Abstract

Quantum TGD reduces to a construction of Kähler geometry for what I call the “World of Classical Worlds”. It has been clear from the beginning that the gigantic super-conformal symmetries generalizing ordinary super-conformal symmetries are crucial for the existence of WCW Kähler metric. 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 type description of gravitation emerges and also the TGD based view about dark matter becomes more precise. String tension is however dynamical rather than pregiven
and the hierarchy of Planck constants is necessary in order to understand the formation of gravitationally bound states. Also the proposal that sparticles correspond to dark matter becomes much stronger: sparticles actually are dark variants of particles.

A crucial element of the construction is the assumption that super-symplectic and other super-conformal symmetries having the same structure as 2-D super-conformal groups can be seen a broken gauge symmetries such that sub-algebra with conformal weights coming as n-ples of those for full algebra act as gauge symmetries. In particular, the Noether charges of this algebra vanish for preferred extremals- this would realize the strong form of holography implied by strong form of General Coordinate Invariance. This gives rise to an infinite number of hierarchies of conformal gauge symmetry breakings with levels labelled by integers $n(i)$ such that $n(i)$ divides $n(i+1)$ interpreted as hierarchies of dark matter with levels labelled by the value of Planck constant $h_{eff} = n \times h$. These hierarchies define also hierarchies of quantum criticalities and are proposed to give rise to inclusion hierarchies of hyperfinte factors of $\Pi_1$ having interpretation in terms of finite cognitive resolution. These hierarchies would be fundamental for the understanding of living matter.

1 Introduction

During last years the understanding of the mathematical aspects of TGD and of its connection with the experimental world has developed rapidly. 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 (“world of classical worlds”). Apart from quantum jump, quantum TGD is essentially theory of classical WCW spinor fields with WCW spinors represented as fermionic Fock states. One can say that Einstein’s geometrization of physics program is generalized to the level of quantum theory.

It has been clear from the beginning that the gigantic super-conformal symmetries generalizing ordinary super-conformal symmetries are crucial for the existence of WCW Kähler metric. 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 $\delta M_2^4 \times CP_2$. The string model type description of gravitation emerges and also the TGD based view about dark matter becomes more precise. String tension is however dynamical rather than pregiven and the hierarchy of Planck constants is necessary in order to understand the formation of gravitationally bound states. Also the proposal that sparticles correspond to dark matter becomes much stronger: sparticles actually are dark variants of particles.
A crucial element of the construction is the assumption that super-symplectic and other super-conformal symmetries having the same structure as 2-D super-conformal groups can be seen as broken gauge symmetries such that sub-algebra with conformal weights coming as $n$-ples of those for full algebra act as gauge symmetries. In particular, the Noether charges of this algebra vanish for preferred extremals - this would realize the strong form of holography implied by strong form of General Coordinate Invariance. This gives rise to an infinite number of hierarchies of conformal gauge symmetry breakings with levels labelled by integers $n(i)$ such that $n(i)$ divides $n(i + 1)$ interpreted as hierarchies of dark matter with levels labelled by the value of Planck constant $h_{eff} = n \times h$. These hierarchies define also hierarchies of quantum criticalities, and are proposed to give rise to inclusion hierarchies of hyperfinite factors of $\Pi_1$ having interpretation in terms of finite cognitive resolution with inclusions being characterized by the integers $n(+1)/n(i)$.

These hierarchies are fundamental for the understanding of living matter. Living matter is fighting in order to stay at criticality and uses metabolic energy and homeostasis to achieve this. In the biological death of the system (self) a phase transition increasing $h_{eff}$ finally takes place. The sub-selves of self experienced by self as mental images however die and are reborn at opposite boundary of the corresponding causal diamond (CD) and they genuinely evolve so that self can be said to become wiser even without dying! The purpose of this fighting against criticality would thus allow a possibility for sub-selves to evolve via subsequent reincarnations. One interesting prediction is the possibility of time reversed mental images. The challenge is to understand what they do mean at the level of conscious experience.

2 Kähler action and -function, super-conformal symmetries, Kähler-Dirac action

2.1 Kähler function, Kähler action, and connection with string models

The definition of Kähler function in terms of Kähler action is possible because space-time regions can have also Euclidian signature of induced metric. Euclidian regions with 4-D $CP_2$ projection - wormhole contacts - are identified as lines of generalized Feynman diagrams - space-time correlates for basic building bricks of elementary particles. Kähler action from Minkowskian regions is imaginary and gives to the functional integrand a phase factor crucial for quantum field theoretic interpretation. The basic challenges are the precise specification of Kähler function of “world of classical worlds” (WCW) and Kähler metric.

There are two approaches concerning the definition of Kähler metric: the conjecture analogous to AdS/CFT duality is that these approaches are mathematically equivalent.

1. The Kähler function defining Kähler metric can be identified as Kähler action for space-time regions with Euclidian signature for a preferred extremal containing 3-surface as the ends of the space-time surfaces inside causal diamond
2.2 Realization of super-conformal symmetries

The detailed realization of various super-conformal symmetries has been also a long standing problem.

1. Super-conformal symmetry requires that Dirac action for string world sheets is accompanied by string world sheet area as part of bosonic action. String world sheets are implied and can be present only in Minkowskian regions if...
2.3 Interior dynamics for fermions, the role of vacuum extremals, and dark matter

The key role of $CP_2$-type and $M^4$-type vacuum extremals has been rather obvious from the beginning but the detailed understanding has been lacking. Both kinds of extremals are invariant under symplectic transformations of $\delta M^4 \times CP_2$, which inspires the idea that they give rise to isometries of WCW. The deformations $CP_2$-type extremals correspond to lines of generalized Feynman diagrams. $M^4$ type vacuum extremals in turn are excellent candidates for the building bricks of many-sheeted space-time giving rise to GRT space-time as approximation. For $M^4$ type vacuum extremals $CP_2$ projection is (at most 2-D) Lagrangian manifold so that the induced Kähler form vanishes and the action is fourth-order in small deformations. This implies the breakdown of the path integral approach and of canonical quantization, which led to the notion of WCW.

If the action in Minkowskian regions contains also string area, the situation changes dramatically since strings dominate the dynamics in excellent approximation and string theory should give an excellent description of the situation: this of course conforms with the dominance of gravitation.

String tension would be proportional to $1/\hbar G$ and this raises a grave classical counter argument. In string model massless particles are regarded as strings, which have contracted to a point in excellent approximation and cannot have length longer than Planck length. How this can be consistent with the formation of gravitationally bound states is however not understood since the required non-perturbative
2.3 Interior dynamics for fermions, the role of vacuum extremals, and dark matter

formulation of string model required by the large valued of the coupling parameter $GMm$ is not known.

In TGD framework strings would connect even objects with macroscopic distance and would obviously serve as correlates for the formation of bound states in quantum level description. The classical energy of string connecting say the two wormhole contacts defining elementary particle is gigantic for the ordinary value of $\hbar$ so that something goes wrong.

I have however proposed [K4, K3, K7] that gravitons - at least those mediating interaction between dark matter have large value of Planck constant. I talk about gravitational Planck constant and one has $h_{eff} = h_{gr} = GMm/v_0$, where $v_0/c < 1$ ($v_0$ has dimensions of velocity). This makes possible perturbative approach to quantum gravity in the case of bound states having mass larger than Planck mass so that the parameter $GMm$ analogous to coupling constant is very large. The velocity parameter $v_0/c$ becomes the dimensionless coupling parameter. This reduces the string tension so that for string world sheets connecting macroscopic objects one would have $T \propto v_0/G^2Mm$. For $v_0 = GMm/\hbar$, which remains below unity for $Mm/m^2_P$, one would have $h_{gr}/\hbar = 1$. Hence action remains small and its imaginary exponent does not fluctuate wildly to make the bound state forming part of gravitational interaction short ranged. This is expected to hold true for ordinary matter in elementary particle scales. The objects with size scale of large neutron (100 $\mu$m in the density of water) - probably not an accident - would have mass above Planck mass so that dark gravitons and also life would emerge as massive enough gravitational bound states are formed. $h_{gr} = h_{eff}$ hypothesis is indeed central in TGD based view about living matter.

If one assumes that for non-standard values of Planck constant only $n$-multiples of super-conformal algebra in interior annihilate the physical states, interior conformal gauge degrees of freedom become partly dynamical. The identification of dark matter as macroscopic quantum phases labeled by $h_{eff}/\hbar = n$ conforms with this.

The emergence of dark matter corresponds to the emergence of interior dynamics via breaking of super-conformal symmetry. The induced spinor fields in the interior of flux tubes obeying Kähler Dirac action should be highly relevant for the understanding of dark matter. The assumption that dark particles have essentially same masses as ordinary particles suggests that dark fermions correspond to induced spinor fields at both string world sheets and in the space-time interior: the spinor fields in the interior would be responsible for the long range correlations characterizing $h_{eff}/\hbar = n$. Magnetic flux tubes carrying dark matter are key entities in TGD inspired quantum biology. Massless extremals represent second class of $M^4$ type non-vacuum extremals.

This view forces once again to ask whether space-time SUSY is present in TGD and how it is realized. With a motivation coming from the observation that the mass scales of particles and sparticles most naturally have the same p-adic mass scale as particles in TGD Universe I have proposed that sparticles might be dark in TGD sense. The above argument leads to ask whether the dark variants of particles correspond to states in which one has ordinary fermion at string world sheet and 4-D fermion in the space-time interior so that dark matter in TGD sense would almost by definition correspond to sparticles!
3 Classical number fields and associativity and commutativity as fundamental law of physics

The dimensions of classical number fields appear as dimensions of basic objects in quantum TGD. Imbedding space has dimension 8, space-time has dimension 4, light-like 3-surfaces are orbits of 2-D partonic surfaces. If conformal QFT applies to 2-surfaces (this is questionable), one-dimensional structures would be the basic objects. The lowest level would correspond to discrete sets of points identifiable as intersections of real and p-adic space-time sheets. This suggests that besides p-adic number fields also classical number fields (reals, complex numbers, quaternions, octonions [A2]) are involved [K5] and the notion of geometry generalizes considerably. In the recent view about quantum TGD the dimensional hierarchy defined by classical number field indeed plays a key role. $H = M^4 \times CP_2$ has a number theoretic interpretation and standard model symmetries can be understood number theoretically as symmetries of hyper-quaternionic planes of hyper-octonionic space.

The associativity condition $A(BC) = (AB)C$ suggests itself as a fundamental physical law of both classical and quantum physics. Commutativity can be considered as an additional condition. In conformal field theories associativity condition indeed fixes the n-point functions of the theory. At the level of classical TGD space-time surfaces could be identified as maximal associative (hyper-quaternionic) sub-manifolds of the imbedding space whose points contain a preferred hyper-complex plane $M^2$ in their tangent space and the hierarchy finite fields-rationals-reals-complex numbers-quaternions-octonions could have direct quantum physical counterpart [K5]. This leads to the notion of number theoretic compactification analogous to the dualities of M-theory: one can interpret space-time surfaces either as hyper-quaternionic 4-surfaces of $M^8$ or as 4-surfaces in $M^4 \times CP_2$. As a matter fact, commutativity in number theoretic sense is a further natural condition and leads to the notion of number theoretic braid naturally as also to direct connection with super string models.

At the level of Kähler-Dirac action the identification of space-time surface as a hyper-quaternionic sub-manifold of $H$ means that the modified gamma matrices of the space-time surface defined in terms of canonical momentum currents of Kähler action using octonionic representation for the gamma matrices of $H$ span a hyper-quaternionic sub-space of hyper-octonions at each point of space-time surface (hyper-octonions are the subspace of complexified octonions for which imaginary units are octonionic imaginary units multiplied by commutating imaginary unit). Hyper-octonionic representation leads to a proposal for how to extend twistor program to TGD framework [K1] [K6].

3.1 How to achieve associativity in the fermionic sector?

In the fermionic sector an additional complication emerges. The associativity of the tangent- or normal space of the space-time surface need not be enough to guarantee the associativity at the level of Kähler-Dirac or Dirac equation. The reason is the presence of spinor connection. A possible cure could be the vanishing of the components of spinor connection for two conjugates of quaternionic coordinates combined with holomorphy of the modes.
3.2 Is super-symmetrized Kähler-Dirac action enough?

Could one do without string area in the action and use only K-D action, which is in any case forced by the super-conformal symmetry? This option I have indeed con-

1. The induced spinor connection involves sigma matrices in $CP_2$ degrees of freedom, which for the octonionic representation of gamma matrices are proportional to octonion units in Minkowski degrees of freedom. This corresponds to a reduction of tangent space group $SO(1,7)$ to $G_2$. Therefore octonionic Dirac equation identifying Dirac spinors as complexified octonions can lead to non-associativity even when space-time surface is associative or co-associative.

2. The simplest manner to overcome these problems is to assume that spinors are localized at 2-D string world sheets with 1-D $CP_2$ projection and thus possible only in Minkowskian regions. Induced gauge fields would vanish. String world sheets would be minimal surfaces in $M^4 \times D^1 \subset M^4 \times CP_2$ and the theory would simplify enormously. String area would give rise to an additional term in the action assigned to the Minkowskian space-time regions and for vacuum extremals one would have only strings in the first approximation, which conforms with the success of string models and with the intuitive view that vacuum extremals of Kähler action are basic building bricks of many-sheeted space-time. Note that string world sheets would be also symplectic covariants.

Without further conditions gauge potentials would be non-vanishing but one can hope that one can gauge transform them away in associative manner. If not, one can also consider the possibility that $CP_2$ projection is geodesic circle $S^1$: symplectic invariance is considerably reduces for this option since symplectic transformations must reduce to rotations in $S^1$.

3. The fist heavy objection is that action would contain Newton’s constant $G$ as a fundamental dynamical parameter: this is a standard recipe for building a non-renormalizable theory. The very idea of TGD indeed is that there is only single dimensionless parameter analogous to critical temperature. One can of course argue that the dimensionless parameter is $\hbar G/R^2$, $R CP_2$ ”radius”.

Second heavy objection is that the Euclidian variant of string action exponentially damps out all string world sheets with area larger than $\hbar G$. Note also that the classical energy of Minkowskian string would be gigantic unless the length of string is of order Planck length. For Minkowskian signature the exponent is oscillatory and one can argue that wild oscillations have the same effect.

The hierarchy of Planck constants would allow the replacement $\hbar \rightarrow \hbar_{eff}$ but this is not enough. The area of typical string world sheet would scale as $h_{eff}$ and the size of CD and gravitational Compton lengths of gravitationally bound objects would scale as $\sqrt{\hbar_{eff}}$ rather than $h_{eff} = GMm/v_0$ which one wants. The only way out of problem is to assume $T \propto (\hbar/\hbar_{eff})^2 \times (1/\hbar_{bar}G)$. This is however un-natural for genuine area action. Hence it seems that the visit of the basic assumption of superstring theory to TGD remains very short.
3.2 Is super-symmetrized Kähler-Dirac action enough?

K-D Dirac equation indeed tends to reduce to a lower-dimensional one: for massless extremals the K-D operator is effectively 1-dimensional. For cosmic strings this reduction does not however take place. In any case, this leads to ask whether in some cases the solutions of Kähler-Dirac equation are localized at lower-dimensional surfaces of space-time surface.

1. The proposal has indeed been that string world sheets carry vanishing $W$ and possibly even $Z$ fields: in this manner the electromagnetic charge of spinor mode could be well-defined. The vanishing conditions force in the generic case 2-dimensionality.

Besides this the canonical momentum currents for Kähler action defining 4 imbedding space vector fields must define an integrable distribution of two planes to give string world sheet. The four canonical momentum currents $\Pi_k\alpha = \partial L_K/\partial \partial_\alpha h_k$ identified as imbedding 1-forms can have only two linearly independent components parallel to the string world sheet. Also the Frobenius conditions stating that the two 1-forms are proportional to gradients of two imbedding space coordinates $\Phi_i$ defining also coordinates at string world sheet, must be satisfied. These conditions are rather strong and are expected to select some discrete set of string world sheets.

2. To construct preferred extremal one should fix the partonic 2-surfaces, their light-like orbits defining boundaries of Euclidian and Minkowskian space-time regions, and string world sheets. At string world sheets the boundary condition would be that the normal components of canonical momentum currents for Kähler action vanish. This picture brings in mind strong form of holography and this suggests that might make sense and also solution of Einstein equations with point like sources.

3. The localization of spinor modes at 2-D surfaces would follow from the well-definedness of em charge and one could have situation in which the localization does not occur. For instance, covariantly constant right-handed neutrinos spinor modes at cosmic strings are completely de-localized and one can wonder whether one could give up the localization inside wormhole contacts.

4. String tension is dynamical and physical intuition suggests that induced metric at string world sheet is replaced by the anti-commutator of the K-D gamma matrices and by conformal invariance only the conformal equivalence class of this metric would matter and it could be even equivalent with the induced metric. A possible interpretation is that the energy density of Kähler action has a singularity localized at the string world sheet.

Another interpretation that I proposed for years ago but gave up is that in spirit with the TGD analog of AdS/CFT duality the Noether charges for Kähler action can be reduced to integrals over string world sheet having interpretation as area in effective metric. In the case of magnetic flux tubes carrying monopole fluxes and containing a string connecting partonic 2-surfaces at its ends this interpretation would be very natural, and string tension would characterize the density of Kähler magnetic energy. String model with dynamical
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string tension would certainly be a good approximation and string tension would depend on scale of CD.

5. There is also an objection. For $M^4$ type vacuum extremals one would not obtain any non-vacuum string world sheets carrying fermions but the successes of string model strongly suggest that string world sheets are there. String world sheets would represent a deformation of the vacuum extremal and far from string world sheets one would have vacuum extremal in an excellent approximation. Situation would be analogous to that in general relativity with point particles.

6. The hierarchy of conformal symmetry breakings for K-D action should make string tension proportional to $1/h_{eff}^2$ with $h_{eff} = h_{gr}$ giving correct gravitational Compton length $\Lambda_{gr} = GM/v_0$ defining the minimal size of CD associated with the system. Why the effective string tension of string world sheet should behave like $(\hbar/h_{eff})^2$?

The first point to notice is that the effective metric $g^{\alpha\beta}$ defined as $h^{kl}\Pi^\alpha_k\Pi^\beta_l$, where the canonical momentum current $\Pi_k^\alpha = \partial L_K/\partial \partial_k h^k$ has dimension $1/L^2$ as required. Kähler action density must be dimensionless and since the induced Kähler form is dimensionless the canonical momentum currents are proportional to $1/\alpha_K$.

Should one assume that $\alpha_K$ is fundamental coupling strength fixed by quantum criticality to $\alpha_K = 1/137$? Or should one regard $g_K^{2}$ as fundamental parameter so that one would have $1/\alpha_K = h_{eff}/4\pi g_K^{2}$ having spectrum coming as integer multiples (recall the analogy with inverse of critical temperature)?

The latter option is the in spirit with the original idea stating that the increase of $h_{eff}$ reduces the values of the gauge coupling strengths proportional to $\alpha_K$ so that perturbation series converges (Universe is theoretician friendly). The non-perturbative states would be critical states. The non-determinism of Kähler action implying that the 3-surfaces at the boundaries of CD can be connected by large number of space-time sheets forming $n$ conformal equivalence classes. The latter option would give $G^{\alpha\beta} \propto h_{eff}^2$ and $det(G) \propto 1/h_{eff}^2$ as required.

7. It must be emphasized that the string tension has interpretation in terms of gravitational coupling on only at the GRT limit of TGD involving the replacement of many-sheeted space-time with single sheeted one. It can have also interpretation as hadronic string tension or effective string tension associated with magnetic flux tubes and telling the density of Kähler magnetic energy per unit length.

Superstring models would describe only the perturbative Planck scale dynamics for emission and absorption of $h_{eff}/h = 1$ on mass shell gravitons whereas the quantum description of bound states would require $h_{eff}/n > 1$ when the masses. Also the effective gravitational constant associated with the strings would differ from $G$.

The natural condition is that the size scale of string world sheet associated with the flux tube mediating gravitational binding is $G(M + m)/v_0$. By expressing string tension in the form $1/T = n^2 hG_1$, $n = h_{eff}/h$, this condition
3.3 Are 4-D spinor modes consistent with associativity?

The condition that octonionic spinors are equivalent with ordinary spinors looks rather natural but in the case of Kähler-Dirac action the non-associativity could leak in. One could of course give up the condition that octonionic and ordinary K-D equation are equivalent in 4-D case. If so, one could see K-D action as related to non-commutative and maybe even non-associative fermion dynamics. Suppose that one does not.

1. K-D action vanishes by K-D equation. Could this save from non-associativity? If the spinors are localized to string world sheets, one obtains just the standard stringy construction of conformal modes of spinor field. The induce spinor connection would have only the holomorphic component \( A_z \). Spinor mode would depend only on \( z \) but K-D gamma matrix \( \Gamma_z \) would annihilate the spinor mode so that K-D equation would be satisfied. There are good hopes that the octonionic variant of K-D equation is equivalent with that based on ordinary gamma matrices since quaternionic coordinated reduces to complex coordinate, octonionic quaternionic gamma matrices reduce to complex gamma matrices, sigma matrices are effectively absent by holomorphy.

2. One can consider also 4-D situation (maybe inside wormhole contacts). Could some form of quaternion holomorphy \[ A1, K6 \] allow to realize the K-D equation just as in the case of super string models by replacing complex coordinate and its conjugate with quaternion and its 3 conjugates. Only two quaternion conjugates would appear in the spinor mode and the corresponding quaternionic gamma matrices would annihilate the spinor mode. It is essential that in a suitable gauge the spinor connection has non-vanishing components only for two quaternion conjugate coordinates. As a special case one would have a situation in which only one quaternion coordinate appears in the solution. Depending on the character of quaternionion holomorphy the modes would be labelled by one or two integers identifiable as conformal weights.

Even if these octonionic 4-D modes exists (as one expects in the case of cosmic strings), it is far from clear whether the description in terms of them is equivalent with the description using K-D equation based ordinary gamma matrices. The algebraic structure however raises hopes about this. The quaternion coordinate can be represented as sum of two complex coordinates as
3.4 Is the view about evolution as reduction of criticality consistent with cosmology?

The naive idea would be that living systems are thermodynamically critical so that life would be inherently unstable phenomenon. One can find support for this view. For instance, living matter as we know it functions in rather narrow temperature range. In this picture the problem is how the emergence of life is possible at all.

TGD suggests a different view. Evolution corresponds to the transformation of gauge degrees of freedom to dynamical ones and leads away from quantum criticality rather than towards it. Which view is correct?

The argument below supports the view that evolution indeed involves a spontaneous drift away from maximal quantum criticality. One cannot however avoid the
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feeling about the presence of a paradox.

1. Maybe the crux of paradox is that quantum criticality relies on NMP and thermodynamical criticality relies on second law which follows from NMP at ensemble level for ordinary entanglement (as opposed to negentropic one) at least. Quantum criticality is geometric criticality of preferred extremals and thermodynamical criticality criticality against the first state function reduction at opposite boundary of CD inducing decoherence and ”death” of self defined by the sequence of state function reductions at fixed boundary of CD. NMP would be behind both criticalities: it would stabilize self and force the first quantum jump killing the self.

2. Perhaps the point is that living systems are able to stay around both thermodynamical and quantum criticalities. This would make them flexible and sensitive. And indeed, the first quantum jump has an interpretation as correlate for volitional action at some level of self hierarchy. Consciousness involves passive and active aspects: periods of repeated state function reductions and acts of volition. The basic applications of hierarchy of Planck constants to biology indeed involve the \( h_{eff} \) changing phase transitions in both directions: for instance, molecules are able to find is each by \( h_{eff} \) reducing phase transition of connecting magnetic flux tubes bringing them near to each other.

The attempt to understand cosmological evolution in terms of hierarchy of Planck constants demonstrates that the view about evolution corresponds to a spontaneous drift away from maximal quantum criticality is feasible.

1. In primordial cosmology one has gas of cosmic strings \( X^2 \times Y^2 \subset M^4 \times CP_2 \). If they behave deterministically as it seems, their symplectic symmetries are fully dynamical and cannot act as gauge symmetries. This would suggest that they are not quantum critical and cosmic evolution leading to the thickening of the cosmic strings would be towards criticality contrary to the general idea. Here one must be however extremely cautious: are cosmic strings really maximally non-critical? The \( CP_2 \) projection of cosmic string can be any holomorphic 2-surface in \( CP_2 \) and there could be criticality against transitions changing geodesic sphere to a holomorphic 2-surface. There is also a criticality against transitions changing \( M^4 \) projection 4-dimensional. The hierarchy of Planck constants could be assignable to the resulting magnetic flux tubes.

In TGD inspired biology magnetic flux tubes are indeed carriers of large \( h_{eff} \) phases. That cosmic strings are actually critical, is also supported by the fact that it does not make sense to assign infinite value of \( h_{eff} \) and therefore vanishing value of \( \alpha_K \) to cosmic strings since Kähler action would become infinite. The assignment of large \( h_{eff} \) to cosmic strings does not seem a good idea since there are no gravitationally bound states yet, only a gas of cosmic strings in \( M^4 \times CP_2 \).

Cosmic strings allow conformal invariance. Does this conformal invariance act as gauge symmetries or dynamical symmetries? Quantization of ordinary strings would suggests the interpretation of super-conformal symmetries as
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It however seems that the conformal invariance of standard strings corresponds to that associated with the modes of the induced spinor field, and these would be indeed full gauge invariance. What matters is however symplectic conformal symmetries - something new and crucial for TGD view. The non-generic character of 2-D $M^4$ projection suggests that a sub-algebra of the symplectic conformal symmetries increasing the thickness of $M^4$ projection of string act as gauge symmetries (the Hamiltonians would be products of $S^2$ and $CP_2$ Hamiltonians). The most plausible conclusion is that cosmic strings recede from criticality as their thickness increases.

2. Cosmic strings are not the only objects involved. Space-time sheets are generated during inflationary period and cosmic strings topologically condense at them creating wormhole contacts and begin to expand to magnetic flux tubes with $M^4$ projection of increasing size. Ordinary matter is generated in the decay of the magnetic energy of cosmic strings replacing the vacuum energy of inflaton fields in inflationary scenarios.

$M^4$ and $CP_2$ type vacuum extremals are certainly maximally critical by their non-determinism and symplectic conformal gauge invariance is maximal for them. During later stages gauge degrees of freedom would transform to dynamical ones. The space-time sheets and wormhole contacts would also drift gradually away from criticality so that also their evolution conforms with the general TGD view.

Cosmic evolution would thus reduce criticality and would be spontaneous (NMP). The analogy would be provided by the evolution of cell from a maximally critical germ cell to a completely differentiated outcome.

3. There is however a paradox lurking there. Thickening cosmic string should gradually approach to $M^4$ type vacuum extremals as the density of matter is reduced in expansion. Could the approach from criticality transforms to approach towards it? The geometry of CD involves the analogs of both Big Bang and Big Crunch. Could it be that the eventual turning of expansion to contraction allows to circumvent the paradox? Is the crux of matter the fact that thickened cosmic strings already have a large value of $h_{eff}$ meaning that they are $n$-sheeted objects unlike the $M^4$ type vacuum extremals.

Could NMP force the first state function reduction to the opposite boundary of CD when the expansion inside CD would turn to contraction at space-time level and the contraction would be experienced as expansion since the arrow of time changes? Note that at the imbedding space level the size of CD increases all the time. Could the ageing and death of living systems be understood by using this analogy. Could the quantum jump to the opposite boundary of CD be seen as a kind of reincarnation allowing the increase of $h_{eff}$ and conscious evolution to continue as NMP demands? The first quantum jump would also generate entropy and thermodynamical criticality could be criticality against its occurrence. This interpretation of thermodynamical criticality would mean that living system by definition live at the borderline of life and death!

4. In this view the purpose of life would to generate negentropy by dying after
having fought against death by all means provided by metabolism and homeostasis! Does not sound sensible! The point is however that the sub-selves of self identifiable as mental images die and are reborn and can become more negentropic. By living long self gives opportunity for its mental images to evolve through a series of re-incarnations.

5. One can raise an objection against this view. If NMP demands that negentropy gain is maximal, self looses free will being always forced to make the choice producing maximal negentropy gain. We would live in the best possible world but very few of us can really agree with this. This suggests that one must and one can weaken NMP. For strong NMP state function reduction selects a sub-space with maximal negentropy: this corresponds to a projector, which gives rise to maximal gain of number theoretical negentropy. Weak form of NMP allows also projections to sub-spaces of these spaces. Ordinary state function reduction would allow only 1-dimensional projections. Assuming fixed state basis one has $2^n-1$ possible choices of the sub-space for a given value of $n$. The connection with $n$-bit Boolean algebra is obvious and suggests an “emotional” realization of Boolean algebra since negentropic entanglement corresponds to a conscious experience with positive emotional coloring. The presence of Evil would be prices for emotional intelligence.

REFERENCES

Mathematics


Books related to TGD


