Exploration

Can One Apply Occam's Razor as a General Purpose Debunking Argument to TGD?

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Abstract

Occarm's razor have been used to debunk TGD. The following arguments provide the information needed by the reader to decide himself. Considerations at three levels. The level of "world of classical worlds" (WCW) defined by the space of 3-surfaces endowed with Kähler structure and spinor structure and with the identification of WCW space spinor fields as quantum states of the Universe: this is nothing but Einstein's geometrization program applied to quantum theory. Second level is space-time level. Space-time surfaces correspond to preferred extremals of Käction in $M^4 \times CP_2$. The number of field like variables is 4 corresponding to 4 dynamically independent imbedding space coordinates. Classical gauge fields and gravitational field emerge from the dynamics of 4-surfaces. Strong form of holography reduces this dynamics to the data given at string world sheets and partonic 2-surfaces and preferred extremals are minimal surface extremals of Kähler action so that the classical dynamics in space-time interior does not depend on coupling constants at all which are visible via boundary conditions only. Continuous coupling constant evolution is replaced with a sequence of phase transitions between phases labelled by critical values of coupling constants: loop corrections vanish in given phase. Induced spinor fields are localized at string world sheets to guarantee well-definedness of em charge. At imbedding space level the modes of imbedding space spinor fields define ground states of super-symplectic representations and appear in QFT-GRT limit. GRT involves post-Newtonian approximation involving the notion of gravitational force. In TGD framework the Newtonian force correspond to a genuine force at imbedding space level.

1 Introduction

Occam's razor argument is one the standard general purpose arguments used in debunking: the debunked theory is claimed to be hopelessly complicated. This argument is more refined that mere "You are a crackpot!" but is highly subjective and often the arguments pro or con are not given. Combined with the claim that the theory does not predict anything Occam's razor is very powerful argument unless the audience includes people who have bothered to study the debunked theory.

Let us take a closer look on this argument and compare TGD superstring models and seriously ask which of these theories is simple.

In superstring models one has strings as basic dynamical objects. They live in target space M^{10}, which in some mysterious manner (something "non-perturbative" it is) spontaneously compactifies to $M^4 \times C$, C is Calabi-Yau space. The number of them is something like 10^{500} or probably infinite: depends on the counting criterion. And this estimate leaves their metric open. This leads to landscape and multiverse catastrophe: theory cannot predict anything. As a matter fact $M^4 \times C$:s must be allowed to deform still in Kaluza-Klein paradigm in which space-time has Calabi-Yau as small additional dimensions. An alternative manner to obtain space-time is as 3-brane. One obtains also higher-D objects. Again by some "nonperturbative" mechanisms. One does not even know what space-time is! Situation looks to me a totally hopeless mess. Reader can conclude whether to regard this as simple and elegant.

I will consider TGD at three levels. At the level of "world of classical worlds" (WCW), at space-time level, and at the level of imbedding space $H = M^4 \times CP_2$. I hope that I can convince the reader about the simplicity of the approach. The simplicity is actually quite shocking and certainly an embarrassing

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experience for the unhappy super string theorists meandering around in the landscape and multiverse. Behind this simplicity are however principles - something, which colleagues usually regard as unpractical philosophizing: "shut-up-and-calculate!"!

2 WCW level: a generalization of Einstein's geometrization program to entire quantum physics

I hope that the reader would read the following arguments keeping in mind the question "Is TGD really hopelessly complicated mess of pieces picked up randomly from theoretical physics?" as one debunker who told that he does not have time to read TGD formulated it.

1. Einstein's geometrization program for gravitation has been extremely successful but has failed for other classical fields, which do not have natural geometrization in the case of abstract four-manifolds with metric. One should understand standard model quantum numbers and also family replication for fermions.

   However, if space-time can be regarded surface in $H = M^4 \times CP_2$ also the classical fields find a natural geometrization as induced fields obtained basically by projecting. Also spinor structure can be induced and one avoids the problems due the fact that generic space-time as abstract 4-manifold does not allow spinor structure. The dynamics of space-time surfaces incredibly simple: only 4 field-like variables corresponding to *four* imbedding space coordinates and induced that of classical geometric fields. Nowadays one would speak of emergence. The complexity emerges from the topology of space-time surfaces giving rise to many-sheeted space-time.

2. Even this view about geometrization is generalized in TGD. Einstein's geometrization program is applied to the entire quantum physics in terms of the geometry of WCW consisting of 3-D surfaces of H. More precisely, in zero energy ontology (ZEO) it consists of pairs of 3-surfaces at opposite boundaries of causal diamond (CD) connected by a preferred extremals of a variational principle to be discussed.

   Quantum states of the Universe would correspond to the modes of formally classical WCW spinor field satisfying the analog of Dirac equation. No quantization: just the construction of WCW geometry and spinor structure. The only genuinely quantal element of quantum theory would be state function reduction and in ZEO its description leads to a quantum theory of consciousness.

To me this sounds not only simple but shockingly simple.

2.1 WCW geometry

Consider first the generalization of Einstein's program of at the level of WCW geometry [11, 7, 6].

1. Since complex conjugation must be geometrized, WCW must allow a geometric representation of imaginary unit as an antisymmetric tensor, which is essentially square root of the negative of the metric tensor and thus allow Kähler structure coded by Kähler function. One must have 4-D general coordinate invariance (GCI) but basic objects are 3-D surfaces. Therefore the definition of Kähler function must assign to 3-surface a unique 4-surface.

   Kähler function should have physical meaning and the natural assumption is that it is Kähler action plus possibly also volume term (twistor lift implies it). Space-time surface would be a preferred extremal of this action. The interpretation is also as an analog of Bohr orbit so that Bohr orbitology would correspond exact rather than only approximate part of quantum theory in TGD framework. One could speak also of quantum classical correspondence.

2. The action principle involves coupling parameters analogous to thermodynamical parameters. Their value spectrum is fixed by the conditions that TGD is quantum critical. For instance Kähler couplings strength is analogous to critical temperature. Different values correspond to different phases. Coupling constant evolution correspond to phase transitions between these phases and loops vanish as in free field theory for $\mathcal{N}=4$ SYM.

3. The infinite-dimensionality of WCW is a crucial element of simplicity. Already in the case of loop spaces the geometry is essentially unique: loop space is analogous to a symmetric space points of the loop space being geometrically equivalent. For loop spaces Riemann connection exists only of the metric has maximal isometries defined by Kac-Moody algebra.

   The generalization to 3-D case is compelling. In TGD Kac-Moody algebra is replaced by super-symplectic algebra, which is much larger but has same basic structure (conformal weights of two kinds) and a fractal hierarchy of isomorphic sub-algebas with conformal weights coming as multiples of those for the entire algebra is crucial. Physics is unique because of its mathematical existence. WCW decompose to a union of sectors, which are infinite-D variants of symmetric spaces labelled by zero modes whose differentials do not appear in the line element of WCW.

All this sounds to me shockingly simple.

2.2 WCW spinor structure

One must construct also spinor structure for WCW [9, 11].

1. The modes of WCW spinor fields would correspond to the solutions of WCW Dirac equation and would define the quantum states of the Universe. WCW spinors (assignable to given 3-surface) would correspond to fermionic Fock states created by fermionic creation operators. In ZEO 3-surfaces are pairs of 3-surfaces assignable to the opposite boundaries of WCW connected by preferred extremal.

   The fermionic states are superpositions of pairs of fermion states with opposite net quantum numbers at the opposite ends of space-time surface at boundaries of CD. The entanglement coefficients define the analogs of S-matrix elements. The analog of Dirac equation is analog for super-Virasoro conditions in string models but assignable to the infinite-D supersymplectic algebra of WCW defining its isometries.

2. The construction of the geometry of WCW requires that the anticommuting gamma matrices of WCW are expressible in terms of fermionic oscillator operators assignable to the induced spinor fields at space-time surface. Fermionic anti-commutativity at space-time level is not assumed but is forced by the anticommutativity of gamma matrices to metric. Fermi statistics is geometrized.

3. The gamma matrices of WCW in the coordinates assignable to isometry generators can be regarded as generators of superconformal symmetries. They correspond to classical charges assignable to the preferred extremals and to fermionic generators. The fermionic isometry generators are fermionic bilinears and super-generators are obtained from them by replacing the second second quantized spinor field with its mode. Quantum classical correspondence between fermionic dynamics and classical dynamics (SH) requires that the eigenvalues of the fermionic Cartan charges are equal to corresponding bosonic Noether charges.

4. The outcome is that quantum TGD reduces to a theory of formally *classical* spinor fields at the level of WCW and by infinite symmetries the construction of quantum states reduces to the construction of representations of super-symplectic algebra which generalizes to Yangian algebra as twistorial picture suggests. In ZEO everything would reduce to group theory, even the construction of scattering amplitudes! In ZEO the construction of zero energy states and thus scattering amplitudes would reduce to that for the representations of Yangian variant of super-symplectic algebra [1] [4, 2, 3].

5. One can go to the extreme and wonder whether the scattering amplitudes as entanglement coefficients for Yangian zero energy states are just constant scalars for given values of zero modes as group invariant for isometries. This would leave only integration over zero modes and if number theoretical universality is assumed this integral reduces to sum over points with algebraic coordinates in the preferred coordinates made possible by the symmetric space property. Certainly this is one of the lines of research to be followed in future.

   Personally I find it hard to imagine anything simpler!

3 Space-time level: many-sheeted space-time and emergence of classical fields and GRT space-time

At space-time level one must consider dynamics of space-time surface and spinorial dynamics.

3.1 Dynamics of space-time surfaces

Consider first simplicity at space-time level.

1. Space-time is identified as 4-D surface in certain imbedding space required to have symmetries of special relativity - Poincare invariance. This resolves the energy problem and many other problems of GRT [10].

   This allows also to see TGD as generalization of string models obtained by replacing strings with 3-surfaces and 2-D string world sheets with 4-D space-time surfaces. Small space-time surfaces are particles, large space-time surfaces the background space-time in which these particles "live". There are only 4 dynamical field like variables for 8-D $M^4 \times CP_2$ since GCI eliminates 4 imbedding space coordinates (they can be taken as space-tme coordinates). This should be compared with the myriads of classical fields for 10-D Einstein's theory coupled to matter fields (do not forget landscape and multiverse!)

2. Classical fields are induced at the level of single space-time sheet from their geometric counterparts in imbedding space. A more fashionable way to say the same is that they emerge. Classical gravitational field correspond to the induced metric, electroweak gauge potentials to induced spinor connection of CP_2 and color gauge potentials to projections of Killing vector fields for CP_2.

3. In TGD the space-time of GRT is replaced by many-sheeted space-time constructed from basic building bricks, which are preferred extremals of Kähler action + volume term. This action emerges in twistor lift of TGD existing only for $H = M^4 \times CP_2$: TGD is completely unique since only M^4 and CP_2 allows twistor space with Kähler structure. This also predicts Planck length as radius of twistor sphere associated with M^4. Cosmological constant appears as the coefficient of the volume term and obeys p-adic length scale evolution predicting automatically correct order of magnitude in the scale of recent cosmos. Besides this one has CP_2 size which is of same order of magnitude as GUT scale, and Kähler coupling strength. By quantum criticality the various parameters are quantized.

   Quantum criticality is basic dynamical principle [7, 14] and discretizes coupling constant evolution: only coupling constants corresponding to quantum criticality are realized and discretized coupling constant evolution corresponds to phase transitions between these values of coupling constants. All radiative corrections vanish so that only tree diagram contribute.

4. Preferred extremals realize strong form of holography (SH) implied by strong form of GCI (SGCI) emerging naturally in TGD framework. That GCI implies SH meaning an enormous simplification at the conceptual level.

One has two choices for fundamental 3-D objects. They could be light-like boundaries between regions of Minkowskian and Euclidian signatures of the induced metric or they could be pairs of space-time 3-surfaces at the ends of space-time surface at opposite boundaries of causal diamond (CD) (CDs for a scale hierarchy). Both options should be correct so that the intersections of these 3-surfaces consisting of partonic 2-surfaces at which light-like partonic orbits and space-like 3-surfaces intersect should carry the data making possible holography. Also data about normal space of partonic 2-surface is involved.

SH generalizes AdS/CFT correspondence by replacing holography with what is very much like the familiar holography. String world, sheets, which are minimal surfaces carrying fermion fields and partonic 2-surfaces intersecting string world sheets at discrete points determine by SH the entire 4-D dynamics. The boundaries of string world sheets are world lines with fermion number coupling to classical Kähler force. In the interior Kähler force vanishes so that one has "dynamics of avoidance" [19] required also by number theoretic universality satisfied if the coupling constants do not appear in the field equations at all: they are however seen in the boundary values stating vanishing of the classical super-symplectic charges (Noether's theorem) so that one obtains dependence of coupling constants via boundary conditions and coupling constant evolutions makes it manifest also classically. Hence the preferred extremals from which the space-time surfaces are engineered are extremely simple objects.

5. In twistor formulation the assumption that the inverse of Kähler coupling strength has zeros of Riemann zeta [18] as the spectrum of its quantum critical values gives excellent prediction for the coupling constant of U(1) coupling constant of electroweak interactions. Complexity means that extremals are extremals of both Kähler action and volume term: minimal surfaces extremals of Kähler action. This would be part of preferred extremal property.

   Why α_K should be complex? If α_K is real, both bosonic and fermionic degrees of freedom for Euclidian and Minkowskian regions decouple completely. This is not physically attractive. If α_K is complex there is coupling between the two regions and the simplest assumption is that there is no Chern-Simons term in the action and one has just continuity conditions for canonical momentum current and hits super counterpart. Note the analogy with the possibility of blackhole evaporation. The presence of momentum exchange is also natural since it gives classical space-time correlates for interactions as momentum exchange.

   The conditions state that sub-algebra of super-symplectic algebra isomorphic to itself and its commutator with the entire algebra annihilate the physical states (classical Noether charges vanish). The condition could follow from minimal surface extremality or provide additional conditions reducing the degrees of freedom. In any case, 3-surfaces would be almost 2-D objects.

6. GRT space-time emerges from many-sheeted space-time as one replaces the sheets of many-sheeted space-time (4-D M^4 projection) to single slightly curved region of M^4 defining GRT space-time. Since test particle regarded as 3-surface touching the space-time sheets of many-sheeted spacetime, test particle experiences the sum of forces associated with the classical fields at the space-time sheets. Hence the classical fields of GRT space-time are sums of these fields. Disjoint union for space-time sheets maps to the sum of the induced fields. This gives standard model and GRT as long range scale limit of TGD.

3.2 How to build TGD space-time from legos?

TGD predicts shocking simplicity of both quantal and classical dynamics at space-time level. Could one imagine a construction of more complex geometric objects from basic building bricks - space-time legos?

Let us list the basic ideas.

1. Physical objects correspond to space-time surfaces of finite size - we see directly the non-trivial topology of space-time in everyday length scales.

2. There is also a fractal scale hierarchy: 3-surfaces are topologically summed to larger surfaces by connecting them with wormhole contact, which can be also carry monopole magnetic flux in which one obtains particles as pairs of these: these contacts are stable and are ideal for nailing together pieces of the structure stably.

3. In long length scales in which space-time surface tend to have 4-D M^4 projection this gives rise to what I have called many-sheeted spacetime. Sheets are deformations of canonically imbedded M^4 extremely near to each other (the maximal distance is determined by CP_2 size scale about 10^4 Planck lengths. The sheets touch each other at topological sum contacts, which can be also identified as building bricks of elementary particles if they carry monopole flux and are thus stable. In $D = 2$ it is easy to visualize this hierarchy.

What could be the simplest surfaces of this kind - legos?

1. Assume twistor lift [14, 16] so that action contain volume term besides Kähler action: preferred extremals can be seen as non-linear massless fields coupling to self-gravitation. They also simultaneously extremals of Kähler action. Also hydrodynamical interpretation makes sense in the sense that field equations are conservation laws. What is remarkable is that the solutions have no dependence on coupling parameters: this is crucial for realizing number theoretical universality. Boundary conditions however bring in the dependence on the values of coupling parameters having discrete spectrum by quantum criticality.

2. The simplest solutions corresponds to Lagrangian sub-manifolds of CP_2: induced Kähler form vanishes identically and one has just minimal surfaces. The energy density defined by scale dependent cosmological constant is small in cosmological scales - so that only a template of physical system is in question. In shorter scales the situation changes if the cosmological constant is proportional the inverse of p-adic prime.

   The simplest minimal surfaces are constructed from pieces of geodesic manifolds for which not only the trace of second fundamental form but the form itself vanishes. Geodesic sub-manifolds correspond to points, pieces of lines, planes, and 3-D volumes in E^3. In CP_2 one has points, circles, geodesic spheres, and CP_2 itself.

3. CP_2 type extremals defining a model for wormhole contacts, which can be used to glue basic building bricks at different scales together stably: stability follows from magnetic monopole flux going through the throat so that it cannot be split like homologically trivial contact. Elementary particles are identified as pairs of wormhole contacts and would allow to nail the legos together to from stable structures.

Amazingly, what emerges is the elementary geometry. My apologies for those who hated school geometry.

3.2.1 Geodesic minimal surfaces with vanishing induced gauge fields

Consider first *static* objects with 1-D CP_2 projection having thus *vanishing* induced gauge fields. These objects are of form $M^1 \times X^3$, $X^3 \subset E^3 \times CP_2$. M^1 corresponds to time-like or possible light-like geodesic (for CP_2 type extremals). I will consider mostly Minkowskian space-time regions in the following.

1. Quite generally, the simplest legos consist of 3-D geodesic sub-manifolds of $E^3 \times CP_2$. For E^3 their dimensions are $D = 1, 2, 3$ and for CP_2, $D = 0, 1, 2$. CP_2 allows both homologically non-trivial resp. trivial geodesic sphere S^2_I resp. S^2_{II}. The geodesic sub-manifolds cen be products $G_3 = G_{D_1} \times G_{D_2}$, $D_2 = 3 - D_1$ of geodesic manifolds G_{D_1}, $D_1 = 1, 2, 3$ for E^3 and G_{D_2}, $D_2 = 0, 1, 2$ for CP_2.

2. It is also possible to have twisted geodesic sub-manifolds G_3 having geodesic circle S^1 as CP_2 projection corresponding to the geodesic lines of $S^1 \subset CP_2$, whose projections to E^3 and CP_2 are geodesic line and geodesic circle respectively. The geodesic is characterized by S^1 wave vector. One can have this kind of geodesic lines even in $M^1 \times E^3 \times S^1$ so that the solution is characterized also by frequency and is not static in CP_2 degrees of freedom anymore.

   These parameters define a four-D wave vector characterizing the warping of the space-time surface: the space-time surface remains flat but is warped. This effect distinguishes TGD from GRT. For instance, warping in time direction reduces the effective light-velocity in the sense that the time used to travel from A to B increases. One cannot exclude the possibility that the observed freezing of light in condensed matter could have this warping as space-time correlate in TGD framework.

   For instance, one can start from 3-D minimal surfaces $X^2 \times D$ as local structures (thin layer in E^3). One can perform twisting by replacing D with twisted closed geodesics in $D \times S^1$: this gives valued map from D to S^1 (subset CP_2) representing geodesic line of $D \times S^1$. This geodesic sub-manifold is trivially a minimal surface and defines a two-sheeted cover of $X^2 \times D$. Wormhole contact pairs (elementary particles) between the sheets can be used to stabilize this structure.

3. Structures of form $D^2 \times S^1$, where D^2 is polygon, are perhaps the simplest building bricks for more complex structures. There are continuity conditions at vertices and edges at which polygons D_i^2 meet and one could think of assigning magnetic flux tubes with edes in the spirit of homology: edges as magnetic flux tubes, faces as 2-D geodesic sub-manifolds and interiors as 3-D geodesic sub-manifolds.

   Platonic solids as 2-D surfaces can be build are one example of this and are abundant in biology and molecular physics. An attractive idea is that molecular physics utilizes this kind of simple basic structures. Various lattices appearing in condensed matter physics represent more complex structures but could also have geodesic minimal 3-surfaces as building bricks. In cosmology the honeycomb structures having large voids as basic building bricks could serve as cosmic legos.

4. This lego construction very probably generalizes to cosmology, where Euclidian 3-space is replaced with 3-D hyperbolic space $SO(3,1)/SO(3)$. Also now one has pieces of lines, planes and 3-D volumes associated with an arbitrarily chosen point of hyperbolic space. Hyperbolic space allows infinite number of tesselations serving as analogs of 3-D lattices and the characteristic feature is quantization of redshift along line of sight for which empirical evidence is found.

5. The structures as such are still too simple to represent condensed matter systems. These basic building bricks can glued together by wormhole contact pairs defining elementary particles so that matter emerges as stabilizer of the geometry: they are the nails allowing to fix planks together, one might say.

3.2.2 Geodesic minimal surfaces with non-vanishing gauge fields

What about minimal surfaces and geodesic sub-manifolds carrying non-vanishing gauge fields - in particular em field (Kähler form identifiable as U(1) gauge field for weak hypercharge vanishes and thus also its contribution to em field)? Now one must use 2-D geodesic spheres of CP_2 combined with 1-D geodesic lines of E^2. Actually both homologically non-trivial resp. trivial geodesic spheres S_I^2 resp. S_{II}^2 can be used so that also non-vanishing Kähler forms are obtained.

The basic legos are now $D \times S_i^2$, $i = I, II$ and they can be combined with the basic legos constructed above. These legos correspond to two kinds of magnetic flux tubes in the ideal infinitely thin limit. There are good reasons to expected that these infinitely thin flux tubes can be thickened by deforming them in E^3 directions orthogonal to D. These structures could be used as basic building bricks assignable to the edges of the tensor networks in TGD.

3.2.3 Static minimal surfaces, which are not geodesic sub-manifolds

One can consider also more complex static basic building bricks by allowing bricks which are not anymore geodesic sub-manifolds. The simplest static minimal surfaces are form $M^1 \times X^2 \times S^1$, $S^1 \subset CP_2$ a geodesic line and X^2 minimal surface in E^3.

Could these structures represent higher level of self-organization emerging in living systems? Could the flexible network formed by living cells correspond to a structure involving more general minimal surfaces - also non-static ones - as basic building bricks? The Wikipedia article about minimal surfaces in E^3 suggests the role of minimal surface for instance in bio-chemistry (see `http://tinyurl.com/zqlv322`).

The surfaces with constant positive curvature do not allow imbedding as minimal surfaces in E^3. Corals provide an example of surface consisting of pieces of 2-D hyperbolic space H^2 immersed in E^3 (see `http://tinyurl.com/ho9uvcc`). Minimal surfaces have negative curvature as also H^2 but minimal surface immersions of H^2 do not exist. Note that pieces of H^2 have natural imbedding to E^3 realized as light-one proper time constant surface but this is not a solution to the problem.

Does this mean that the proposal fails?

1. One can build approximately spherical surfaces from pieces of planes. Platonic solids represents the basic example. This picture conforms with the notion of monadic manifold having as a spine a discrete set of points with coordinates in algebraic extension of rationals (preferred coordinates allowed by symmetries are in question). This seems to be the realistic option.

2. The boundaries of wormhole throats at which the signature of the induced metric changes can have arbitrarily large M^4 projection and they take the role of blackhole horizon. All physical systems have such horizon and the approximately boundaries assignable to physical objects could be horizons of this kind. In TGD one has minimal surface in $E^3 \times S^1$ rather than E^3. If 3-surface have no space-like boundaries they must be multi-sheeted and the sheets co-incide at some 2-D surface analogous to boundary. Could this 3-surface give rise to an approximately spherical boundary.

3. Could one lift the immersions of H^2 and S^2 to E^3 to minimal surfaces in $E^3 \times S^1$? The constancy of scalar curvature, which is for the immersions in question quadratic in the second fundamental form would pose one additional condition to non-linear Laplace equations expressing the minimal surface property. The analyticity of the minimal surface should make possible to check whether the hypothesis can make sense. Simple calculations lead to conditions, which very probably do not allow solution.

Does the stationary spherically symmetric star model of GRT based on Reissner-Nordström or Schwartschild metric have minimal surface counterpart? Do Robertson-Walker type cosmologies allow minimal surface representatives? In [19] these questions are answered.

3.2.4 Dynamical minimal surfaces: how space-time manages to engineer itself?

At even higher level of self-organization emerge dynamical minimal surfaces. Here string world sheets as minimal surfaces represent basic example about a building block of type $X^2 \times S_i^2$. As a matter fact, S^2 can be replaced with complex sub-manifold of CP_2.

One can also ask about how to perform this building process. Also massless extremals (MEs) representing TGD view about topologically quantized classical radiation fields are minimal surfaces but now the induced Kähler form is non-vanishing. MEs can be also Lagrangian surfaces and seem to play fundamental role in morphogenesis and morphostasis as a generalization of Chladni mechanism [17, 16]. One might say that they represent the tools to assign material and magnetic flux tube structures at the nodal surfaces of MEs. MEs are the tools of space-time engineering. Here many-sheetedness is essential for having the TGD counterparts of standing waves.

3.3 Induced spinor structure

The notion of induced spinor field deserves a more detailed discussion. Consider first induced spinor structures [9].

1. Induced spinor field are spinors of $M^4 \times CP_2$ for which modes are characterized by chirality (quark or lepton like) and em charge and weak isospin.

2. Induced spinor spinor structure involves the projection of gamma matrices defining induced gamma matrices. This gives rise to superconformal symmetry if the action contains only volume term.

   When Kähler action is present, superconformal symmetry requires that the modified gamma matrices are contractions of canonical momentum currents with imbedding space gamma matrices. Modified gammas appear in the modified Dirac equation and action, whose solution at string world sheets trivializes by super-conformal invariance to same procedure as in the case of string models.

3. Induced spinor fields correspond to two chiralities carrying quark number and lepton number. Quark chirality does not carry color as spin-like quantum number but it corresponds to a color partial wave in CP_2 degrees of freedom: color is analogous to angular momentum. This reduces to spinor harmonics of CP_2 describing the ground states of the representations of super-symplectic algebra.

   The harmonics do not satisfy correct correlation between color and electroweak quantum numbers although the triality t=0 for leptonic waves and t=1 for quark waves. There are two manners to solve the problem.

   (a) Super-symplectic generators applied to the ground state to get vanishing ground states weight instead of the tachyonic one carry color and would give for the physical states correct correlation: leptons/quarks correspond to the same triality zero(one partial wave irrespective of charge state. This option is assumed in p-adic mass calculations [8].

   (b) Since in TGD elementary particles correspond to pairs of wormhole contacts with weak isospin vanishing for the entire pair, one must have pair of left and right-handed neutrinos at the second wormhole throat. It is possible that the anomalous color quantum numbers for the entire state vanish and one obtains the experimental correlation between color and weak quantum numbers. This option is less plausible since the cancellation of anomalous color is not local as assume in p-adic mass calculations.

The understanding of the details of the fermionic and actually also geometric dynamics has taken a long time. Super-conformal symmetry assigning to the geometric action of an object with given dimension an analog of Dirac action allows however to fix the dynamics uniquely and there is indeed dimensional hierarchy resembling brane hierarchy.

1. The basic observation was following. The condition that the spinor modes have well-defined em charge implies that they are localized to 2-D string world sheets with vanishing W boson gauge fields which would mix different charge states. At string boundaries classical induced W boson gauge potentials guarantee this. Super-conformal symmetry requires that this 2-surface gives rise to 2-D action which is area term plus topological term defined by the flux of Kähler form.

2. The most plausible assumption is that induced spinor fields have also interior component but that the contribution from these 2-surfaces gives additional delta function like contribution: this would be analogous to the situation for branes. Fermionic action would be accompanied by an area term by supersymmetry fixing modified Dirac action completely once the bosonic actions for geometric object is known. This is nothing but super-conformal symmetry.

   One would actually have the analog of brane-hierarchy consisting of surfaces with dimension D= 4,3,2,1 carrying induced spinor fields which can be regarded as independent dynamical variables and characterized by geometric action which is D-dimensional analog of the action for Kähler charged point particle. This fermionic hierarchy would accompany the hierarchy of geometric objects with these dimensions and the modified Dirac action would be uniquely determined by the corresponding geometric action principle (Kähler charged point like particle, string world sheet with area term plus Kähler flux, light-like 3-surface with Chern-Simons term, 4-D space-time surface with Kähler action).

3. This hierarchy of dynamics is consistent with SH only if the dynamics for higher dimensional objects is induced from that for lower dimensional objects - string world sheets or maybe even their boundaries orbits of point like fermions. Number theoretic vision [12] suggests that this induction relies algebraic continuation for preferred extremals. Note that quaternion analyticity [14] means that quaternion analytic function is determined by its values at 1-D curves.

4. Quantum-classical correspondences (QCI) requires that the classical Noether charges are equal to the eigenvalues of the fermionic charges for surfaces of dimension $D = 0, 1, 2, 3$ at the ends of the CDs. These charges would not be separately conserved. Charges could flow between objects of dimension $D + 1$ and D - from interior to boundary and vice versa. Four-momenta and also other charges would be complex as in twistor approach: could complex values relate somehow to the finite life-time of the state?

   If quantum theory is square root of thermodynamics as zero energy ontology suggests, the idea that particle state would carry information also about its life-time or the time scale of CD to which is associated could make sense. For complex values of α_K there would be also flow of canonical and super-canonical momentum currents between Euclidian and Minkowskian regions crucial for understand gravitational interaction as momentum exchange at imbedding space level.

5. What could be the physical interpretation of the bosonic and fermionic charges associated with objects of given dimension? Condensed matter physicists assign routinely physical states to objects of various dimensions: is this assignment much more than a practical approximation or could condensed matter physics already be probing many-sheeted physics?

3.4 SUSY and TGD

From this one ends up to the possibility of identifying the counterpart of SUSY in TGD framework [15].

1. In TGD the generalization of much larger super-conformal symmetry emerges from the super-symplectic symmetries of WCW. The mathematically questionable notion of super-space is not needed: only the realization of super-algebra in terms of WCW gamma matrices defining super-symplectic generators is necessary to construct quantum states. As a matter of fact, also in QFT approach one could use only the Clifford algebra structure for super-multiplets. No Majorana condition on fermions is needed as for $\mathcal{N} = 1$ space-time SUSY and one avoids problems with fermion number non-conservation.

2. In TGD the construction of sparticles means quite concretely adding fermions to the state. In QFT it corresponds to transformation of states of integer and half-odd integer spin to each other. This difference comes from the fact that in TGD particles are replaced with point like particles.

3. The analog of $\mathcal{N} = 2$ space-time SUSY could be generated by covariantly constant right handed neutrino and antineutrino. Quite generally the mixing of fermionic chiralities implied by the mixing of M^4 and CP_2 gamma matrices implies SUSY breaking at the level of particle masses (particles are massless in 8-D sense). This breaking is purely geometrical unlike the analog of Higgs mechanism proposed in standard SUSY.

There are several options to consider.

1. The analog of brane hierarchy is realized also in TGD. Geometric action has parts assignable to 4-surface, 3-D light like regions between Minkowskian and Euclidian regions, 2-D string world sheets, and their 1-D boundaries. They are fixed uniquely. Also their fermionic counterparts - analogs of Dirac action - are fixed by super-conformal symmetry. Elementary particles reduce so composites consisting of point-like fermions at boundaries of wormhole throats of a pair of wormhole contacts.

   This forces to consider 3 kinds of SUSYs! The SUSYs associated with string world sheets and space-time interiors would certainly be broken since there is a mixing between M^4 chiralities in the modified Dirac action. The mass scale of the broken SUSY would correspond to the length scale of these geometric objects and one might argue that the decoupling between the degrees of freedom considered occurs at high energies and explains why no evidence for SUSY has been observed at LHC. Also the fact that the addition of massive fermions at these dimensions can be interpreted differently. 3-D light-like 3-surfaces could be however an exception.

2. For 3-D light-like surfaces the modified Dirac action associated with the Chern-Simons term does not mix M^4 chiralities (signature of massivation) at all since modified gamma matrices have only CP_2 part in this case. All fermions can have well-defined chirality. Even more: the modified gamma matrices have no M^4 part in this case so that these modes carry no four-momentum - only electroweak quantum numbers and spin. Obviously, the excitation of these fermionic modes would be an ideal manner to create spartners of ordinary particles consting of fermion at the fermion lines. SUSY would be present if the spin of these excitations couples - to various interactions and would be exact in absence of coupling to interior spinor fields.

   What would be these excitations? Chern-Simons action and its fermionic counterpart are non-vanishing only if the CP_2 projection is 3-D so that one can use CP_2 coordinates. This strongly suggests that the modified Dirac equation demands that the spinor modes are covariantly constant and correspond to covariantly constant right-handed neutrino providing only spin.

   If the spin of the right-handed neutrino adds to the spin of the particle and the net spin couples to dynamics, $\mathcal{N} = 2$ SUSY is in question. One would have just action with unbroken SUSY at QFT limit? But why also right-handed neutrino spin would couple to dynamics if only CP_2 gamma matrices appear in Chern-Simons-Dirac action? It would seem that it is independent degree of freedom having no electroweak and color nor even gravitational couplings by its covariant constancy. I have ended up with just the same SUSY-or-no-SUSY that I have had earlier.

3. Can the geometric action for light-like 3-surfaces contain Chern-Simons term?

   (a) Since the volume term vanishes identically in this case, one could indeed argue that also the counterpart of Kähler action is excluded. Moreover, for so called massless extremals of Kähler action reduces to Chern-Simons terms in Minkowskian regions and this could happen quite generally: TGD with only Kähler action would be almost topological QFT as I have proposed. Volume term however changes the situation via the cosmological constant. Kähler-Dirac action in the interior does not reduce to its Chern-Simons analog at light-like 3-surface.

   (b) The problem is that the Chern-Simons term at the two sides of the light-like 3-surface differs by factor $\sqrt{-1}$ coming from the ratio of $\sqrt{g_4}$ factors which themselves approach to zero: oOne would have the analog of dipole layer. This strongly suggests that one should not include Chern-Simons term at all.

   Suppose however that Chern-Simons terms are present at the two sides and α_K is real so that nothing goes through the horizon forming the analog of dipole layer. Both bosonic and fermionic degrees of freedom for Euclidian and Minkowskian regions would decouple completely but currents would flow to the analog of dipole layer. This is not physically attractive.

   The canonical momentum current and its super counterpart would give fermionic source term $\Gamma^n \Psi_{int,\pm}$ in the modified Dirac equation defined by Chern-Simons term at given side $\pm$: $\pm$ refers to Minkowskian/Euclidian part of the interior. The source term is proportional to $\Gamma^n \Psi_{int,\pm}$ and Γ^n is in principle mixture of M^4 and CP_2 gamma matrices and therefore induces mixing of M^4 chiralities and therefore also 3-D SUSY breaking. It must be however emphasized that Γ^n is singular and one must be consider the limit carefully also in the case that one has only continuity conditions. The limit is not completely understood.

(c) If α_K is complex there is coupling between the two regions and the simplest assumption has been that there is no Chern-Simons term as action and one has just continuity conditions for canonical momentum current and hits super counterpart.

The cautious conclusion is that 3-D Chern-Simons term and its fermionic counterpart are absent.

4. What about the addition of fermions at string world sheets and interior of space-time surface ($D = 2$ and $D = 4$). For instance, in the case of hadrons $D = 2$ excitations could correspond to addition of quark in the interior of hadronic string implying additional states besides the states obtained assuming only quarks at string ends. Let us consider the interior ($D = 4$). For instance, inn the case of hadrons $D = 2$ excitations could correspond to addition of quark in the interior of hadronic string implying additional states besides the states obtained assuming only quarks at string ends. The smallness of cosmological constant implies that the contribution to the four-momentum from interior should be rather small so that an interpretation in terms of broken SUSY might make sense. There would be mass $m \sim .03$ eV per volume with size defined by the Compton scale $\hbar/m$. Note however that cosmological constant has spectrum coming as inverse powers of prime so that also higher mass scales are possible.

   This interpretation might allow to understand the failure to find SUSY at LHC. Sparticles could be obtained by adding interior right-handed neutrinos and antineutrinos to the particle state. They could be also associated with the magnetic body of the particle. Since they do not have color and weak interactions, SUSY is not badly broken. If the mass difference between particle and sparticle is of order $m = .03$ eV characterizing dark energy density ρ_{vac}, particle and sparticle could not be distinguished in higher energy physics at LHC since it probes much shorter scales and sees only the particle. I have already earlier proposed a variant of this mechanism but without SUSY breaking.

   To discover SUSY one should do very low energy physics in the energy range $m \sim .03$ eV having same order of magnitude as thermal energy $kT = 2.6 \times 10^{-2}$ eV at room temperature 25 °C. One should be able to demonstrate experimentally the existence of sparticle with mass differing by about $m \sim .03$ eV from the mass of the particle (one cannot exclude higher mass scales since Λ is expected to have spectrum). An interesting question is whether the sfermions associated with standard fermions could give rise to Bose-Einstein condensates whose existence in the length scale of large neutron is strongly suggested by TGD view about living matter.

4 Imbedding space level

In GRT the description of gravitation involve only space-time and gravitational force is eliminated. In TGD also imbedding space level is involved with the description [14].

1. The incoming and outgoing states of particle reaction are labelled by the quantum numbers associated with the isometries of the imbedding space and by the contributions of super-symplectic generators and isometry generators to the quantum numbers. This follows from the fact that the ground states of super-symplectic representations correspond to the modes of imbedding space spinors fields. These quantum numbers appear in the S-matrix of QFT limit too. In particular, color quantum numbers as angular momentum like quantum numbers at fundamental level are transformed to spin-like quantum numbers at QFT limit.

2. In GRT the applications rely on Post-Newtonian approximation (PNA). This means that the notion of gravitational force is brought to the theory although it has been eliminated from the basic GRT. This is not simple. One could argue that there is genuine physics behind this PNA and TGD suggests what this physics is.

   At the level of space-time surfaces particles move along geodesic lines and in TGD minimal surface equation states the generalization of the geodesic line property for 3-D particles. At the imbedding space level gravitational interaction involves exchanges of four-momentum and in principle of color quantum numbers too. Indeed, there is an exchange of classical charges through the light-like 3-surfaces defining the boundaries of Euclidian regions defining Euclidian regions as "lines" of generalized scattering diagrams. This however requires that Kähler coupling strength is allowed to be complex (say correspond to zero of Riemann Zeta). Hence in TGD also Newtonian view would be correct and needed.

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References

[1] Yangian symmetry. Available at: http://en.wikipedia.org/wiki/Yangian.

[2] Witten E Dolan L, Nappi CR. Yangian Symmetry in $D = 4$ superconformal Yang-Mills theory. Available at: http://arxiv.org/abs/hep-th/0401243, 2004.

[3] Plefka J Drummond J, Henn J. Yangian symmetry of scattering amplitudes in $\mathcal{N} = 4$ super Yang-Mills theory. Available at: http://cdsweb.cern.ch/record/1162372/files/jhep052009046.pdf, 2009.

[4] Arkani-Hamed N et al. The All-Loop Integrand For Scattering Amplitudes in Planar N=4 SYM. Available at: http://arxiv.org/find/hep-th/1/au:+Bourjaily_J/0/1/0/all/0/1, 2010.

[5] Pitkänen M. Basic Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdclass/tgdclass.html#class, 2006.

[6] Pitkänen M. Construction of WCW Kähler Geometry from Symmetry Principles. In *Quantum Physics as Infinite-Dimensional Geometry*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdgeom/tgdgeom.html#compl1, 2006.

[7] Pitkänen M. Identification of the WCW Kähler Function. In *Quantum Physics as Infinite-Dimensional Geometry*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdgeom/tgdgeom.html#kahler, 2006.

[8] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics*. Onlinebook. Available at: http://tgdtheory.fi/public_html/padphys/padphys.html#mless, 2006.

[9] Pitkänen M. WCW Spinor Structure. In *Quantum Physics as Infinite-Dimensional Geometry*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdgeom/tgdgeom.html#cspin, 2006.

[10] Pitkänen M. Why TGD and What TGD is? In *Topological Geometrodynamics: an Overview*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdview/tgdview.html#WhyTGD, 2013.

[11] Pitkänen M. Recent View about Kähler Geometry and Spin Structure of WCW . In *Quantum Physics as Infinite-Dimensional Geometry*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdgeom/tgdgeom.html#wcwnew, 2014.

[12] Pitkänen M. Unified Number Theoretical Vision. In *TGD as a Generalized Number Theory*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdnumber/tgdnumber.html#numbervision, 2014.

[13] Pitkänen M. About Preferred Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdclass/tgdclass.html#prext, 2015.

[14] Pitkänen M. From Principles to Diagrams. Onlinebook.Available at: http://tgdtheory.fi/public_html/tgdquantum/tgdquantum.html#diagrams, 2016.

[15] Pitkänen M. SUSY in TGD Universe. In *p-Adic Physics*. Onlinebook. Available at: http://tgdtheory.fi/public_html/padphys/padphys.html#susychap, 2012.

[16] Pitkänen M. How the hierarchy of Planck constants might relate to the almost vacuum degeneracy for twistor lift of TGD? Available at: http://tgdtheory.fi/public_html/tgdquantum/tgdquantum.html#hgrtwistor, 2016.

[17] Pitkänen M. The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis? Available at: http://tgdtheory.fi/public_html/articles/godin.pdf, 2016.

[18] Pitkänen M. Does Riemann Zeta Code for Generic Coupling Constant Evolution? . Available at: http://tgdtheory.fi/public_html/articles/fermizeta.pdf, 2015.

[19] Pitkänen M. About minimal surface extremals of Kähler action. Available at: http://tgdtheory.fi/public_html/articles/minimalkahler.pdf, 2016.