Essay

Views about Free Will & The Anatomy of State Function Reduction

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ABSTRACT

Even some physicists have now accepted "free will" into their vocabulary. However, many writers remain unaware of the distinctions between experienced time and the geometric time of physics. Thus, many of them make the error of eliminating conscious mind from the picture in the process of trying to understand free will. The outcome is that free will is something effective and emergent or free will is resulting from deterministic but non-predictable/non-computable process. In Topological Geometrodynamics ("TGD"), zero energy ontology would realize blocks as causal diamonds ("CD") and would extend free will from a mere choice between given alternatives to creation of new worlds.

Key Words: free will, quantum state, measurment theory, state function reduction.

Views about Free Will

My humble question is: Why on earth something very complex or non-computable would generate sensation "I decide to do this"? A non-deterministic behavior serves as a correlate of free will, but non-predictable (yet possibly deterministic) behavior does not imply experience of free will. I am aware that understanding free will is as difficult as understanding of the nature of time. I have been trying to communicate my thoughts related to free will and the relationship between experienced time and the geometric time of physics for many years.

Sabine Hossenfelder: Free Will function

Sabine Hossenfelder has a blog piece entitled "Free will function". I agree with her that the idea about emergent free will is self-deception. Free will does not emerge from a deterministic microscopic dynamics.

The believers in emergence say that free will is an effective concept. This is really not the case but useful. If the system in question is complex enough and behaves non-predictably as seen by outsider one can say that it has effective free will. But why the impossibility to predict a deterministic dynamics in practice would generate the experience "I will do this". There is absolutely no justification for this belief.

A good objection against this identification comes from neuroscience and is described in the article The Brain on Trial by David Eagleman. People suffering Tourette's syndrome, split brain

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patients, persons with side personalities, and patients with choreic motions behave from the point of view of an outsider who would have free will. Using biblical language: they act as if being possessed. They do not experience free will. Who wills? Who uses the biological body of the patient? Are we merely our brains and bodies? Who uses my biological body? What is this "me"? Is this particular biological body used only by single intentional agent, by single "me" only?

(Comment: Effective theories have become the basic norm of theoretical physics today. No one can seriously claim that string models say anything about the world of experimental physicists. But there is a loop hole. By postulating effective field theory approach one can build entire landscape of effective theories. This to me is nonsense but it works. The only honest reaction would be to admit that string models are nice theories but not theories about the world we live in.)

Hossenfelder suggests as a solution something that she calls free will function. She considers a machine spitting out digits of π. This process is fully deterministic but outsider has no means of predicting what the next digit will be and what number the digit sequence represents unless he manages to get the program code. The proposal is that our brain has this kind of free will function. The strange assumption is that the inability to predict would in some mysterious manner generate experience of free will. But Hossenfelder as a physicist has learned that one must forget all subjective elements when doing science. In this mental framework the only conceivable goal of a theory of consciousness is to eliminate it. The fruitless searches of "consciousness modules" assumed to reside somewhere in the brain are fruits of similar "consciousness as function" thinking.

Sean Carroll: Free will as real as baseball

Sean Carroll has also written about free will in his blog piece "Free will as real as baseball". Carroll belongs to the effective theory camp and sees free will as a convenient tool of description just like baseball is seen by a reductionist as a convenient abstraction to describe the dynamics of a condensed matter system.

Carroll makes two claims:

1. Free will is inconsistent with the laws of physics. This is the case only if the experienced time and geometric time of physics are the same but they are not as many realize. Experienced time is irreversible and there is no subjective future. Geometric time is reversible and future and past are in the same footing. In general relativity, 4-D space-time region becomes the basic entity instead of time = constant snapshot which is the basic entity according to Newtonian thinking. All writers except Scott Aaronson seem to belong to the species of Newtonians as far as their views about time are considered.

2. Physics is completely understood in everyday realm. But do we really understand the physics underlying living matter?

Interestingly, Carroll notices analogy of poorly understood notion of free will with the poorly understood notion of time. The arrow of time is in conflict with microscopic reversibility but,

according to Carroll, physicists do not see this as a problem so that it is not a problem! The effective theory solution is simple: The arrow of time somehow emerges!

This seems to me self-deception. One should admit this and really try to understand Second Law of thermodynamics. If one does this, the first observation is that Boltzmann's equations are deduced by assuming the occurrence of state function reductions in time scale much shorter than the time scale of observations. State function reduction is what makes quantum physics non-deterministic at the level of single quantum system. This is internally inconsistent: the determinism of Schrödinger equation is in conflict with state function reduction if one identifies experienced time with the geometric time of physics. One should be able to resolve this logical flaw by requiring that the two types of times are different. If we have two types of times, we also have two independent causalities: the causality of field equations and that of free will. This will be the first step towards the real solution.

Carroll also presents what he calls the consequent argument: it begins with a statement that the past is fixed, so free will obeying field equation is impossible since it would change both future and past. I think that this is wrong: the assumption about fixed past in the geometric sense need not be true but the subjective/experienced past is. Indeed, in state function reduction the geometric past changes in Wheeler's delayed choice experiment. Maybe Wheeler's general relativistic background helped him to make this conceptual leap similar to the TGD view about quantum jump.

In the TGD framework, quantum states are superpositions of classical histories and quantum jumps replace them with new ones and the average geometric past also changes. The finding of Libet - that in volitional act neural activity begins a fraction of second before the conscious decisions - supports the idea that we are replacing our geometric past with a new one in the subjective/experienced time.

Carroll does notice the ethical aspect of the problem: If we really believe that free will is illusion, we have no justification for moral rules. The criminals would be doomed to perform their crimes at the moment of Big Bang. We experience free will as everyone can testify. We should accept this and then try to understand its physical correlates. In fact, neuroscience has led to quite concrete progress in the understanding of the correlations between biology and behavior.

Scott Aaronson's view

Scott Aaronson studied the idea of reducing free will to behavior observed from outside. Aaronson's thought experiment considers a Turing like test allowing you to decide whether you have free will. A computer model of you would be built using all available data about the initial state of your brain: this of course assumes determinism or at least quantum statistical determinism. If the computer is able to mimic your behavior faithfully, one can say that you have no free will. The proponent of effective free will might say that the longer the needed computer code is, the more you have effective free will. This kind of free-will-meter is of course not possible in practice.

Aaronson presents the non-cloning theorem of quantum theory as a first principle objection against Turing test of free-will-meter. Even in principle it is not possible to construct complete copy of brain state to make a complete simulation possible. This kind of machine would be successful in what Aaronson calls Toddler test but this would be a fake success. Any toddler says completely predictably "No" to any question. We however know that the toddler expresses by behaving irrationally that he/she has discovered his/her free will.

Aaronson brings in special relativity and notices that free will means also backward causation if it is to be consistent with the causality of field equations. From this it would be only a short step to the realization that the causality of free will could act in the space of quantum states defined as superposition of solutions of classical field equations consistent with holography in the sense that 3-D section determines the entire space - at least below certain scale! The problem would have been solved! Aaronson makes a near miss!

To sum up, Aaronson dimly realizes that in general relativity - and in any 4-D Universe obeying general coordinate invariance - we live in a kind of block world consisting of 4-D blocks but the other writers continue in the good old Newtonian style. In TGD, zero energy ontology would realize blocks as causal diamonds ("CD") and would extend free will from a mere choice between given alternatives to creation of new worlds. Hossenfelder realizes that emergence is self-deception. Carroll grasps the full meaning of the absence of free will at the level of moral issues.

The Anatomy of State Function Reduction

The proposal of Svetlichny

The basic objection against assigning free will to state function reduction in the sense of wave mechanics is that state function reduction from the point of view of outsider is like playing dice. One can of course argue that for an outsider *any* form of free will looks like throwing a dice since causally effective experience of free will is accompanied by non-determinism. We simply do not know what is the experience possibly associated with the state function reduction. The lesson is that we must carefully distinguish between two levels: the single particle level and ensemble level. When we can say that something is random, we are talking about ensembles, not about single member of ensemble.

Svetlichny takes the objection seriously and notices that quantum measurement means a division of system to three parts: measured system, measuring system and external world and argues that in some cases this division might not be unique. The choice of this division would have interpretation as an act of free will. I leave it to the reader to decide whether this proposal is plausible or not.

TGD view about state function reduction

What can one say about the situation in TGD framework? There are several differences as compared to the standard measurement theory which is just certain *ad hoc* rules combined with

the Born rule. This rule applies naturally in TGD framework and is not *ad hoc* in infinite-D context.

I consider here the general anatomy of quantum jump in zero energy ontology (ZEO):

1. TGD ontology differs from the standard one. Space-time surfaces and quantum states as such are zombies in TGD Universe: consciousness is in the quantum jump. Conscious experience is in the change of the state of the brain, brain state as such is not conscious. Self means integration of quantum jumps to higher level quantum jumps and the hierarchy of quantum jumps and hierarchy of selves can be identified in ZEO. It has the hierarchy of causal diamonds (CDs) and space-time sheets as geometrical correlates. In TGD Universe brain and body are not conscious: rather, conscious experience is about brain and body and this leads to the illusion caused by the assimilation with the target of sensory input: I am what I perceive.

2. In TGD framework, one does not assume the division of the system to a product of measured system, measuring system, and external world before the measurement. Rather, this kind of divisions is the outcomes of state function reduction which is part of quantum jump involving also the unitary process. Note that standard measurement theory is not able to say anything about the dynamics giving rise to this kind of divisions.

3. State function reduction cascade as a part of quantum jump - this holistic view is one new element - proceeds in zero energy ontology (ZEO) from long to short length scales CD→sub-CDs→..., and stops when Negentropy Maximization Principle (NMP defining the variational principle of consciousness is also something new) does not allow to reduce entanglement entropy for any subsystem pair of subsystem un-entangled with the external world. This is the case if the sub-system in question is such that all divisions to two parts are negentropically entangled or form entangled bound state.

For a given subsystem occurring in the cascade the splitting into an unentangled pair of measured and measuring system can take place if the entanglement between these subsystems is entropic. The splitting takes place for a pair with largest entanglement entropy and defines measuring and measured system.

Who measures who? This seems to be a matter of taste and one should not talk about measuring system as conscious entity in TGD Universe, where consciousness is in quantum jump:

4. The factorization of integer to primes is a rather precise number theoretical analogy for what happens, and the analogy might actually have a deeper mathematical meaning since Hilbert spaces with prime dimension cannot be decomposed into tensor products. Any factorization of integer to a product of primes corresponds to a cascade of state function reductions. At the first step division takes place to two integers and several alternative divisions are possible. The pair for which the reduction of entanglement entropy is largest, is preferred. The resulting two integers can be further factorized to two integers, and the process continues and eventually stops when all factors are primes and no further factorization is possible.

One could even assign to any decomposition n= rs the analogs of entanglement probabilities as p_1= log(r)/log(n) and p_2= log(s)/log(n). NMP would favor the divisions to factors r and s which are as near as possible to n/2.

Negentropically entangled system is like prime. Note however that these systems can still make an analog of state function reduction which does not split them but increases the negentropy for all splittings of system to two parts. This would be possible only in the intersection of real and p-adic worlds, that is, for living matter. My cautious proposal is that just this kind of systems - living systems - can experience free will: either in the analog of state function reduction process increasing their negentropy or in state function process reducing their entanglement with environment.

5. In standard measurement theory observer chooses the measured observables and the theory says nothing about this process. In TGD the measured observable is the density matrix for a pair formed by any two entangled parts of sub-system division for which negentropy gain is maximal in quantum measurement defines the pair. Therefore both the measurement axis and the pair representing the target of measurement and measurer are selected in quantum jump.

6. Quantum measurement theory assumes that measurement correlates classical long range degrees of freedom with quantal degrees of freedom. One could say that the direction of the pointer of the measurement apparatus correlates faithfully with the value of the measured microscopic observable. This requires that the entanglement is reduced between microscopic and macroscopic systems.

I have identified the "classical" degrees of freedom in TGD framework as zero modes which by definition do not contribute to the line-element of WCW although the WCW metric depends on zero modes as external parameters. The induced Kähler field represents an infinite number of zero modes whereas the Hamiltonians of the boundaries of CD define quantum fluctuating degrees of freedom.

The reduction of the entanglement between zero modes and quantum fluctuating degrees of freedom is an essential part of quantum measurement process. Also state function reductions between microscopic degrees of freedom are predicted to occur and this kind of reductions lead to decoherence so that one can apply quantum statistical description and derive Boltzmann equations. Also state function reductions between different values of zero modes are possible and one could perhaps assign "telepathic" effects with them.

The differences from the standard quantum measurement theory are that several kinds of state function reductions are possible and that the division to classical and quantum fluctuating degrees of freedom has a purely geometric meaning in TGD framework:

7. One can even imagine quantum parallel state function reduction cascades. This would make possible quantum parallel dissipation, which would be something new. My original proposal was that in hadronic physics this could make possible a state function reduction cascade proceeding in quark scales while hadronic scales would remain entangled so that

one could apply statistical description to quarks as parts of a system, which is quantum coherent in hadronic length scale.

Further questions

There are many other interesting issues:

1. In ZEO the choice of the quantization axes and would fix the moduli of the causal diamond CD: the preferred time direction defined by the line connecting the tips of CD, the spin quantization axis, etc. This choice certainly occurs. Does it reduce to the measurement of a density matrix for some decomposition of some subsystem to a pair? Or should one simply assume state function reductions also at this level meaning localization to a sector of WCW corresponding to given CD. This would involve localization in the moduli space of CDs selecting some boost of a CD with fixed quantized proper time distance between it tips, fixed spin directions for positive and negative energy parts of zero energy states defined by light-like geodesics at its light-like boundary. Preferred complex coordinates for CP_2, etc.

2. Zero energy states are characterized by arrow of geometric time in the sense that either positive or negative energy parts of states have well defined particles numbers and single particle numbers but not both. State function reduction is possible only for positive or negative energy part of the state but not both. This should relate very closely to the fact that our sensory percepts defined by state function reductions are mostly about the upper or lower boundary of CD.

3. In ZEO quantum jumps can also lead to generation of new sub-Universes, sub-CDs carrying zero energy states. Quantum jumps can also involve phase transitions changing p-adic space-time sheets to real ones and these could serve as quantum correlates for intentional actions. Also the reverse process changing matter to thoughts is possible. These possibilities are totally unimaginable in the quantum measurement theory for systems describable by wave mechanics.

4. There is also the notion of finite measurement resolution described in terms of inclusions of hyperfinite factors at quantum level and in terms of braids at space-time level.

To summarize, a lot of theory building is needed in order to fuse all new elements to a coherent framework. In this framework standard quantum measurement theory is only a collection of *ad hoc* rules and can catch only a small part of what really happens. Certainly, standard quantum measurement theory is far from being enough for the purposes of consciousness theorist.