Negentropic entanglement, NMP, braiding and topological quantum computation

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1 Introduction

Negentropic entanglement [K2] for which number theoretic entropy characterized by p-adic prime is negative so that entanglement carries information, is in key role in TGD inspired theory of consciousness and quantum biology.

1. The key feature of negentropic entanglement is that density matrix is proportional to unit matrix so that the assumption that state function reduction corresponds to the measurement of density matrix does not imply state function reduction to one-dimensional sub-space. This special kind of degenerate density matrix emerges naturally for the hierarchy $h_{eff} = nh$ interpreted in terms of a hierarchy of dark matter phases. I have already earlier considered explicit realizations of negentropic entanglement assuming that E is invariant under the group of unitary or orthogonal transformations (also subgroups of unitary group can be considered -say symplectic group). One can however consider much more general options and this leads to a connection with topological quantum computation (TQC).

2. Entanglement matrix E equal to $1/\sqrt{n}$ factor times unitary matrix U (as a special case orthogonal matrix O) defines a density matrix given by $\rho = UU^\dagger/n = Id_n/n$, which is group invariant. One has NE respected by state function reduction if NMP is assumed. This would give huge number of negentropically entangled states providing a representation for some unitary group or its subgroup (such as symplectic group). In principle any unitary representation of any Lie group would allow representation in terms of NE. In principle any unitary representation of any Lie group would allow a representation in terms of NE.

3. In physics as generalized number theory vision, a natural condition is that the matrix elements of E belong to the algebraic extension of p-adic numbers used so that discreted algebraic subgroups of unitary or orthogonal group are selected. This realizes evolutionary hierarchy as a hierarchy of p-adic number fields and

their algebraic extensions, and one can imagine that evolution of cognition proceeds by the generation of negentropically entangled systems with increasing algebraic dimensions and increasing dimension reflecting itself as an increase of the largest prime power dividing n and defining the p-adic prime in question.

4. One fascinating implication is the ability of TGD Universe to emulate itself like Turing machine: unitary S-matrix codes for scattering amplitudes and therefore for physics and negentropically entangled subsystem could represent sub-matrix for S-matrix as rules representing "the laws of physics" in the approximation that the world corresponds to n-dimension Hilbert space. Also the limit $n \rightarrow \infty$ makes sense, especially so in the p-adic context where real infinity can correspond to finite number in the sense of p-adic norm. Here also dimensions n given as products of powers of infinite primes can be formally considered.

2 Restrictions on the entanglement matrix and braid statistics

One can consider various restrictions on E.

1. In 2-particle case the stronger condition that E is group invariant implies that unitary matrix is identity matrix apart from an overall phase factor: $U = exp(i\phi)Id$. In orthogonal case the phase factor is ± 1. For n-particle NE one can consider group invariant states by using n-dimensional permutation tensor $\epsilon_{i_1,\ldots i_n}$.

2. One can give up the group invariance of E and consider only the weaker condition that permutation is represented as transposition of entanglement matrix: $C_{ij} \rightarrow C_{ij}$. Symmetry/antisymmetry under particle exchange would correspond to $C_{ji} = \epsilon C_{ij}$, $\epsilon = \pm 1$. This would give in orthogonal case $OO^T = O^2 = Id$ and $UU^* = Id$ in unitary case.

   In the unitary case particle exchange could be identified as hermitian conjugation $C_{ij} \rightarrow C^*_{ji}$ and one would have $U^2 = Id$. Euclidian gamma matrices γ_i define unitary and hermitian generators of Clifford algebra having dimension 2^{2m} for $n = 2m$ and $n = 2m + 1$. It is relatively easy to verify that the squares of completely anti-symmetrized products of k gamma matrices representing exterior algebra normalized by factor $1/\sqrt{k!}$ are equal to unit matrix. For $k = n$ the antisymmetrized product gives essentially permutation symbol times the product $\prod_k \gamma_k$. In this manner one can construct entanglement matrices representing negentropic bi-partite entanglement.

3. The possibility of taking tensor products $\epsilon_{ij..k...n}\gamma_i \otimes \gamma_j .. \otimes \gamma_k$ of k gamma matrices means that one can has also co-product of gamma matrices. What is interesting is that quantum groups important in topological quantum computation as well as the Yangian algebra associated with twistor Grassmann approach to scattering amplitudes possess co-algebra structure [K3]. TGD leads also to the proposal that this structure plays a central role in the construction of scattering amplitudes. Physically the co-product is time reversal of product representing fusion of particles.

4. One can go even further. In 2-dimensional QFTs braid statistics replaces ordinary statistics [K1, K4]. The natural question is what braid statistics could correspond to at the level of NE. Braiding matrix is unitary so that it defines NE. Braiding as a flow replaces the particle exchange and lifts permutation group to braid group serving as its infinite covering. The allowed unitary matrices representing braiding in tensor product are constructed using braiding matrix R representing the exchange for two braid strands? The well-known Yang-Baxter equation for R defined in tensor product as an invertible element (`http://en.wikipedia.org/wiki/YangBaxter_equation`) expresses the associativity of braiding operation. Concretely it states that the two braidings leading from 123 to 321 produce the same result. Entanglement matrices constructed R as basic operation would correspond to unitary matrices providing a representation for braids and each braid would give rise to one particular NE.

   This would give a direct connection with TQC for which the entanglement matrix defines a density matrix proportional to $n \times n$ unit matrix: R defines the basic gate [B1]. Braids would provide a concrete representation for NE giving rise to "Akashic records". I have indeed proposed the interpretation of braidings as fundamental memory representations much before the vision about Akashic records. This kind of entanglement matrix need not represent only time-like entanglement but can be also associated also with space-like entanglement. The connection with braiding matrices supports the view that magnetic flux tubes are carriers of negentropically entangled matter and also suggests that this kind of entanglement between -say- DNA and nuclear or cell membrane gives rise to TQC.

Some comments concerning the covering space degrees of freedom associated with $h_{eff} = nh$ viz. ordinary degrees of freedom are in order.

1. Negentropic entanglement with n entangled states would correspond naturally to $h_{eff} = nh$ and is assigned with "many-particle" states, which can be localized to the sheets of covering but one cannot exclude similar entanglement in other degrees of freedom. Group invariance leaves only group singlets and states which are not singlets are allowed only in special cases. For instance for $SU(2)$ the state $|j,m\rangle = |1,0\rangle$ represented as 2-particle state of 2 spin 1/2 particles is negentropically entangled whereas the states $|j,m\rangle = |1,\pm1\rangle$ are pure.

2. Negentropic entanglement associated with $h_{eff} = nh$ could factorize as tensor product from other degrees of freedom. Negentropic entanglement would be localised to the covering space degrees of freedom but there would be entropic entanglement in the ordinary degrees of freedom - say spin. The large value of h_{eff} would however scale up the quantum coherence time and length also in the ordinary degrees of freedom. For entanglement matrix this would correspond to a direct sum proportional to unitary matrices so that also density matrix would be a direct sum of matrices $p_nE_n = p_nId_n/n$, $\sum p_n = 1$ correspond ing to various values of "other quantum numbers", and state function reduction could take place to any subspace in the decomposition. Also more general entanglement matrices for which the dimensions of direct summands vary, are possible.

3. One can argue that NMP does not allow halting of quantum computation. The counter argument would be that the halting is not needed if it is indeed possible to deduce the structure of negentropically entangled state by an interaction free quantum measurement replacing the state function reduction with "externalised" state function reduction. One could speak of interaction free TQC. This TQC would be reading of "Akashic records". NE should be able to induce a conscious experience about the outcome of TQC which in the ordinary framework is represented by the reduction probabilities for various possible outcomes.

   One could also counter argue that NMP allows the transfer of NE from the system so that TQC halts. NMP allows this if some another system receives at least the negentropy contained by NE. The interpretation would be as the increase of information obtained by a conscious observer about the outcome of halted quantum computation. It am not able to imagine how this could happen at the level of details.

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