Topological Geometrodynamics: an Overall View

M. Pitkänen
Email: matpitka@rock.helsinki.fi.
http://www.helsinki.fi/∼matpitka/.

Abstract

An overall view about the recent state of quantum TGD is given.

Two manners to end up with TGD

One can end up with TGD as a solution of energy problem of general relativity by assuming that space-time is representable as a 4-surface in certain higher-dimensional space-time allowing Poincare group as isometries. TGD results also as a generalization of string model obtained by replacing strings with light-like 3-surfaces representing partons. The choice $H = M^4 \times CP_2$ leads to a geometrization of elementary particle quantum numbers and classical fields. Simple topological considerations lead to the notion of many-sheeted space-time and general vision about quantum TGD. In particular, already classical considerations strongly suggests fractality meaning infinite hierarchy of copies of standard model physics in arbitrarily long length and time scales. The vacuum degeneracy of Kähler action in turn means a failure of approaches based on path integrals and canonical quantization and leaves the generalization of the notion of Wheeler's super-space the only viable road to quantum theory.

p-Adic mass calculations and generalization of number concept

The success of p-adic mass calculations motivates the generalization of the notion of number obtained by gluing reals and various algebraic extensions of p-adic number fields together along common algebraic numbers. This means also a generalization of the notion of the imbedding space, and it becomes possible to speak about real and p-adic space-time sheets whose

intersection consists of discrete set of algebraic points belonging to the algebraic extension of the p-adic numbers in question. p-Adic physics is interpreted as physics of cognition and intentionality with p-adic space sheets defining the "mind stuff" of Descartes.

Physical states as classical spinor fields in the world of classical worlds

In quantum TGD quantum states can be identified as modes of classical spinor fields in the "world of classical worlds" consisting of light-like 3-surfaces. More precisely: $CH = CH_+ \cup CH_-$, $CH_\pm = \cup_m CH_m^\pm$, $m \in M^4$. Here $CH_m^\pm$ is the space of light-like 3-surfaces of $H_\pm = M_\pm^4 \times CP_2$. Light-like 3-surface has dual interpretations as random light-like orbit of a partonic 2-surface or a basic dynamical unit with the assumption of light-likeness justified as a gauge choice allowed by the 4-D general coordinate invariance. The condition that the world of classical worlds allows Kähler geometry is highly non-trivial and the simpler example of loop space geometry suggests that the existence of an infinite-dimensional isometry group, naturally identifiable as canonical transformations of $\delta H_\pm$, is necessary. Configuration space would decompose to a union of infinite-dimensional symmetric spaces labelled by zero modes having interpretation as classical dynamical variables essential in quantum measurement theory. Space-time surface identified as a preferred extremal of Kähler action is analogous to Bohr orbit so that quantum theory emerges already at the level of configuration space geometry.

Magic properties of 3-D light-like surfaces

The very special conformal properties of both boundary $\delta M_\pm^4$ of 4-D light-cone and of light-like partonic 3-surfaces imply a generalization and extension of the super-conformal symmetries of super-string models to 3-D context without loosing the crucial 1-D Virasoro algebra now associated with the light-like coordinate. Light-likeness is respected by conformal transformations of H made local with respect to the partonic 3-surface.

Light-likeness of partonic 3-surfaces fixes the partonic quantum dynamics uniquely and Chern-Simons action determines the classical dynamics of partonic 3-surfaces and the modified Dirac action obtained as its supersymmetric counterpart fixes the dynamics of the second quantized free fermionic fields in terms of which configuration space gamma matrices and configuration space spinors can be constructed. In particular, fermionic statistics is geometrized. Only the light-likeness property involving the notion of induced metric breaks the topological QFT property of the theory.

The resulting $N = 4$ super-conformal symmetry involves super-canonical algebra (SC)and super Kac-Moody algebra (SKM). There are considerable differences as compared to string models. Super generators carry fermion number, no sparticles are predicted, SKM algebra and corresponding Virasoro algebra do not annihilate physical states, four-momentum does not appear in Virasoro generators so that there are no problems with Lorentz invariance, and mass squared is p-adic thermal expectation of conformal weight.

The properties of infinite-dimensional Clifford algebras as a key to the understanding of the theory

Infinite-dimensional Clifford algebra can be regarded as a canonical example of a von Neumann algebra known as hyper-finite factor of type II_1 characterized by the defining condition that the trace of infinite-dimensional unit matrix equals to unity: $Tr(id) = 1$. The most obvious implication is the absence of fermionic divergences whereas the absence of bosonic divergences is guaranteed by the basic properties of the configuration space Kähler geometry.

The special properties of this algebra, which are very closely related to braid and knot invariants, quantum groups, spin chains, integrable models, and conformal field theories, generate several new insights and ideas about the structure of quantum TGD.

a) There are reasons to hope that entire quantum TGD emerges from a local version of this algebra. The requirement that the local version is not isomorphic with the algebra itself is highly non-trivial if the local version is obtained by multiplying the algebra with a tensor factor representing imbedding space-time points in terms of generators of Clifford algebra. The only manner to achieve non-triviality is to multiply the algebra with a non-associative tensor factor representing hyper-octonions M^8. Space-times could be regarded equivalently as surfaces in M^8 or in $M^4 \times CP_2$ and dynamics would reduces to associativity (hyper-quaternionicity) or co-associativity condition. It is rather remarkable that CP_2 forced by standard model physics has also purely number theoretic interpretation.

b) Jones inclusions $\mathcal{N} \subset \mathcal{M}$ of these algebras lead to quantum measurement theory with a finite measurement resolution characterized by $\mathcal{N}$. Quantum Clifford algebra $\mathcal{M}/\mathcal{N}$ interpreted as $\mathcal{N}$-module creates physical states modulo resolution. Complex rays of the state space resulting in the ordinary state function reduction are replaced by $\mathcal{N}$-rays and the notions of unitarity, hermiticity, and eigenvalue generalize. Non-commutative physics would be interpreted in terms of a finite measurement resolution rather than something emerging below Planck length scale. An important implication is that a finite measurement sequence can never completely reduce quantum entanglement so that entire universe would be organic whole.

b) Quantum classical correspondence suggests that Jones inclusions have space-time correlates. This leads to a generalization of the imbedding space obtained by gluing infinite number of copies of H regarded as singular bundles over $H/G_a \times G_b$, where $G_a \times G_b$ is a subgroup of $SU(2) \times SU(2) \subset SL(2,C) \times SU(3)$. Ordinary Planck constant is naturally quantized as $\hbar = (n_a/n_b)\hbar_0$, where n_i is the order of maximal cyclic subgroup of G_i. The hierarchy of Planck constants is interpreted in terms of dark matter hierarchy.

About the construction of S-matrix

The construction of S-matrix involves several nontrivial elements.

a) Zero energy ontology, which is suggested already by the fact that Robertson-Walker cosmologies correspond to vacuum extremals in TGD inspired cosmology, states that all physical states have vanishing net quantum numbers and decompose to positive and negative energy components. There are reasons to believe that the U-matrix characterizing the unitary process associated with quantum jump is rather trivial from the point of view of particle physics. This would explain why positive energy ontology is so good an approximation. A more natural identification of particle physics S-matrix is as unitary entanglement coefficients for time like entanglement between positive and negative energy states which at space-time level are located at boundaries of future and past light-cones with time like separation. This hypothesis makes sense thanks to the condition $Tr(SS^\dagger) = Tr(Id) = 1$. The condition that sub-factor $\mathcal{N} \subset \mathcal{M}$ defines a measurement resolution, implies that S-matrix is crossing symmetric with respect to the multiplication with elements of $\mathcal{N}$.

b) The $N = 4$ super-conformal invariance extended to 3-D situation poses very stringent additional conditions on S-matrix elements. The conserved charges associated with super-conformal symmetries commuting with Cartan algebra of rotation and color groups and expressible as 2-D integrals allow a reduction to 1-dimensional integrals. This sub-algebra can be supersymmetrized if fermions obey stringy anti-commutation relations. The interpretation would be in terms of quantum measurement theory. Note that p-adic counterparts of various charges can be defined as their real values if they are algebraic numbers.

c) The generalized eigen modes of the modified Dirac operator assign to a partonic 3-surface a unique value of p-adic prime p. This allows a first principle formulation of renormalization group equations for p-adic coupling constant evolution at the level of "free theory" rather than in terms of radiative corrections.

d) Number theoretical universality leads to the hypothesis that S-matrix elements must be algebraic numbers. This is achieved naturally if the definition of S-matrix elements involves only data in the intersection of real and p-adic counterparts of the p-adic 3-surface associated with the real parton and obeying the same algebraic equations. Algebraicity is possible at parton level due to the almost topological QFT nature of dynamics. This leads naturally to the notion of number theoretic braid and a connection with braiding S-matrices. Also the concept of number theoretic string emerges.

e) The partonic vertices appearing in S-matrix elements should be expressible in terms of N-point functions of almost topological $N = 4$ conformal field theory but with the p-adically questionable N-fold integrals over string replaced with sums over the strands of a braid: spin chain type string discretization would be in question. Propagators, that is correlations between partonic 2-surfaces, are due to the interior dynamics of space-time sheets which means deviation from super string theory. Another function of interior degrees of freedom is to provide zero modes of CH metric identifiable as classical degrees of freedom of quantum measurement theory entangling with quantal degrees of freedom at partonic 3-surfaces.

References

Online books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview.* http://www.helsinki.fi/∼matpitka/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry.* http://www.helsinki.fi/∼matpitka/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time.* http://www.helsinki.fi/∼matpitka/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *Quantum TGD.* http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html.

[5] M. Pitkänen (2006), *TGD as a Generalized Number Theory.* http://www.helsinki.fi/∼matpitka/tgdnumber/tgdnumber.html.

[6] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy.*
http://www.helsinki.fi/∼matpitka/paddark/paddark.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics.*
http://www.helsinki.fi/∼matpitka/freenergy/freenergy.html.

Online books about TGD inspired theory of consciousness and quantum biology

[8] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems.*
http://www.helsinki.fi/∼matpitka/bioselforg/bioselforg.html.

[9] M. Pitkänen (2006), *Quantum Hardware of Living Matter.*
http://www.helsinki.fi/∼matpitka/bioware/bioware.html.

[10] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness.*
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html.

[11] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory.*
http://www.helsinki.fi/∼matpitka/genememe/genememe.html.

[12] M. Pitkänen (2006), *TGD and EEG.*
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html.

[13] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms.*
http://www.helsinki.fi/∼matpitka/hologram/hologram.html.

[14] M. Pitkänen (2006), *Magnetospheric Consciousness.*
http://www.helsinki.fi/∼matpitka/magnconsc/magnconsc.html.

[15] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory.*
http://www.helsinki.fi/∼matpitka/magnconsc/mathconsc.html.