TGD inspired theory of consciousness and living systems

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Abstract

Topological Geometro-Dynamics (TGD) proposes a unification of fundamental interactions by identifying space-times as 4-surfaces in 8-D space $H = M^4 \times CP_2$, whose geometry codes for standard model symmetries and geometrizes known fields. Point-like particle is replaced with 3-surface (3-space). One ends up with the notions of many-sheeted space-time and magnetic body (MB) central in TGD inspired quantum biology. p-Adic and adelic physics follows from the extension of physics to describe also the correlates of cognition and imagination. Adelic physics predicts a hierarchy of Planck constants labelling phases of ordinary matter interpreted as dark matter: the predicted quantum coherence in arbitrarily long scales is crucial for quantum biology. Quantum TGD replaces standard ontology with "zero energy ontology" (ZEO) replacing quantum state as time=constant snapshot with zero energy state (ZES) identified as a superposition of deterministic classical time evolutions - kind of quantum program.

Keywords: Biology, consciousness, unified theories, geometrization of physics, quantum measurement theory.

Contents

1 Introduction

In the sequel the basic ideas of TGD inspired quantum theory of consciousness and biology are considered [K3] [L15, L16] (see http://tinyurl.com/ycxm2tpd and http://tinyurl.com/yyyk6fu8). The representation follows closely the representation held in Baden-Baden (31st International Conference on Systems Research, Informatics and Cybernetics InterSymp 2019: Symposium on Causal and Anticipative Systems in Living Science, Biophysics, Quantum Mechanics, Relativity).

Topological Geometrodynamics (TGD) [K1, K4] (see http://tinyurl.com/y5byyhc2) is a 41 year old proposal for a unification of fundamental interactions based on new view about space-time inspired by the problem of General Relativity (GRT) with classical conservation laws ("energy problem"). Matter makes GRT space-time curved leading to the loss of the symmetries of Minkowski space M^4 of Special Relativity (SRT). Poincare invariance implies the conservation laws of energy, momentum, and angular momentum via Noether's theorem lost in GRT.

If space-time is a 4-surface in space of form $H = M^4 \times S$, S some compact space with very small size, space-time isometries are raised to those of H to regain Poincare symmetries. $S = S = CP_2$ codes for the symmetries of standard model.

TGD proper as a physical theory involves several threads.

1. Classical TGD at space-time level: $X^4 \subset H = X^4 \subset M^4 \times CP_2$. The new elements are many-sheeted space-time topologically non-trivial in all scales, and topological field quantization implying that physical systems have field identity, field body, in particular magnetic body (MB) [L9, L8] (see `http://tinyurl.com/yxpomw9y`).

   One ends up to a geometrization of gravitational field and gauge fields of the standard model as induced fields. The QFT limit is obtained by replacing the sheets of many-sheeted space-time with slightly curved region of M^4 and identifying gauge potentials and gravitational field as superpositions of induced fields at various space-time sheets.

2. Quantum TGD replaces Wheeler's superspace with the "World of Classical Worlds" (WCW) as the space of 3-surfaces, which are by holography in 1-1 correspondence with space-time space-time surfaces identified as preferred extremals (PEs) of the basic variational principle and analogous to Bohr orbits: classical physics becomes an exact part of quantum physics [L6, L7] (see `http://tinyurl.com/y3pycull`). Einstein's geometrization of classical physics extends to that of quantum physics. The geometry of WCW and physics is highly unique from its mere existence requiring maximal group of isometries:a result proved by Freed for loop spaces [A2].

3. Number theoretical vision is also a part of TGD (see `http://tinyurl.com/y4cto4go`). p-Adic number fields serve as correlates of cognition and imagination. Space-time is replaced with a book like structure having both real and various p-adic space-time sheets as pages. The outcome is adelic physics as fusion of various p-adic physics [L1, L2] (see `http://tinyurl.com/ycbhse5c`). The extensions of rationals (EQ) induce extensions of p-adic numbers fields and of adeles giving rise to a hierarchy of physics having interpretation in terms of evolution induced by the increase of the complexity of the EQ. Adelic physics leads also the hierarchy of Planck constants $h_{eff}/h_0 = n$ with n identified as dimension of EQ making possible quantum coherence in arbitrarily long time scales essential for understanding living matter.

   Second aspect of number theoretical vision are classical number fields: reals, complex numbers, quaternions and octonions. $M^8 - H$ correspondence [L13, L14] (see `http://tinyurl.com/y5c4vnjj`) allowing to interpret complexified M^8 as complexified octonions allows to map surfaces of M^8 identified as roots of octonionic polynomials to PEs in $H = M^4 \times CP_2$.

4. Twistor lift of TGD generalizes ordinary twistor approach [L19, L20] so that 4-D masslessness implying problems in twistor approach is replaced with 8-D masslessness so that masses can be non-vanishing in 4-D sense. 4-D space-time surfaces are replaced with the analogs of their twistor bundles for which twistor structure is induced from 6+6-D twistor space of H - a product of twistor spaces of M^4 and CP_2. Twistor space has Kähler structure only for M^4 and CP_2 [A3]. Since Kähler structure is necessary for the twistor lift of TGD, TGD is unique. One outcome is length scale dependent cosmological constant taking a central role in the theory.

2 TGD based quantum biology

One can approach TGD inspired quantum biology by making questions.

Problem #1: How to understand coherence of living systems? If only bio-chemistry is involved, we would be sacks of water and sacks of water do not climb in trees or write poems. Could quantum coherence induce the coherence? What entity serve as intentional agent and how it could realize its intentions?

1. Topological field quantization applies to electric and magnetic fields [L8] (see `http://tinyurl.com/yxpomw9y`). For instance, magnetic field decomposes to flux tubes having finite thickness. Radiation fields are topologically quantized to topological light rays. Each system has its

fields at separate space-time sheets touching each other only via wormhole contacts: system has field body, in particular magnetic body (MB) having hierarchical onion-like structure corresponding to the hierarchy of space-time sheets.

2. MB serves as the intentional agent using biological body (BB) as motor instrument and sensory receptor. MB controls BB via dark photon dark photon beams with large h_{eff}. The double BB + environment is replaced with the triple MB + BB+ environment.The vision about life as nothing but biochemistry is given up.

3. Experiments of Blackman [J2] and others demonstrated the quantal effects of ELF radiation on vertebrate brain. For the ordinary value of Planck constant these effects are however impossible since the energy $E = hf$ of EEG photons is extremely small. This motivated what eventually became $h_{eff}/h_0 = n$ hypothesis derivable now from adelic physics [L1, L2].

4. Dark matter at the flux tubes of MB corresponds to $h_{eff}/h_0 = n$ phases and induces coherence of visible living matter. The generalization and re-interpretation of Nottale's hypothesis [E1], which reads as $h_{eff} = h_{gr} = GMm/v_0$, where $v_0 < c$ has dimensions of velocity and M and m are masses at the ends of the magnetic flux tube along which gravitons travel is essential element. The hypothesis implies that the cyclotron energy scale for charged particle is independent on m. The spectrum of Josephson frequencies for cell membrane is universal but now the energies are inversely proportional to h_{eff}.

Problem #2: How MB uses BB as sensory receptor and motor instrument?

1. Dark photons with large h_{eff} serve as as communication and control tools. Josephson frequencies would be involved with the communication of sensory data to MB and cyclotron frequencies with control by MB. Dark photons are assumed to transform to biophotons [L10] [K2] (see `http://tinyurl.com/y5z4bog3`) with energies covering visible and UV associated with the transitions of bio-molecules. The control by MB which layers having size even larger than that of Earth means that remote mental interactions are routine in living matter.

2. In ZEO field body and MB correspond to 4-D rather than 3-D field patterns. Quantum states are replaced by quantum counterparts of behaviors and biological functions. The basic mechanism used by MB would be generation of conscious holograms by using dark photon reference beams from MB and their reading. In ZEO also the time reversals of these processes are possible and make possible to understand memory as communications with geometric past. Sensory perception and memory recall would be time reversals of each other and correspond to sequences of SSRs. Motor action would correspond to BSRs.

Problem #3: Why metabolism? Particles with nonstandard h_{eff}/h_0 have higher energy as a rule. For instance, atomic binding energies are proportional to $1/h_{eff}^2$ and thus smaller. Cyclotron energies are proportional to h_{eff}. Metabolic rnergy is needed to excite particles to dark states and thus to increase their "IQ" .

This picture suggests a generalization of the view about self-organization based on non-equilibrium thermodynamics with a quantum view based on number theory, in particular the hierarchy of Planck constants [L5]. In non-equililbrium thermodynamics energy feed is a prerequisite of self-organization leading to a generation of coherent structures in long length scales and master-slave hierarchy is central. TGD can be at least formally seen as complex square root of thermodynamics, which leads to the question whether also ordinary self-organization could reduce to the hierarchy of Planck constants so that quite generally the coherent structures in long length scales could be seen as analogs of life forms with coherence induced by quantum coherence at the level of MBs. Hierarchy of MBs defining master slave hierarchy with ordinary matter at the bottom of the hierarchy would replace ordinary master slave hierarchy and quantum theory would make itself visible in all scales.

Problem #4: What is evolution? Evolution as increase of $h_{eff}/h_0 = n$ means increase of the dimension of extension of rationals in statistical sense at least since the number of extensions with dimension larger than given integer n is infinite and those with dimension smaller n is finite: algebraic complexity increases.

Problem #5: What about genetic code?

1. Chemical genetic code need not be fundamental if chemistry is only a shadow of the dynamics of MB: more naturally it would be induced by MB mimicking genetic code at dark level. I have proposed a dark variant of genetic code associated with dark nuclei at magnetic flux tubes [L12, L18] (see `http://tinyurl.com/yalny39x`): dark proton triplet would serve as a codon. Dark DNA, RNA, tRNA, amino-acids (AAs) exist and the numbers of various codons and of AAs and also the numbers of genetic codons coding for given AA are correctly predicted.

2. Dark-dark and dark-visible communications are required. Frequency resonance mechanism could be involved with dark-dark communications and energy resonance with dark-visible communications. Cyclotron frequencies of dark protons at the magnetic field of flux tube and Josephson frequencies associated with cell membrane are natural frequencies.

3. Communication requires a code and genetic code is the natural guess. Ordinary codons would be replaced with 3-chords. One could speak of music of light. One ends up with this code from a model for harmony. Music expresses and creates emotions and "music of light" could provide correlates for moods/emotions at the molecular level (see `http://tinyurl.com/y3auow4a`).

   There is a connection with Platonic geometries speculated already by Pythagoras. Hamilton cycles at icosahedron *resp.* dodecahedron would realize 12-note *resp.* 20-note scale as closed self-non-intersecting curve connecting neighboring points and going through all vertices. For icosahedron the 20 triangular faces define 20 allowed 3-chords of the harmony: there is a large number of harmonies. For dodecahedron the 12 5-chords associated with 12 pentagonal faces define a unique harmony. There is a natural mapping of 5-chords to 3-chords. The fusion of 2 icosahedral and 2 dodecahedral harmonies gives 20+20+12+12 =64 chords allowing an identification in terms of the genetic code. The number 20 of triangular faces relates to the number of amino-acides. The numbers of codons coding for given amino-acid are predicted correctly.

   Problem #6: What is morphogenesis? If biology is mere chemistry, its is very difficult to answer this question. If space-time topology is non-trivial in all scales, situation changes dramatically. All structures - including bio-molecules, membrane like structures, organelles, organs, ... - would be 4-D space-time surfaces, dynamical patterns, and morphogenesis would emerge at classical level [L17, L11].

3 How to end up with TGD inpired theory of consciousness?

Materialism/physicalism is kind of meta problem eliminating altogether any serious consideration of the problem. Consciousness is assumed to be property of physical system completely fixed by its physical state. Free will would be illusion. The term conscious-"ness" already reflects the materialistic view. In finnish language the word "tajunta" avoids the interpretation as a property. To proceed, one must give up physicalism. One can proceed further to TGD inspired theory of consciousness by making questions.

Problem #1: How free will could be consistent with the determinism of field equations? What free will could be? It sees that behaviour is built from deterministic time evolutions connecting initial and final states: functions, behaviors, computer programs. Could free be in the selection between them. This suggests a new ontology in which deterministic time evolution becomes basic entity instead of time=constant snapshot of history.

Problem #2: Similar problem plagues quantum measurement theory. State function reduction (SR) is non-deterministic and Schrödinger equation deterministic. This has led to myriads of "interpretations".

The key idea is to replace the usual approach to physics equations as initial value problem with single time =constant snapshot with positions and initial velocities fixed with boundary value problem. One has two time=constant snapshots t_1 and t_2 and fixes now only the initial positions (but not velocities) at them. This can be generalized to fields and their initial values and even to space-time surfaces by replacing boundary values with 2 3-surfaces at time=constant snapshots. This picture is not quite correct but is concrete. A more precise picture will be described below.

Problem disappears if SR selecs between quantum history defined as a superposition of classical deterministic histories - preferred exremals (PEs) of classical action. Classical physics would become exact part of quantum theory rather than mere approximation. One could speak of zero energy ontology (ZEO): zero energy states (ZESs) would be superpositions of pairs of ordinary quantum states (time=constant snapshot) at different values t_1 and t_2 of time coordinates and only those pairs connected by deterministic time evolution would be allowed.

This would imply classical and quantum conservation laws and total quantum numbers for initial and final states would be same - for book keeping purposes one can say that total conserved quantum numbers are opposite at the two ends - this is the practice in quantum field theories. Hence the term ZES.

The classical time evolutions in the superposition defining ZES are analogous to events in classical sense. They are however not events in the sense of non-terministic SRs and cannot involve free will.

Problem #3: Experienced time and geometric time of physicist are very different. Subjective time however correlates with the geometric time: contents of sensory experience correspond to moment of geometric time with accuracy of .1 second.

Are there two times and two causalities? Could subjective time correspond to a sequence of SRs occurring between ZESs. The correlation between the two times requires that in SR the temporal distance $t_1 - t_2$ increases. Two arrows of time are possible- either t_1 or t_2 changes.

Problem #4: Observer is still an outsider in quantum theory. Observations affect the measured system but there is not attempt to understand the observer as a part of quantum system. Quantum theory of consciousness sould be a generalization of quantum measurement theory. The central notion is that of self replacing that of observer.

1. Self is a system having quantum identity and thus able to remain unentangled during time evolution. Schrödinger evolution with non-trivial interactions however entangles the system immediately.

   On the other hand, Zeno effect is known to occur and means that system remains un-entangled when observables are measured repeatedly. Isn't ordinary ontology enough? In some sense conscious entity - self - should have part remaining un-entangled during subsequent measurements.

2. Here zero energy ontology (ZEO) comes in rescue. ZESs are superpositions of pairs of ordinary states at times t_1 and $t_2 > t_1$. Could the state assignable to self at say t_1 be un-entangled and remain unaffected during subsequent SRs affecting only the states at t_2? Self could be identified as the development of ZES by a sequence of unitary evolutions of the active part of the state at t_2 followed by SR each. Self would have passive part P corresponding to t_1 - the unchanging part of self and the active part A assignable to t_2 corresponding to sensory input and everything related to it.

   Self would be a generalized Zeno effect. t_2 would increase - at least in statistical sense in each unitary evolution between two SRs. The increase of t_2 would correspond to the increase of clock time. There would be the desired correspondence between experienced time as a sequence of these SRs and geometric/clock time as $t = t_2 - t_1$. The sensory input and all induced by it would come from these SRs and allow to assign clock time to experienced time flow.

   The SR in question cannot correspond to ordinary SR since in standard quantum theory nothing would happen in it (Zeno effect). This "small" SR (SSR) is however analogous to so called weak SR (see `http://tinyurl.com/zt36hpb`) which is much like classical measurement.

3. What about standard SR - the "big" SR (BSR)? Above it was assumed that t_1 corresponds to P. Why also why $t_2 > t_1$ could not correspond to P? The arrow of time a property of ZES would be reversed. Could BSRs correspond to SRs changing the roles of A and P. The identification would be as "death" of self and reincarnation as self with opposite arrow of time. These reduction would take place routinely in elementary particle scales, where the lifetimes of selves would be shorter. In the next BSR self would reincarnate in the original arrow of time.

Problem #5: Are we the only conscious systems or is pan-psychism realized in some sense? For physicist it is very difficult to imagine anything but pan-panpsychism. There would be self hierarchy corresponding to length scale hierarchy. Self would have sub-selves, which it experiences as mental images. Sub-sub-selves would be experienced as kind of averages. Self in turn defines mental image of self above it. These 3 preferred levels in hierarchy for given self would correspond to super-ego-ego-Id triplet of Freud.

The sequence of reincarnations can be experienced by self in the phenomenon of after images in which visual (say) mental image re-appears repeatedly. The time reversal of the mental images would not be experienced by self.

Problem #6: As already noticed, the realization of ZEO in terms of snapshots is not realistic. How to realize ZEO physically? Standard quantum theory does not allow the realization of ZEO. TGD framework led to ZEO and to a realization for the notion of self.

1. Quite generally, one can solve the basic problem of quantum measurement theory by re-placing initial value problem of classical physics with boundary value problem. A pair of time=constant snapshots is however not the optimal choice.

   Rather, causal diamond (cd) formed as an intersection of future and past directed light-cones of M^4 is a more natural notion. cd is formed as spherical light front expands for time $T/2$ and contracts for time $T/2$ after that. The temporal distance between the tips of cd is T. The boundary of cd has two pieces opposite to each other. They are parts of light-cone boundary meeting at the sphere $r = T/2$. At the level of H cd is replaced with CD $=cd \times CP_2 \subset M^4 \times CP_2$.

   CD is identified as a imbedding space correlate for self determining the perceptive field of self. One has actually entire hierarchy of CDs within CDs with varying quantized size assignable to self hierarchy.

   (a) CD is more natural than pair of time=constant snapshots of H since the infinite size of the space-bounded by time=constant snapshots of H is mathematically problematic. The boundary of CD is also connected.

   (b) CD is natural in WCW geometry since its boundary has symplectic transformations of light-cone boundary as infinite-D symmetries analogous to Kac-Moody symmetries with light-like radial coordinate in the same role as the complex coordinate in conformal field theories. The metric 2-D of light-cone boundary of M^4 also implies huge extension of ordinary conformal symmetries.

   (c) CD has a natural interpretation as a correlate for the perceptive field of self. The past-direct light-cone defines the region about which sensory input comes as classical signals. The intersection of future directed light-cone with past-directed light-cone boundary defines the region from which the sensory input from self as a conscious entity emerges.

2. Zero energy ontology (ZEO) involves the hierarchy of causal diamonds (CDs) as correlates for perceptive fields of selves. The idea about ZES as pair of states at time t_1 and t_2 is not natural in TGD framework and is replaced with a notion consistent with the infinite-dimensional symmetries of TGD assignable to the light-cone boundary and to light-like 3-surfaces which play key role in TGD.

3. ZESs are superpositions of deterministic classical time evolutions connecting passive "lower" boundary P and active "upper" boundary A of CD. The classical deterministic time evolution corresponds to a space-time surface - preferred extremal (PE) - connecting the 3-surfaces at P and A. There are also spinor fields obeying deterministic dynamics dictated by super-conformal symmetry.

4. The active boundary A of CD moves farther away from the passive boundary P by unitary time evolutions inducing de-localization of A. SSR induces localization of A and after it ZES corresponds to single CD. The temporal distance between the tips of CD increases in statistical sense.

   In BSR the roles of A and P change and the former P begins to shift to opposite direction of geometric time. CD however increases in statistical sense all the subjective time. This

increase would correspond to cosmic expansion. Could selves evolve gradually evolve to entire cosmologies? Their energy content would increase. This is not prevented by ZEO: classical conservation laws hold true for all PEs but due to the localizations of CDs energy conservation in quantal sense can be broken slightly.

In Appendix quite recent direct experimental evidence for ZEO provided by experiments of Minev et al [L3] is discussed: a longer discussion can be found at [L3]. These findings allow also to interpret Libet's findings related to the active aspects of consciousness [J1].

Problem #7: What about the physical and possible space-time correlates for cognition and imagination?

1. p-Adic number fields, $p = 1, 2, 3, 5, 7...$ [A1] obtained as completions of rationals emerged to TGD via p-adic mass calculations relying p-adic length scale hypothesis (see `http://tinyurl.com/y3auow4a`) are for several reasons natural candidates for the correlates of cognition. p-Adic topology defined by ultrametric was proposed already by Parisi [B2] to be natural for description of cognition. Non-determinism of p-adic differential equations due to the p-adic pseudo-constants having vanishing derivative but depending on finite number of pinary digits serves as a natural space-time correlate for imagination. Only the regions in which pseudo-constant are genuine constants have real counterparts and are realizable imaginations.

2. p-Adic physics would be a natural correlate for cognition. Correlates of imagination would be space-time sheets obeying the same field equations as real ones. Cognitive representation are discrete and finite and would consist of a discrete sets of point of space-time surface for which imbedding space coordinates belong to an extension of rationals so that they are shared by real and various p-adic space-time sheets.

3. Ramified primes of n-D extension allow product composition as a product of primes of the extension such that the number of these primes is smaller than n with some primes of extension appearing as powers higher than 1. In the case of split primes this number has the maximal value n and for non-split primes the number is 1: the numbers of these two kinds of primes are infinite whereas the number of ramified primes is finite. Furthermore, the p-adic counterparts of polynomials defining space-time surface in M^8 and extension of rationals via their roots have in $O(p) = 0$ approximation multiple roots so that they correspond to critical dynamics for cognition and physics too.

   The quantum criticality of TGD therefore suggests that ramified primes are both cognitively and physically preferred (defining preferred p-adic length scales as kind of set of organisms able to live in symbiosis). Therefore the collection of ramified primes of extension defines a special set. For hierarchies of polynomials obtained by functional composition $P = P_{n_k} \circ P_{n_{k-1}....n_1}$ of irreducible polynomials with the property $P_r(0) = 0$ the ramified primes of all levels are ramified of P and analogous to conserved genes as also the extensions in the hierarchy. One obtains infinite number of evolutionary hierarchies with conserved "genes" having also interpretation as an abstraction hierarchy.

Problem #8: How to understand intelligence and evolution of intelligence?

1. p-Adic number fields allow an infinite number of extensions induced by finite-dimensional extensions of rationals: besides algebraic extensions one can have extensions defined by roots of e. These define a hierarchy in which algebraic complexity increases.

2. The natural interpretation for the increase of the dimension of algebraic extension of rationals is as increase of the complexity of cognition and evolution can be assigned to the increase of extension of rationals. This increase is unavoidable since the number of extensions with dimension larger than given integer n is infinite and those with dimension smaller than n is finite. The value of effective Planck constant $h_{eff}/h_0 = n$ introduced by observations about effects of ELF em fields on brain and proposed to label a hierarchy of dark matters as phases of ordinary matter could correspond to the dimension of extension. The larger the value of n, the large the scale of quantum coherence, and the more complex the living systems in question.

Remark: Shannon formula with the logarithm of probability replaced with the logarithm of the p-adic norm of probability allows negative values of Shannon entropy having interpretation as information associated with the entanglement [L15] (see `http://tinyurl.com/ycxm2tpd`. Ordinary entanglement entropy measures the ignorance about the state of either entangled system.

3. All p-adic numbers fields are needed and this leads to a fusion of reals and the extensions of p-adic number fields induced by given extension of rationals to form an adele [L1, L2] (see `http://tinyurl.com/ycbhse5c`). The hierarchy of adeles defines an evolutionary hierarchy. The dimension $n = h_{eff}/h_0$ of extension serves as a universal "IQ".

4. A physical correlate for ethics is suggestive. Good deeds increase conscious information of the Universe. Bad deeds reduce the conscious information. Bad deeds indeed force secrecy and reduction of conscious information: evil doer does not usually boast with his deeds and unethical acts lead to secrecy.

These question represent only a small fraction of what must be understood. What are the correlates for directed attention, intentionality, emotions, memory, anticipation, qualia, etc..

4   Appendix: Experimental support for ZEO

After writing thsi version of article, I learned about highly interesting experimental results by Minev et al [L3] (see `https://arxiv.org/abs/1803.00545`) providing rather concerete experimental support for ZEO [L3].

4.1   Findings of Minev et al

I encountered a very interesting ScienceDaily article "*Physicists can predict the jumps of Schrdinger's cat (and finally save it)*" (see `http://tinyurl.com/y5lpe2eo`). The experimental findings described in the article are extremely interesting from the point of view provide by TGD inspired quantum measurement theory relying on Zero Energy Ontology (ZEO) and provides a test for it.

In standard quantum measurement theory (Copenhagen interpretation) of Bohr quantum jump is random in the sense that it occurs with predictable probabilities to an eigenstate of the measured observables. Quantum jumps are also instantaneous and their occurrence cannot be predicted and even less prevented - except by monitoring - Zeno effect.

The findings of Minev et al are described in the article "*To catch and reverse a quantum jump mid-flight*" [L3] (see `https://arxiv.org/abs/1803.00545`). The outcome of quantum jump is indeed unpredictable but the time of occurrence is to high degree predictable: there is a detectable warning signal, period of "flight" from the initial to the final state!

A curious feature is that the external signal responsible for the quantum jump can be stopped during the "flight" from the initial to final state. As if the quantum jump is analogous to a domino effect. It is also claimed that the jump can be reversed during flight period by a control signal: if jump has already occurred then one might argue that the control signal induces quantum jump in opposite direction when applied at time which is roughly the mid-time of "flight".

4.2   Direct experimental evidence for ZEO

If the findings by Minev et al are replicable, one is forced to give up the basic assumption of the standard quantum measurement theory stating that state function reductions occur completely randomly and instantaneously. State function reduction (SR) looks like a continuous, deterministic process. Bohr's theory would be dead also officially and one must finally go back to the blackboard and start serious thinking about fundamentals. It took 92 years - almost a century! State function reduction (SR) is definitely more complex phenomenon than predicted by Bohr.

What is most intriguing that SR looks smooth, deterministic classical time evolution although the outcome is not predictable. People loving hidden variables might be happy but better to think about this more precisely before jumping to any conclusions. Authors apply so called quantum trajectory theory to describe the findings [B3] and report that the model is able to predict the parameters of the parameterization with one per cent accuracy.

Zero energy ontology (ZEO) based view about quantum measurement and the relationship between geometric and subjective time explains why state function reduction looks like a deterministic process. Unfortunately, what ZEO is, is not completely clear [L4]. This allows to consider two options.

1. Both options imply that one can apparently anticipate quantum jump. This could be however an illusion: the observed classical time evolution could occur *after* the quantum jump in opposite direction of time. The fact that the absence of the signal inducing quantum jump does not affect the occurrence of quantum jump suggests that the "flight" period indeed represents the classical evolution after the quantum jump in the reversed direction of time so that the absence of the external signal would not anymore affect the situation.

   The most plausible interpretation for the control signal apparently stopping the reduction process is that it induces the reversal of the quantum jump already occurred. A careful analysis to distinguish between subjective and geometric time and arrows of time for the observer and atom would be needed.

2. The more conventional option nearer to the interpretation of experimenters is that the observed time evolution occurs *before* the quantum jump in standard direction. The period before quantum jump consists of a sequence of "small" state function reductions - "weak" measurements. $M^8 - H$ duality suggests a concrete assignment of the moments of time to them [?]nd there would be also the last moment of this kind. After these things proceed to "big" state function reduction in analogy with domino effect. It is not however obvious why the classical time evolution should appear to converge to the final outcome deterministically so that this option does not look plausible.

Interestingly, the Libet's findings that conscious decision is preceded by neural activity [J1] could be interpreted in the same manner. Free will would not be an illusion anymore. Rather, the time reversed deterministic and smooth geometric time evolution starting from the final state of act of free will (index finger raised) would lead to brain state in geometric past apparently giving rise to the raising of the index finger. The crucial point would be the fact that there are two times: subjective time and geometric time.

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