Wigner's friend and Schrödinger's cat

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August 18, 2016

Abstract

Wigner's friend is one of the paradoxes of quantum measurement theory used to argue that consciousness is necessarily involved with quantum measurement. TGD view about state function reduction transforms quantum measurement theory to a theory of consciousness and allows to avoid the paradox but one encounters are related problem: how (say) qubit and in particular, its meaning are communicated. Quantum teleportation allows the communication of qubits and the temporary fusion of communicating entities to single larger entity is natural looking solution to the communication of meaning.

I encountered in Facebook discussion Wigner's friend paradox (seehttp://tinyurl.com/jpnvtp5 and http://tinyurl.com/ze6bmem). Wigner leaves his friend to the laboratory together with Schrödinger's cat and the friend measures the state of cat: the outcome is "dead" or "alive". Wigner returns and learns from his friend what the state of the cat is. The question is: was the state of cat fixed already earlier or when Wigner learned it from his friend. In the latter case the state of friend and cat would have been superposition of pairs in which cat was alive and friend new this and cat was dead also now friend new this. Entanglement between cat and bottle would have been transferred to that between cat+bottle and Wigner's friend. Recall that this kind of information transfer occur in quantum computation and quantum teleportation allows to transfer arbitrary quantum state but destroys the original.

The original purpose of Wigner was to demonstrate that consciousness is involved with the state function collapse.

TGD view is that the state function collapse can be seen as moment consciousness [K2, K1]. Or more precisely, self as conscious entity corresponds to a repeated state function reduction sequence to the same boundary of causal diamond (CD). One might say that self is generalized Zeno effect in Zero Energy Ontology (ZEO). The first reduction to the opposite boundary of CD means death of self and re-incarnation at opposite boundary as time reversed self. The experiencet flow of time corresponds to the shift of the non-fixed boundary of self reduction by reduction farther from the fixed boundary - also the state at it changes. Thus subjective time as sequence of reductions is mapped to clock time identifiable as the temporal distance between the tips of CD. Arrow of time is generated but changes in death-reincarnation.

In TGD inspired theory of consciousness the intuitive answer to the question of Wigner looks obvious. If the friend measured the state of cat, it was indeed dead or alive already before Wigner arrived. What remains is the question what it means for Wigner, the "ultimate observer", to learn about the state of the cat from his friend. The question is about what conscious communications are.

Consider first the situation in the framework of standard quantum information theory.

1. Quantum teleportation (see http://tinyurl.com/omfkydh) could make it possible to transfer arbitrary quantum state from the brain of Wigner's friend to Wigner's brain. Quantum teleportation involves generation of Bell state (see http://tinyurl.com/z9g8rar of qubits assignable with Wigner's friend (A) and Wigner (B).

2. This quantum state can be constructed by a joint measurement of component of spin in same direction at both A and B. One of the four eigenstates of (by convention) the operator $Q^z = J_x^{1)} \otimes J_y^{2)} - J_y^{1)} \otimes J_x^{2)}$ is the outcome. For spinors the actions of J_x and J_y change the

sign of J_z eigenvalue so that it becomes possible to construct the Bell states as eigenstates of Q^z.

3. After that Wigner's friend measures both the qubit representing cat's state, which is to be communicated and the qubit at A. The latter measurement does not allow to predict the state at B. Wigner's friend communicates the two bits resulting from this measurement to Wigner classically. On basis of these two classical bits his friend performs some unitary operation to the qubit at his end and transforms it to qubit that was to be communicated.

This allows to communicate the qubit representing measurement outcome (alive/dead). But what about meaning? What guarantees that the meaning of the bit representing the state of the cat is the same for Wigner and his friend? One can also ask how the joint measurement can be realized: its seems to require the presence of system containing $A \otimes B$. To answer these questions one must introduce some notions of TGD inspired theory of consciousness: self hierarchy and subself=mental image identification.

TGD inspired theory of consciousness predicts that during communication Wigner and his friend form a larger entangled system: this makes possible sharing of meaning. Directed attention means that subject and object are entangled. The magnetic flux tubes connecting the two systems would serve as a correlate for the attention. This mechanism would be at work already at the level of molecular biology. Its analog would be wormholes in ER-EPR corresponence proposed by Maldacena and Susskind. Note that directed attention brings in mind the generation of the Bell entangled pair A-B. It would make also possible quantum teleportation.

Wigner's friend could also symbolize the "pointer of the measurement apparatus" constructed to detect whether cats are dead of alive. Consider this option first. If the pointer is subsystem defining subself of Wigner, it would represent mental image of Wigner and there would be no paradox. If qubit in the brain in the brain of Wigner's friend replaces the pointer of measurement apparatus then during communication Wigner and his friend form a larger entangled system experiencing this qubit. Perhaps this temporary fusion of selves allows to answer the question about how common meaning is generated. Note that this would not require quantum teleportation protocol but would allow it.

Negentropically entangled objects are key entities in TGD inspired theory of consciousness and the challenge is to understand how these could be constructed and what their properties could be. These states are diametrically opposite to unentangled eigenstates of single particle operators, usually elements of Cartan algebra of symmetry group. The entangled states should result as eigenstates of poly-local operators. Yangian algebras involve a hierarchy of poly-local operators, and twistorial considerations inspire the conjecture that Yangian counterparts of super-symplectic and other algebras made poly-local with respect to partonic 2-surfaces or end-points of boundaries of string world sheet at them are symmetries of quantum TGD [K3]. Could Yangians allow to understand maximal entanglement in terms of symmetries?

1. In this respect the construction of maximally entangled states using bi-local operator $Q^z = J_x \otimes J_y - J_x \otimes J_y$ is highly interesting since entangled states would result by state function. Single particle operator like J_z would generate un-entangled states. The states obtained as eigenstates of this operator have permutation symmetries. The operator can be expressed as $Q^z = f^z_{ij} J^i \otimes J^j$, where f^A_{BC} are structure constants of SU(2) and could be interpreted as co-product associated with the Lie algebra generator J^z. Thus it would seem that unentangled states correspond to eigenstates of J^z and the maximally entangled state to eigenstates of co-generator Q^z. Kind of duality would be in question.

2. Could one generalize this construction to n-fold tensor products? What about other representations of SU(2)? Could one generalize from SU(2) to arbitrary Lie algebra by replacing Cartan generators with suitably defined co-generators and spin 1/2 representation with fundamental representation? The optimistic guess would be that the resulting states are maximally entangled and excellent candidates for states for which negentropic entanglement is maximized by NMP [K2].

3. Co-product is needed and there exists a rich spectrum of algebras with co-product (quantum groups, bialgebras, Hopf algebras, Yangian algebras). In particular, Yangians of Lie

algebras are generated by ordinary Lie algebra generators and their co-generators subject to constraints. The outcome is an infinite-dimensional algebra analogous to one half of Kac-Moody algebra with the analog of conformal weight N counting the number of tensor factors. Witten gives a nice concrete explanation of Yangian [**?**] for which co-generators of T^A are given as $Q^A = \sum_{i<j} f^A_{BC} T^B_i \otimes T^C_j$, where the summation is over discrete ordered points, which could now label partonic 2-surfaces or points of them or points of string like object (see `http://arxiv.org/abs/hep-th/0401243`). For a practically totally incomprehensible description of Yangian one can look at the Wikipedia article (see `https://en.wikipedia.org/wiki/Yangian`).

4. This would suggest that the eigenstates of Cartan algebra co-generators of Yangian could define an eigen basis of Yangian algebra dual to the basis defined by the totally unentangled eigenstates of generators and that the quantum measurement of poly-local observables defined by co-generators creates entangled and perhaps even maximally entangled states. A duality between totally unentangled and completely entangled situations is suggestive and analogous to that encountered in twistor Grassmann approach where conformal symmetry and its dual are involved. A beautiful connection between generalization of Lie algebras, quantum measurement theory and quantum information theory would emerge.

REFERENCES

Books related to TGD

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