to biochemical life could have taken place?
6. Are bacteria able to induce phase transition to super fluid phase?
7. Is there a connection between biology, dark fusion, and nuclear fusion?

8. How the fourth phase of water discovered by Pollack is formed?
9. Pollack's mechanism and photosynthesis
10. Metabolic energy is not information but is needed to transfer negentropic entanglement
11. Is time reversal involved with Pollack effect?
12. Could dark protons and electrons be involved with di-electric breakdown and conduction in electrolytes?
13. A model for protocell based on Pollack effect
14. Mysteries associated with lightnings, ball lightnings and the electrosphere of Earth

5.4 Comments about puzzling experimental findings

This section gives a list of TGD inspired comments about various puzzling experimental findings in biology.

1. Cell memory and magnetic body
2. Magnetic body as genetic editor?
3. E_8 symmetry, harmony, and genetic code
4. Mechanism for the transfer of genetic information from soma cells to germ cells
5. Bacteria behave like spin system: Why?
6. Gut cells having no mitochondria survive: evidence for quantum credit card mechanism
7. Could the replication of mirror DNA teach something about chiral selection?
8. Taos hum as remote metabolism?
9. Could the presence of light affect weight?
10. Weight change for electrets and "weight of soul"
11. Are viruses fragments of topological quantum computer code?
12. About Comorosan effect in the clustering of RNA II polymerase proteins
13. An island at which body size shrinks
14. Could also RNA and protein methylation be involved with expression of molecular emotions
15. How do slime molds learn?

16. Learning by conditioning and learning by discovery
17. Why diseases do not like alkaline environments?
18. Covid19 and TGD
19. Oumuamua and TGD
20. Are mistletoes quantum energy thieves?
21. A chordate able to regenerate copies of it when dissected into 3 parts

6 TGD inspired theory of consciousness

TGD inspired theory of consciousness could be seen as a generalization of quantum measurement theory forced by ZEO and the possibility of having unitary entanglement giving rise to degenerate density matrix for which natural number theoretic information measure provided by the p-adic analog of Shannon entropy exists. Negentropy Maximization Principle (NMP) would be the basic variational principle consistent with second law. NMP would imply evolution as an accumulation of potentially conscious information - "Akashic records".

6.1 The notion of self and NMP

The notion of self is central for TGD and it is now possible formulate this notion rather convincingly using ZEO based view about state function reduction. Negentropy Maximization Principle (NMP) [K9] is the basic variational principle of TGD inspired quantum measurement theory behind TGD inspired theory of consciousness. The possibility of NE stable under NMP would be crucial for the understanding of living systems and evolution.

There have been several steps of progress related to the notion of self.

1. As already explained, strong form of NMP states that negentropy gain in quantum jump is maximal. The problem is that this does not allow free will in the sense as we tend to use: to make wrong choices!

Weak NMP allows to chose any projection operator and sub-space, which is any sub-space of the sub-space defined by the projection operator. Even 1-dimensional in which case standard state function reduction occurs and the system is isolated from the environment as a prize for sin! Surprisingly, weak form supports evolution since selves can choose the option for which negentropy of the final state is higher than otherwise. In particular, generalization of p-adic length scale hypothesis follows.

2. There is no need to assume interaction free measurements to read the NE. The sequence of state function reductions to fixed boundary CD defining self is enough to make NE conscious. Therefore the theory simplifies.

3. There is no need to keep the idea that p-adic-to-real transitions represent the transformation of intentions to actions and their reversals to the formation of thoughts. Sensory and cognitive aspects of existence are present as real and p-adic sectors of adelic space-time in all scales - even in elementary particle length scales as the success of p-adic mass calculations demonstrated already two decades ago - I am a slow learner!

One gets rid of the notion of p-adic manifold based on the map of real manifold to its p-adic counter part since strong form of holography allows to construct both real and p-adic preferred extremals from string world sheets and partonic 2-surfaces as basic data in the intersection of reality and various p-adicities. Preferred p-adic primes can be understood: it might even be that the preferred extremals exist only for them.

1. Self or only a model of self?
2. How to construct Akashic records and read them?
3. Some critical questions relating to Maya and Akashic records
4. More precise formulation of Negentropy Maximization Principle
5. NMP and Consciousness
6. Negentropic entanglement, NMP, braiding and TQC
7. One Mind theory, Akashic records, and negentropic entanglement
8. What self is?
9. Is evolution 3-adic?
10. Intentions, cognitions, time, and p-adic physics
11. Connection between Boolean cognition and emotions
12. Can one identify quantum physical correlates of ethics and moral?
13. How preferred p-adic primes could be determined?
14. Could adelic approach allow to understand the origin of preferred p-adic primes?
15. Updated Negentropy Maximization Principle
16. Breakthroughs in the number theoretic vision about TGD
17. p-Adic physics as physics of cognition and imagination
18. Impressions created by TSC 2015 conference
19. About quantum measurement and quantum computation in TGD Universe
20. About negentropic entanglement as analog of an error correction code

21. Ontology-Epistemology duality?
22. About Fermi-Dirac and Bose-Einstein statistics, negentropic entanglement, Hawking radiation, and firewall paradox in TGD framework
23. Should we start to bury free will?
24. How Ramanujan did it?
25. TGD Inspired Comments about Integrated Information Theory of Consciousness
26. NMP and adelic physics
27. “Final” solution to the qualia problem
28. Number theoretical feats and TGD inspired theory of consciousness
29. Wigner’s friend and Schrödinger’s cat
30. Cloning of maximally negentropic states is possible: DNA replication as cloning of this kind of states?
31. Is cloning of love possible?
32. p-Adic physics as physics of cognition and imagination and counterparts of recursive functions
33. About interactions of selves and their time reversals (and few words about ghosts)
34. Chemical qualia as number theoretical qualia?
35. Some TGD inspired comments related to quantum measurement theory
36. Consciousness is more like sequence of flashes than continuous stream
37. Maxwell’s demon from TGD viewpoint
38. Your eyes are the mirrors of my soul!
39. Multiple personality disorder as a Golden Road to a theory of consciousness?
40. Interesting result about binocular rivalry
41. New results in the geometric model of bio-harmony
42. Increase of the dimension of extension of rationals as the emergence of a reflective level of consciousness
43. Sensory perception and motor action as time reversals of each other: a royal road to the understanding of other minds?
44. How dreams are transformed to realities?

45. Quantum theory cannot consistently describe the use of itself: really?
46. What bio-teleportation could mean?
47. Still about quantum measurement theory in ZEO
48. Could quantum randomness have something to do with classical chaos?
49. The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group
50. Comparing Penrose-Hameroff theory with TGD inspired theory of consciousness
51. Could brain be represented by a hyperbolic geometry?
52. Binaural beat as a support for TGD view about brain
53. New Physics View about Language
54. Negentropy Maximization Principle and Second Law
55. About the role of Galois groups in TGD framework
56. Galois groups and genetic code
57. Pythagorean number mysticism, music harmony, and genetic code
58. Chemical bonds as flux tube links and realization of dark codons using only dark protons
59. Dark 3N-resonances and quantum teleportation
60. Quantum flute
61. Does the phenomenon of super oscillation challenge energy conservation?
62. Can quasi-time crystal be created by a Fibonacci process?: TGD point of view

6.2 The notion of time

ZEO provides a new view about state function reduction and leads also to the understanding of the connection between subjective time and geometric time and of the arrow of time [K1] [L13].

1. Little but important step in the understanding the arrow of time
2. About time delays related to passive aspects of consciousness: once again
3. Questions and answers about time
4. Sensory organs as seats of primary sensory qualia and memory recall as seeing in time direction

5. Does the flow of subjective time correspond to the increase of the average value of effective Planck constant?
6. How time reversed mental images differ from mental images?
7. Deconstruction and reconstruction in quantum physics and conscious experience
8. Inverse Research on Decisions Shows Instinct Makes Us Behave Like Cyborgs, not Robots: Really?
9. Confirmation of Santilli's detection of antimatter galaxies via a telescope with concave lenses: really?
10. Re-incarnation as a basic prediction of TGD inspired theory of consciousness
11. What does Negentropy Maximization Principle really say?
12. NMP and self
- 13.
14. Is conscious experience without definite causal order possible?
15. Retrocausality and TGD
16. WCW and the notion of intentional free will
17. The arrow of time is relative: experimental support
18. Sensory perception and motor action as time reversals of each other: a royal road to the understanding of other minds?
19. Could one distinguish experimentally between standard and TGD views about time?
20. The relationship between p-adic time and discrete flow of geometric time defined by quantum jumps
21. When does "big" state function reduction as universal death and re-incarnation with reversed arrow of time take place?
22. Conscious problem solving and quantum counterpart of computationalism in TGD
23. Arrow of time in neuroscience: TGD based view
24. Ageing as approach of magnetic body and biological body to thermal equilibrium
25. Could I go to bed today and wake-up yesterday morning?
26. Why the outcome of an event would be more predictable if it is known to occur?

27. How could the higher levels of MB use the brain to realize their free will?
28. Aging from TGD point of view
29. Are we living in the past?
30. How can the perception of quale have a finite duration?

6.3 Music, consciousness, emotions, cognition, genetic code

The observations that icosahedron has 12 vertices (number of notes in 12-note scale) and has 20 vertices (the number of amino-acids) led to a cascade of ideas [L2, L1] [K14]. The outcome involves characterization of basic musical harmonics in terms of allowed 3-chords and a model for genetic code predicting it correctly in terms of symmetries of Hamiltonian cycles representing imbeddings of 12-note scale at icosahedron. This leads also to a proposal that basic bio-molecules could communicate by using music represented as 3-chords of dark photons with frequencies in the same range as audible frequencies. This would give a highly detailed realization of the vision about realization of genetic code in terms of frequencies.

- (a) Pythagoras, music, sacred geometry, and genetic code
- (b) Geometric theory of harmony
- (c) Genes music and icosahedron
- (d) Harmony music and religious myths
- (e) Combinatorial Hierarchy: two decades later
- (f) What could be the physical origin of Pythagorean scale?
- (g) Slime holds: conscious intelligence without central nervous system?
- (h) About the Correspondence of Dark Nuclear Genetic Code and Ordinary Genetic Code
- (i) Homonymy of the genetic code from TGD point of view
- (j) The experiments of Masaru Emoto with emotional imprinting of water
- (k) Does RNA code for pain?
- (l) New results in the geometric model of bio-harmony
- (m) Icosa-tetrahedral and icoso-dodecahedral bioharmonies as candidates for genetic code
- (n) An Overall View about Models of Genetic Code and Bio-harmony

- (o) The details of the genetic code in the model based on bio-harmony
- (p) How could the representations of genetic code as dark 3-chords and nucleotide triplets relate?
- (q) How compose beautiful light music in bioharmony?
- (r) Is genetic code part of fundamental physics in TGD framework?
- (s) Is analysis as a cognitive process analogous to particle reaction?
- (t) MeshCODE theory from TGD point of view
- (u) The realization of genetic code in terms of dark nucleon triplets

6.4 Magnetic body and neuroscience

EEG and its possible variants mediate dark photon communications between biological body and magnetic body having onion-like structure with layers which can be of the size of Earth and even exceed it. Together with ZEO this leads to rather interesting speculations.

- (a) Hypnosis as remote mental interaction
- (b) What is EEG made of?
- (c) Psychedelics induced experiences and magnetic body
- (d) How visual percepts are constructed?
- (e) The effects of psychedelics as a key to the understanding of remote mental interactions?
- (f) Do neurons have their own genomes?
- (g) Evidence for the notion of magnetic body from brain synchrony without corpus callosum
- (h) About physical representations of genetic code in terms of dark nuclear strings
- (i) Two proposals for physical realization of genetic code predicting correctly the numbers of codons coding given amino-acid
- (j) Non-locality in quantum theory, in biology and neuroscience, and in remote mental interactions: TGD perspective
- (k) Could dark DNA, RNA, tRNA and amino-acids correspond to different charge states of codons?
- (l) Are sound-like bubbles whizzing around in DNA essential to life?

- (m) Is bio-catalysis a shadow of dark bio-catalysis based on generalization of genetic code?
- (n) What about quantum entanglement between codons?
- (o) Comparing TGD view about quantum biology with McFadden's views
- (p) Further pieces of evidence for the notion of magnetic body
- (q) Magnetic body, biophotons, and prediction of scaled variant of EEG
- (r) Biophotons and evolution of intelligence
- (s) Evidence for the notion of magnetic body from brain synchrony without corpus callosum
- (t) About double slit experiments of Dean Radin
- (u) DMT: connector to God or bio-chemical waste?
- (v) DMT, pineal gland, and the new view about sensory perception, dreams/hallucinations, and imagination
- (w) Could Alzheimer's disease be cured?
- (x) Why Alzheimer does not destroy some aspects of consciousness?
- (y) Artificial Intelligence, Natural Intelligence, and TGD
- (z) What could idiot savants teach to us about Natural Intelligence?
 - () Does the action of anesthetes prevent the formation of cognitive mental images?
 - () Emotions as sensory percepts about the state of magnetic body?
 - () Getting memories by eating those who already have them
 - () How did language emerge?
 - () How brain selectively remembers new places?
 - () Dance of the honeybee and New Physics
 - () Revolution in neuroscience: Hebb's rules updated?
 - () Quantum magic: interview of Dean Radin
 - () The experiments of Masaru Emoto with emotional imprinting of water
 - () Does RNA code for pain?
 - () Dark valence electrons and color vision

- () Sensory perception and motor action as time reversals of each other: a royal road to the understanding of other minds?
- () Could cancer be a disease of magnetic body?
- () Interpretation of the experiments of Montagnier et al
- () Understanding the dark magnetic bodies of biomolecules: concrete view about bio-quantum coherence
- () Mice in magnetic fields
- () Long term sensory memories in TGD framework
- () How could the TQC programs representing basic bio-reactions emerge?
- () Motor actions as TQC programs written by Nature itself
- () Multilocal viruses
- () Immortal jellyfish in zero energy ontology
- () TGD inspired model for magneto-reception and circadian rhythm
- () Phase transitions generating dark phases and sensory perception
- () Zero energy ontology and quantum model for nerve pulse
- () 50 Hz electric stimulation of central lateral thalamus can wake up from anaesthesia
- () Could brain be represented by a hyperbolic geometry?
- () Binaural beat as a support for TGD view about brain
- () New Physics View about Language
- () Schumann resonances and consciousness
- () EEG and the structure of magnetosphere
- () AI research may have hit a dead end
- () Has AI hit a dead end?
- () The rational and intuitive modes of problem solving from the TGD point of view
- () Sensory hubs in the brain are shifting although they should not
- () About TGD view of neuron
- () Humans are different
- () Horizontal Gene Transfer by Remote Replication?
- () Does consciousness survive bodily death?
- () DMT experiences and hyperbolic geometry

6.5 Microtubules in TGD

Microtubules as quantum antennas [K13] represents one of the oldest ideas of TGD inspired quantum biology and relies on so called massless extremals [K8]. There are new experimental findings about microtubules giving support for their identification as macroscopic quantum systems. TGD provides a possible interpretation of the findings.

- (a) Are microtubules macroscopic quantum system
- (b) Orch-Or theory of Penrose and Hameroff and new experimental findings about microtubules
- (c) A model for anesthetic action
- (d) Anesthetes again
- (e) Impressions from SSE-2016 conference
- (f) How AC voltage at critical frequencies could induce transition to micro-tubular superconductivity?
- (g) Delayed luminescence for microtubules, quantum gravitation, and the mechanism of anesthesia
- (h) Comparison of Orch-OR hypothesis with the TGD point of view
- (i) Comparison of Orch-OR hypothesis with the TGD point of view
- (j) Snow flakes, Emoto effect, and Pollack effect: life at quantum criticality?

7 Miscellaneous

7.1 General question related to unified theories and sociology around them

This subsection contains links to various topics related to the building of unified theories.

- (a) Why trust a theory?
- (b) Could the interpretation of Planck mass be totally wrong?
- (c) Emergence of 3-space or only the emergence of experience about 3-space?
- (d) Does quantum gravity look like a mission impossible because of our cherished beliefs?
- (e) Dogmatism, ego, and elite of mental images

- (f) Two styles of theorizing: conservative and radical
- (g) The future of physics according to Nima-Arkani Hamed
- (h) Could the sufferings of the dying superstring theory be finally over?
- (i) When big dream changes to its diametric opposite?
- (j) When we will start to make theoretical physics again?
- (k) Are the laws of physics inevitable?
- (l) About list of unsolved problems in physics
- (m) Musings on the Current Status of HEP
- (n) Why AI pattern recognition can differ dramatically from human pattern recognition?
- (o) Could string theorists be finally approaching the discovery of number theoretical physics
- (p) The latest interpretation of quantum theory
- (q) John Baez about Noether's theorem in algebraic approach
- (r) Is there a chronon of time?
- (s) Penrose and the importance of intuition
- (t) Superdeterminism and TGD

7.2 Varying topics

The topics of this section does not have any common denominator.

- (a) Three atmospheric puzzles with a common solution
- (b) How to design your own light saber?
- (c) Palmer's Invariant Set Theory and TGD
- (d) Is the impossible EM drive possible in TGD Universe?
- (e) Laundry pile phenomenon and various dimensions
- (f) The world is really simple: even neural nets are able to model it!
- (g) Induction coils in many-sheeted space-time
- (h) Narcissism, ethics, and adeles
- (i) What would you choose: Alcubierre drive or superluminal quantum teleportation in zero energy ontology?
- (j) A duality between certain non-hermitian systems in flat space with unitary systems in curved space

7.3 TGD related topics

The articles here are related to TGD or the reactions created by TGD (or rather total absence of them).

- (a) New book about TGD
- (b) Basic course in misunderstanding publicly what TGD is
- (c) Can one apply Occam's razor as a general purpose debunking argument to TGD?
- (d) Answer to a question about general aspects of TGD
- (e) Does Monster have place in TGD Universe?
- (f) Are we all artists?: or what my "Great Experience" taught me about consciousness
- (g) Some layman considerations related to the fundamentals of mathematics
- (h) Have you ever felt like being a unified theorist living at wrong century?
- (i) Brief summary of TGD
- (j) Books split in pieces and homepage re-organized
- (k) A visit to Baden-Baden
- (l) But can one calculate anything?
- (m) Year 2019 in TGD
- (n) What next in TGD?
- (o) Nature Physics and physics
- (p) Why not publish a book about TGD?
- (q) Summary of TGD (a lot of figures!)
- (r) Quantum asymmetry between space and time?

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