Exploration

On Statistics, Negentropic Entanglement, Hawking Radiation & Firewall Paradox in TGD Framework

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Abstract

In quantum field theories (QFTs) defined in 4-D Minkowski space spin statistics theorem forces spin statistics connection: fermions/bosons with half-odd integer/integer spin correspond to totally antisymmetric/symmetric states. TGD is not a QFT and one is forced to challenge the basic assumptions of 4-D Minkowskian QFT. In the following it is show that the notion of many-sheeted space-time combined with strong form of holography (SH), Zero Energy Ontology (ZEO), Negentropy Maximization Principle (NMP), hierarchy of Planck constants $h_{eff} = n \times h$ with the identification of h_{eff} as gravitational Planck constant $h_{gr} = GMm/v_0$, $v_0/c \leq 1$ challenges the standard form of spin and statistics connection, suggests that quantum gravitation in astrophysical scales could be highly relevant for life, and also leads to new views about firewall paradox.

1   Introduction

In quantum field theories (QFTs) defined in 4-D Minkowski space spin statistics theorem forces spin statistics connection: fermions/bosons with half-odd integer/integer spin correspond to totally antisymmetric/symmetric states. TGD is not a QFT and one is forced to challenge the basic assumptions of 4-D Minkowskian QFT. In the following it is show that the notion of many-shheeted space-time combined with strong form of holography (SH), Zero Energy Ontology (ZEO), Negentropy Maximization Principle (NMP), hierarchy of Planck constants $h_{eff} = n \times h$ with the identification of h_{eff} as gravitational Planck constant $h_{gr} = GMm/v_0$, $v_0/c \leq 1$ challenges the standard form of spin and statistics connection, suggests that quantum gravitation in astrophysical scales could be highly relevant for life, and also leads to new views about firewall paradox.

1. In TGD framework the fundamental reason for the fermionic statistics are anticommutation relations for the gamma matrices of the "World of Classical Worlds" (WCW). This naturally gives rise to geometrization of the anticommutation relations of induced spinor fields at space-time surfaces. The only fundamental fields are second quantized space-time spinors, which implies that the statistics of bosonic states is induced from the fermionic one since they can be regarded as many-fermion states. At WCW level spinor fields are formally classical.

   Strong form of holography (SH) forced by strong form of General Coordinate Invariance (SGCI) implies that induced spinor fields are localized at string world sheets. 2-dimensionality of the basic objects (string world sheets and partonic 2-surfaces inside space-time surfaces) makes possible braid statistics, which is more complex than the ordinary one. The phase corresponding to 2π rotation is not ± 1 but a root of unitary and the phase can be even replaced with non-commuting analog of phase factor.

   What about the ordinary statistics of QFTs expected to hold true at the level of imbedding space $H = M^4 \times CP_2$? Can one deduce it from the q-variants of anticommutation relations for fermionic oscillator operators - perhaps by a suitable transformation of oscillator operators? Is the Fermi/Bose statistics at imbedding space level an exact notion or does it emerge only at the QFT limit when many-sheeted space-time sheets are lumped together and approximated as a slightly curved region of empty Minkowski space?

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2. Zero energy ontology (ZEO) means that physical systems are replaced by pairs of positive and negative energy states defined at the opposite boundaries of causal diamond (CD). CDs form a fractal hierarchy. Does this mean that the usual statistics must be restricted to coherence regions defined by CDs rather than assume it in entire H? This assumption looks reasonable since it would allow to milden the rather paradoxical looking implications of statistics and quantum identify for particles.

2   Negentropic entanglement, quantum monogamy, and biology

Interesting questions relate to the notion of negentropic entanglement (NE) and quantum monogamy.

1. Two states are negentropically entangled if their density matrix is proportional to projection operator and thus proportional to unit matrix. This require also algebraic entanglement coefficients. For bipartite entanglement this is guaranteed if the entanglement coefficients form a unitary matrix apart from normalization factor. The so called quantum monogamy theorem has a highly non-trivial implication for NE. In its mildest form it states that if two entangled systems are in a 2-particle state which is pure, the entire system must be de-entangled from the rest of the Universe. As a special case this applies to NE. A stronger form of monogamy states that two maximally entangled qubits cannot have entanglement with a third system. It is essential that one has qubits. For 3-valued color one can have maximal entanglement for 3-particle states (baryons). For instance, the negentropic entanglement associated with N identical fermions is maximal for subsystems in the sense that density matrix is proportional to a projection operator.

   Quantum monogamy could be highly relevant for the understanding of living matter. Biology is full of binary structures (DNA double strand, lipid bi-layer of cell membrane, epithelial cell layers, left and right parts of various brain nuclei and hemispheres, right and left body parts, married couples,...). Could given binary structure correspond at some level to a negentropically entangled pure state and could the system at this level be conscious? Could the loss of consciousness accompany the formation of a system consisting of a larger number of negentropically entangled systems so that 2-particle system ceases to be pure state and is replaced by a larger pure state. Could something like this take place during sleep?

2. NE seems to relate also to the statistics. Totally antisymmetric many-particle states with permutations of states in tensor product regarded as different states can be regarded as negentropically entangled for any subsystem since the density matrix is projection operator. Here one could of course argue that the configuration space must be divided by the permutation group of n objects so that permutations do not represent different states. It is difficult to decide which interpretation is correct so that let us consider the first interpretation.

   The traced out states for subsystems of many-fermion state are not pure. Could fermionic statistics emerge at imbedding space-level from the braid statistics for fundamental fermions and Negentropy Maximization Principle (NMP) favoring the generation of NE? Could CD be identified as a region inside which the statistics has emerged? Are also more general forms of NE possible and assignable to more general representations of permutation group? Could ordinary fermions and bosons be also in states for which entanglement is not negentropic and does not have special symmetry properties? Quantum monogamy plus purity of the state of conscious system demands decomposition into de-entangled sub-systems - could one identify them as CDs? Does this demand that the entanglement due to statistics is present only inside CDs/selves?

3. At space-time level space-time sheets (or space-like 3-surfaces or partonic 2-surfaces and string world sheets by SH) serve as natural candidates for conscious entities at space-time level. At imbedding space level elementary particles associated with various space-time sheets inside given CD would

contain elementary particles having NE forced by statistics. But doesn't this imply that space-time sheets cannot define separate conscious entities?

The notion of finite resolution for quantum measurement, cognition, and consciousness suggests a manner to circumvent this conclusion. One has entanglement hierarchies assignable to the length scale hierarchies defined by p-adic length scales, hierarchy of Planck constants and hierarchy of CDs. Entanglement is defined in given resolution and the key prediction is that two systems unentangled in given resolution can be entangled in an improved resolution. The space-time correlate for this kind of situation are space-time sheets, which are disjoint in given resolution but contain topologically condensed smaller space-time sheets connected by thin flux tubes serving as correlates for entanglement.

The paradoxical looking prediction is that at a given level of hierarchy characterized by size scale for CD or space-time surface two systems can be un-entangled although their subsystems are entangled. This is impossible in standard quantum theory. If the sharing of mental images by NE between subselves of separate selves makes sense, contents of consciousness are not completely private as often assumed in theories about consciousness. For instance, stereo vision could rely on fusion and sharing of visual mental images assignable to left and right brain hemispheres and generalizes to the notion of stereo consciousness making to consider the possibility of shared collective consciousness. An interpretation suggesting itself is that selves correspond to space-time sheets and collective levels of consciousness to CDs.

Encouragingly, dark elementary particles would provide a basic example about sharing of mental images. Dark variants of elementary particles could be negentropically entangled by statistics condition in macroscopic scales and form part of a kind of stereo consciousness, kind of pool of fundamental mental images shared by conscious entities. This could explain why for instance the secondary p-adic time scale for electron equal to $T = .1$ seconds corresponds to a fundamental biorhythm.

3 Quantum monogamy and firewall paradox

Quantum monogamy relates also to the firewall paradox of blackhole physics discussed from TGD viewpoint in [3].

1. There are two entanglements involved. There is entanglement between Alice entering the blackhole and Bob remaining outside it. There is also the entanglement between blackhole and Hawking radiation implied if Hawking radiation is only apparently thermal radiation and blackhole plus radiation defines a pure quantum state. If so, Hawking evaporation does not lead to a loss of information. In this picture blackhole and Hawking radiation are assumed to form a single pure system.

   Since Alice enters blackhole (or its boundary), one can identify Alice as part of the modified blackhole being entangled with the original blackhole and forming a pure state. Thus Alice would form an entangled pure quantum state with both Bob and Hawking blackhole. This in conflict with quantum monogamy. The assumption that Alice and blackhole are un-entangled does not look reasonable. But why Alice, Bob and blackhole could not form pure entangled 3-particle state or belong to a larger entangled state?

2. In TGD framework the firewall problem seems to be mostly due to the use of poorly defined terms. The first poorly defined notion is blackhole as a singularity of GRT. In TGD framework the analog for the interiors of the blackhole are space-time regions with Euclidian signature of induced metric and accompany all physical systems. Second poorly defined notion is that of information. In TGD framework one can define a measure for conscious information using p-adic mathematics and it

is non-vanishing for NE. This information characterizes always two-particle system - either as a pure system or part of a larger system. Thermodynamical negentropy formally defined as negative of entropy characterizes single particle (or ignorance about its state) in ensemble so that the two notions are not equivalent albeit closely related. Further, in the case of blackhole one cannot speak of information going down to blackhole with Alice since information is associated with a pair formed by Alice and some other system outside blackhole like objects or perhaps at its surface. Finally, the notion is hierarchy of Planck constants allows NE in even astrophysical scales. Therefore entangling Bob, Alice, and TGD counterpart of blackhole is not a problem. Hence the firewall paradox seems to dissolve.

3. The hierarchy of Planck constants $h_{eff} = n \times h$ connects also with dark quantum gravity via the identification $h_{eff} = h_{gr}$, where $h_{gr} = GMm/v_0$, $v_0/c \leq 1$, is gravitational Planck Planck constant. $v_0/c < 1$ is velocity parameter characterizing system formed by the central mass M and small mass m, say elementary particle.

This allows to generalize the notion of Hawking radiation [4] (see this, this, and this), and one can speak about dark variant of Hawking radiation and assign it with any material object rather than only blackhole. The generalized Hawking temperature is proportional to the mass m of the particle at the gravitational flux tubes of the central object and to the ratio R_S/R of the Schwartschild radius R_S and radius R for the central object. Amazingly, the Hawking temperature for solar Hawking radiation in the case of proton corresponds to physiological temperature. This finding conforms with the vision that bio-photons result from dark photons with $h_{eff} = h_{gr}$. Dark Hawking radiation could be very relevant for living matter in TGD Universe!

Even more, by extending [4] (see this and this) Jeremy England's vision about life [1] (`http://tinyurl.com/o64rd7o`), one ends up via SH to suggest that the Hawking temperature equals to the Hagedorn temperature assignable to flux tubes regarded as string like objects! This assumption fixes the value of string tension and is highly relevant for living matter in TGD Universe since it guarantees that subsystems can become time-reversed with high probability in state function reduction. The frequent occurrence of time reversed mental images makes possible long term memory and planned action and one ends up with thermodynamics of consciousness. This is actually not new: living systems are able to defy second law and the notion of syntropy was introduced long time ago by Fantappie [2].

4. Does one get rid of firewall paradox in TGD Universe? It is difficult answer the question since it is not at all clear that there exists any paradox anymore. For instance, the assumption that blackhole represents pure state looks in TGD framework rather ad hoc and the NE between blackhole and other systems outside it looks rather natural if one accepts the hierarchy of Planck constants.

It would however seems to me that the TGD analog of dark Hawking radiation along flux tubes is quite essential for communications and even more, for what it is to be Alice and Bob and even for their existence! The flux tube connections of living systems to central star and planets could be an essential part of what it is to be alive as I have already earlier suggested with the inspiration coming from $h_{eff} = h_{gr}$. In this framework biology and astrophysics would meet in highly non-trivial manner.

References

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