

Re-examination of the basic notions of TGD inspired theory of consciousness

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December 7, 2017

Abstract

TGD inspired theory of consciousness is based on certain basic assumptions such as the identification of state function reduction as a measurement of universal observable identified density matrix characterizing entanglement and Negentropy Maximization Principle (NMP) as fundamental principle. Both the adelic approach and the notion of “World of Classical Worlds” (WCW) force to challenge these assumptions.

1. Adelic approach strongly suggests the reduction of NMP to number theoretic physics somewhat like second law reduces to probability theory: there would be no need to postulate NMP as a separate principle and NMP would hold true only in statistical sense so that we would not live in the best possible world as strongest form of NMP would imply. The dimension of the extension rationals characterizing the hierarchy level of physics and defined an observable measured in state function reductions is positive and can only increase in statistical sense. Therefore the maximal value of entanglement negentropy increases as new entangling number theoretic degrees of freedom emerge. $h_{eff}/h = n$ identifiable as factor of Galois group of extension characterizes the number of these degrees of freedom for given space-time surfaces as number of its sheets.
2. State function reduction is hitherto assumed to correspond always to a measurement of density matrix which can be seen as a reaction of subsystem to its environment. This makes perfect sense at space-time level. Higher level measurements occur however at the level of WCW and correspond to a localization to some sector of WCW determining for instance the quantization axes of various quantum numbers. Even the measurement of $h_{eff}/h = n$ would measure the dimension of Galois group and force a localization to an extension with Galois group with this dimension. These measurements cannot correspond to measurements of density matrix since different WCW sectors cannot entangle by WCW locality.

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1 Introduction

TGD inspired theory of consciousness is based on certain basic assumptions such as the identification of state function reduction as a measurement of universal observable identified density matrix characterizing entanglement and Negentropy Maximization Principle (NMP) as fundamental principle. Both the adelic approach and the notion of “World of Classical Worlds” (WCW) force to challenge these assumptions.

1.1 Do all state function reductions correspond to measurements of density matrix?

The earlier approach has assumed that state function reduction always corresponds to a measurement of density matrix serving as a universal observable. Measurement of density matrix allows to measure simultaneously arbitrary number of commuting observables by assuming to be a function of product of measured commuting observables represented as matrices. This makes sense at space-time level but at the level of WCW one encounters difficulties. For instance, the choice of quantization axis corresponds to a higher level choice localization to a sector of WCW with moduli characterizing this choice. Also the measurement of $h_{eff}/h = n$ measuring the dimension of Galois group would make sense and force a localization to an extension with Galois group with this dimension. Single entanglement between different points of WCW is not possible (WCW spinor field is analogous to classical spinor describing single particle state and no second quantization is assumed at the level of WCW and one has complete locality), this selection cannot correspond to a measurement of density matrix.

But is the measurement of density matrix really the only possible quantum measurement and does it correspond to act of goal directed intentional free will? Density matrix characterizes entanglement with environment. Is the measurement of density matrix only a reaction: a choice amongst given alternatives. Eastern philosophers make a sharp distinction between real intentional action and mere reaction. For instance, Krishnamurti talks a lot about this and sees that basically all problems of human kind is that we have not been able to transcend to the level at which our actions would be more than reactions.

Genuine intentional actions would very naturally correspond to self measurements realized as WCW localities such as fixing the quantization axis, or selecting the extension of rationals defining particular evolutionary level of adelic hierarchy, or choosing the boundary of CD at which state function reductions occur (arrow of geometric time) are possible.

1.2 Is NMP a fundamental principle or does it follow from adelic physics?

NMP has been regarded as a fundamental principle of TGD inspired theory of consciousness. Adelic approach however strongly suggests the reduction of NMP to number theoretic physics somewhat like second law reduces to probability theory: there would be no need to postulate NMP as a separate principle and NMP would hold true only in statistical sense so that we would not live in the best possible world as strongest form of NMP would imply. The dimension of the extension rationals characterizing the hierarchy level of physics and defined an observable measured in state function reductions is positive and can only increase in statistical sense. Therefore the maximal value of entanglement negentropy increases as new entangling number theoretic degrees of freedom emerge. $h_{eff}/h = n$ identifiable as factor of Galois group of extension characterizes the number of these degrees of freedom for given space-time surfaces as number of its sheets.

This forces to re-think what happens in the state function reduction in which the passive boundary of state function reduction becomes opposite boundary meaning death of self and its re-incarnation as time-reversed self: this reduction has been seen as strongest support for NMP as fundamental principle rather than consequence of adelic physics. The new view relies of the observation that the states at passive boundary are eigenstates of some observables, call them passive observables. The reductions at active boundary must correspond to measurements of observables commuting with the passive observables. Self as a generalized Zeno effect can live

only as long as it is able to measure observables commuting with the passive ones. The increase the dimension of extension of rationals in unitary time evolutions between reductions - number theoretic evolution - could generate new observables commuting with the passive observables. Self lives as long as it evolves.

In the sequel I describe briefly the basic of TGD inspired theory of consciousness as generalization of quantum measurement theory to ZEO (ZEO), describe the definition of self, consider the question whether NMP is needed as a separate principle or whether it is implied is in statistical sense by the unavoidable statistical increase of $n = h_{eff}/h$ if identified as a factor of the dimension of Galois group extension of rationals defining the adeles, and finally summarize the vision about how p-adic physics serves as a correlate of cognition and imagination.

In the sequel I will use some shorthand notations for key principles and notions. General Coordinate Invariance (GCI); World of Classical Worlds (WCW); Strong Form of GCI (SGCI); Strong Form of Holography (SH); Preferred Extremal (PE); Zero Energy Ontology (ZEO); Negentropy Maximization Principle (NMP); Negentropic entanglement (NE) are the most often occurring acronyms.

2 From quantum measurement theory to a theory of consciousness

The notion of self can be seen as a generalization of the poorly defined definition of the notion of observer in quantum physics. In the following I take the role of skeptic trying to be as critical as possible.

The original definition of self was as a subsystem able to remain unentangled under state function reductions associated with subsequent quantum jumps. The density matrix was assumed to define the universal observable. Note that a density matrix, which is power series of a product of matrices representing commuting observables has in the generic case eigenstates, which are simultaneous eigenstates of all observables. Second aspect of self was assumed to be the integration of subsequent quantum jumps to coherent whole giving rise to the experienced flow of time.

2.1 Self as generalized Zeno effect

The precise identification of self allowing to understand both of these aspects turned out to be difficult problem. I became aware the solution of the problem in terms of ZEO (ZEO) only rather recently (2014).

1. Self corresponds to a sequence of quantum jumps integrating to single unit as in the original proposal, but these quantum jumps correspond to state function reductions to a fixed boundary of causal diamond CD leaving the corresponding parts of zero energy states invariant - "small" state function reductions. The parts of zero energy states at second boundary of CD change and even the position of the tip of the opposite boundary changes: one actually has wave function over positions of second boundary (CD sizes roughly) and this wave function changes. In positive energy ontology these repeated state function reductions would have no effect on the state (Zeno effect) but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and self: self is generalized Zeno effect.
2. The first quantum jump to the opposite boundary corresponds to the act of "free will" or birth of re-incarnated self. Hence the act of "free will" changes the arrow of psychological time at some level of hierarchy of CDs. The first reduction to the opposite boundary of CD means "death" of self and "re-incarnation" of time-reversed self at opposite boundary at which the the temporal distance between the tips of CD increases in opposite direction. The sequence of selves and time reversed selves is analogous to a cosmic expansion for CD. The repeated birth and death of mental images could correspond to this sequence at the level of sub-selves.
3. This allows to understand the relationship between subjective and geometric time and how the arrow of and flow of clock time (psychological time) emerge. The average distance

between the tips of CD increases on the average as long as state function functions occur repeatedly at the fixed boundary: situation is analogous to that in diffusion. The localization of contents of conscious experience to boundary of CD gives rise to the illusion that universe is 3-dimensional. The possibility of memories made possibly by hierarchy of CDs demonstrates that this is not the case. Self is simply the sequence of state function reductions at same boundary of CD remaining fixed and the lifetime of self is the total growth of the average temporal distance between the tips of CD.

2.2 State function reductions at the level of WCW

One can identify several rather abstract state function reductions selecting a sector of WCW.

1. There are quantum measurements inducing localization in the moduli space of CDs with passive boundary and states at it fixed. In particular, a localization in the moduli characterizing the Lorentz transform of the upper tip of CD would be measured. The measured moduli characterize also the analog of symplectic form in M^4 strongly suggested by twistor lift of TGD - that is the rest system (time axis) and spin quantization axes. Of course, also other kinds of reductions are possible.
2. Also a localization to an extension of rationals defining the adeles should occur. Could the value of $n = h_{eff}/h$ be observable? The value of n for given space-time surface at the active boundary of CD could be identified as the order of the smallest Galois group containing all Galois groups assignable to 3-surfaces at the boundary. The superposition of space-time surface would not be eigenstate of n at active boundary unless localization occurs. It is not obvious whether this is consistent with a fixed value of n at passive boundary.

The measured value of n could be larger or smaller than the value of n at the passive boundary of CD but in statistical sense n would increase by the analogy with diffusion on half line defined by non-negative integers. The distance from the origin unavoidably increases in statistical sense. This would imply evolution as increase of maximal value of negentropy and generation of quantum coherence in increasingly longer scales.

3. A further abstract choice corresponds to the replacement of the roles of active and passive boundary of CD changing the arrow of clock time and correspond to a death of self and re-incarnation as time-reversed self.

2.3 Can the reductions at the level of WCW reduce to measurements of density matrix?

Can one assume that these measurements reduce to measurements of a density matrix of either entangled system as assumed in the earlier formulation of NMP, or should one allow both options. This question actually applies to all quantum measurements and leads to a fundamental philosophical questions unavoidable in all consciousness theories.

1. Do all measurements involve entanglement between the moduli or extensions of two CDs reduced in the measurement of the density matrix? Non-diagonal entanglement would allow final states states, which are not eigenstates of moduli or of n : this looks strange. This could also lead to an infinite regress since it seems that one must assume endless hierarchy of entangled CDs so that the reduction sequence would proceed from top to bottom. It looks natural to regard single CD as a sub-Universe.

For instance, if a selection of quantization axis of color hypercharge and isospin (localization in the twistor space of CP_2) is involved, one would have an outcome corresponding to a quantum superposition of measurements with different color quantization axis!

Going philosophical, one can also argue, that the measurement of density matrix is only a reaction to environment and does not allow intentional free will.

2. Can one assume that a mere localization in the moduli space or for the extension of rationals (producing an eigenstate of n) takes place for a fixed CD - a kind of self measurement possible

for even unentangled system? If there is entanglement in these degrees of freedom between two systems (say CDs), it would be reduced in these self measurements but the outcome would not be an eigenstate of density matrix. An interpretation as a realization of intention would be appropriate.

3. If one allows both options, the interpretation would be that state function reduction as a measurement of density matrix is only a reaction to environment and self-measurement represents a realization of intention.
4. Self measurements would occur at higher level say as a selection of quantization axis, localization in the moduli space of CD, or selection of extension of rationals. A possible general rule is that measurements at space-time level are reactions as measurements of density matrix whereas a selection of a sector of WCW would be an intentional action. This because formally the quantum states at the level of WCW are as modes of classical WCW spinor field single particle states.
5. If the selections of sectors of WCW at active boundary of CD commute with observables, whose eigenstates appear at passive boundary (briefly *passive observables*) meaning that time reversal commutes with them - they can occur repeatedly during the reduction sequence and self as a generalized Zeno effect makes sense.

If the selections of WCW sectors at active boundary do not commute with passive observables then volition as a choice of sector of WCW must change the arrow of time. Libet's findings show that conscious choice induces neural activity for a fraction of second before the conscious choice. This would imply the correspondences "*big*" measurement changing the arrow of time - self-measurement at the level of WCW - intentional action and "*small*" measurement - measurement at space-time level - reaction.

Self as a generalized Zeno effect makes sense only if there are active commuting with passive observables. If the passive observables form a maximal set, the new active observables commuting with them must emerge. The increase of the size of extension of rationals might generate them by expanding the state space so that self would survive only as long as it evolves.

Otherwise there would be only single unitary time evolution followed by a reduction to opposite boundary. This makes sense only if the sequence of "big" reductions for sub-selves can give rise to the time flow experienced by self: the birth and death of mental images would give rise to flow of time of self.

A hierarchical process starting from given CD and proceeding downwards to shorter scales and stopping when the entanglement is stable is highly suggestive and favors self measurements. CDs would be a correlate for self hierarchy. One can say also something about the anatomy and correlates of self hierarchy.

1. Self experiences its sub-selves as mental images and even we would represent mental images of some higher level collective self. Everything is conscious but consciousness can be lost or at least it is not possible to have memory about it. The flow of consciousness for a given self could be due to the quantum jump sequences performed by its sub-selves giving rise to mental images.
2. By quantum classical correspondence self has also space-time correlates. One can visualize sub-self as a space-time sheet "glued" by topological sum to the space-time sheet of self. Subsystem is not described as a tensor factor as in the standard description of subsystems. Also sub-selves of selves can entangle negentropically and this gives rise to a sharing of mental images about which stereo vision would be basic example. Quite generally, one could speak of stereo consciousness. Also the experiences of sensed presence [J2] could be understood as a sharing of mental images between brain hemispheres, which are not themselves entangled. This is possible also between different brains. In the normal situation brain hemispheres are entangled.

3. At the level of 8-dimensional imbedding space the natural correlate of self would be CD (causal diamond). At the level of space-time the correlate would be space-time sheet or light-like 3-surface. The contents of consciousness of self would be determined by the space-time sheets in the interior of CD. Without further restrictions the experience of self would be essentially four-dimensional. Memories would be like sensory experiences except that they would be about the geometric past and for some reason are not usually colored by sensory qualia. For instance .1 second time scale defining sensory chronon corresponds to the secondary p-adic time scale characterizing the size of electron's CD (Mersenne prime M_{127}), which suggests that Cooper pairs of electrons are essential for the sensory qualia.

The above argument states that the measurements at the level of WCW cannot be regarded as measurements of a density matrix since no second quantization at level of WCW is carried out. About a year after developing this argument I realized that the hierarchy of infinite primes suggests an infinite hierarchy of second quantizations. Could the counterpart for the hierarchy of infinite primes be realized at WCW level automatically? One can indeed interpret the measurements at WCW as either localizations or as reductions of entanglement between states associated with different points of WCW. The point is that the disjoint union of 3-surfaces X^3 and Y^3 can be regarded either as a pair (X^3, Y^3) of 3-surfaces in $WCW \times WCW$ or as a 3-surface $Z^3 = X^3 \cup Y^3 \subset WCW$. The general identity behind this duality $WCW = WCW \times WCW = \dots = WCW^n = \dots$

One could think the situation in terms of $(X^3, Y^3) \in WCW \times WCW$ in which case one can speak of entanglement between WCW spinor modes associated with X^3 and Y^3 reduced by the measurement of density matrix. Second interpretation as a localization of wave function of $Z^3 = X^3 \cup Y^3 \in WCW$.

2.4 Experimental support for the relative arrow of time

It has been found that the arrow of time is relative [?] (see <http://tinyurl.com/yatp6dum>). Expressing this in more cautious terms, heat can flow from from system with temperature T_1 to a system with temperature $T_2 > T_1$ if there is correlation between the two systems meaning that the density matrix for the two nuclear systems (samples consisting of hydrogen atoms and carbon atoms) is not mere tensor product of density matrices but contains an additional term describing correlation. It must be emphasized that this finding is not in conflict with the standard view about second law which only says that heat flows from system with higher temperature to that with lower temperature provided that there are no correlations between the systems.

The argument runs as follows. The mutual information for the uncorrelated systems vanishes, and since it can only increase this implies flow of heat in the standard direction. If the mutual information is non-vanishing in the initial situation (due to the correlation) it can also decrease and this can give a heat flow in non-standard direction. This has been observed.

Although one can model the finding using standard thermodynamics, one can ask whether something deeper might be involved. Should one be cautious and talk only about the changing direction of heat flow due to the breaking of the basic assumptions of thermodynamics, and avoid speaking about direction of thermodynamical time? Or could a genuine change of the arrow of time take place? Going even deeper, one must ask what thermodynamical time, the time of physicist (geometric time), and the arrow of time do really mean? What is the relationship between these two times? This leads to ponder questions about the basics of quantum measurement theory and here I can only consider TGD based vision [L2].

1. The basic prediction of zero energy ontology (ZEO) is that the arrow of geometric time can have both signs whereas the arrow of subjective time (relating closely to thermodynamic time) defined by experience created by sequence of state function reductions is always the same. The arrow of geometric time is indeed relative. The flow of geometric time corresponds to the increase of distance between tips of causal diamond (CD) and the increase in particular reduction is at either tip of CD and in this manner defines arrow of time. CD grows either "upwards" or "downwards". A geometric measure for experienced time is that distance between the tips of CD which always increases.

Time reflection symmetry (T) with respect to the center of CD is broken in TGD: the classical time evolutions of space-time surfaces are not T mirror images of each other. This is true also

for the quantal evolutions defined by zero energy states essentially as quantum superpositions of classical evolutions. States and their time reversals obey the initial conditions at opposite boundaries of CD. Arrow of time is forced by the place (either boundary of CD), where initial conditions are posed, not by the initial conditions themselves.

2. One must however remember that ZEO describes genuine quantum systems whereas thermodynamics describes ensemble, which is a highly idealized notion. In ZEO arrow of geometric time would change in each "big" quantum jump and would remain the same during the sequence of "small" state function reductions defining the counterpart of Zeno effect or weak measurement.
3. Initial conditions breaking the basic assumptions of thermodynamics induce correlations and the heat flow in "wrong" direction in the model for the finding. The arrow of time is claimed to be changed in time interval of length of order 2 millisecond. Interestingly, millisecond happens to characterize the time scale of nerve pulse and ZEO predicts that in living matter the change of the arrow of time takes place routinely. In ZEO based description the growth of the temporal distance between the tips of CD would be of order 2 milliseconds.

It would be however the opposite boundary of CD in geometric past that would recede farther away. One can argue that it is not possible to measure the position of the past boundary of CD directly. But is it possible to measure the distance between the tips of CD indirectly from the behavior of the ensemble? ZEO would suggest that the time appearing in the Hamiltonian modelling the system corresponds to the distance between tips of CD and never decreases. The change of the direction of heat flow would correspond to the reduction to the original boundary of CD in the experiment and the correlation would make ZEO visible.

If the two descriptions are equivalent, the initial correlations for the ensemble force should correspond to posing initial conditions at the non-standard boundary of CD leading to the reversal of the arrow of time. The very act of posing the correlations would correspond to a "big" state function reduction to opposite boundary of CD. In standard quantum measurement theory state preparation indeed corresponds to this state function reduction so that the two descriptions might be consistent.

3 NMP and self

The view about Negentropy Maximization Principle (NMP) [K2] has co-evolved with the notion of self and I have considered many variants of NMP.

1. The original formulation of NMP was in positive energy ontology and made same predictions as standard quantum measurement theory. The new element was that the density matrix of sub-system defines the fundamental observable and the system goes to its eigenstate in state function reduction. As found, the localizations at to WCW sectors define what might be called self-measurements and identifiable as active volitions rather than reactions.
2. In p-adic physics one can assign with rational and even algebraic entanglement probabilities number theoretical entanglement negentropy (NEN) satisfying the same basic axioms as the ordinary Shannon entropy but having negative values and therefore having interpretation as information. The definition of p-adic negentropy (real valued) reads as $S_p = -\sum P_k \log(|P_k|_p)$, where $|\cdot|_p$ denotes p-adic norm. The news is that $N_p = -S_p$ can be positive and is positive for rational entanglement probabilities. Real entanglement entropy S is always non-negative.

NMP would force the generation of negentropic entanglement (NE) and stabilize it. NNE resources of the Universe - one might call them Akashic records- would steadily increase.

3. A decisive step of progress was the realization is that NTU forces all states in adelic physics to have entanglement coefficients in some extension of rationals inducing finite-D extension of p-adic numbers. The same entanglement can be characterized by real entropy S and p-adic negentropies N_p , which can be positive. One can define also total p-adic negentropy: $N = \sum_p N_p$ for all p and total negentropy $N_{tot} = N - S$.

For rational entanglement probabilities it is easy to demonstrate that the generalization of adelic theorem holds true: $N_{tot} = N - S = 0$. NMP based on N_{tot} rather than N would not say anything about rational entanglement. For extensions of rationals it is easy to find that $N - S > 0$ is possible if entanglement probabilities are of form X_i/n with $|X_i|_p = 1$ and n integer [L1]. Should one identify the total negentropy as difference $N_{tot} = N - S$ or as $N_{tot} = N$?

Irrespective of answer, large p-adic negentropy seems to force large real entropy: this nicely correlates with the paradoxical finding that living systems tend to be entropic although one would expect just the opposite [L1]: this relates in very interesting manner to the work of biologist Jeremy England [II]. The negentropy would be cognitive negentropy and not visible for ordinary physics.

4. The latest step in the evolution of ideas NMP was the question whether NMP follows from number theory alone just as second law follows from probability theory! This irritates theoretician's ego but is victory for theory. The dimension n of extension is positive integer and cannot but grow in statistical sense in evolution! Since one expects that the maximal value of negentropy (define as $N - S$) must increase with n . Negentropy must increase in long run.

3.1 Number theoretic entanglement can be stable

Number theoretical Shannon entropy can serve as a measure for genuine information assignable to a pair of entanglement systems [K2]. Entanglement with coefficients in the extension is always negentropic if entanglement negentropy comes from p-adic sectors only. It can be negentropic if negentropy is defined as the difference of p-adic negentropy and real entropy.

The diagonalized density matrix need not belong to the algebraic extension since the probabilities defining its diagonal elements are eigenvalues of the density matrix as roots of N :th order polynomial, which in the generic case requires n -dimensional algebraic extension of rationals. One can argue that since diagonalization is not possible, also state function reduction selecting one of the eigenstates is impossible unless a phase transition increasing the dimension of algebraic extension used occurs simultaneously. This kind of NE could give rise to cognitive entanglement.

There is also a special kind of NE, which can result if one requires that density matrix serves a universal observable in state function reduction. The outcome of reduction must be an eigen space of density matrix, which is projector to this subspace acting as identity matrix inside it. This kind NE allows all unitarily related basis as eigenstate basis (unitary transformations must belong to the algebraic extension). This kind of NE could serve as a correlate for "enlightened" states of consciousness. Schrödinger's cat is in this kind of state stably in superposition of dead and alive and state basis obtained by unitary rotation from this basis is equally good. One can say that there are no discriminations in this state, and this is what is claimed about "enlightened" states too.

The vision about number theoretical evolution suggests that NMP forces the generation of NE resources as NE assignable to the "passive" boundary of CD for which no changes occur during sequence of state function reductions defining self. It would define the unchanging self as negentropy resources, which could be regarded as kind of Akashic records. During the next "re-incarnation" after the first reduction to opposite boundary of CD the NE associated with the reduced state would serve as new Akashic records for the time reversed self. If NMP reduces to the statistical increase of $h_{eff}/h = n$ the consciousness information contents of the Universe increases in statistical sense. In the best possible world of SNMP it would increase steadily.

3.2 Does NMP reduce to number theory?

The heretic question that emerged quite recently is whether NMP is actually needed at all! Is NMP a separate principle or could NMP reduced to mere number theory [K2]? Consider first the possibility that NMP is not needed at all as a separate principle.

1. The value of $h_{eff}/h = n$ should increase in the evolution by the phase transitions increasing the dimension of the extension of rationals. $h_{eff}/h = n$ has been identified as the number of sheets of some kind of covering space. The Galois group of extension acts on number theoretic

discretizations of the monadic surface and the orbit defines a covering space. Suppose n is the number of sheets of this covering and thus the dimension of the Galois group for the extension of rationals or factor of it.

2. It has been already noticed that the “big” state function reductions giving rise to death and reincarnation of self could correspond to a measurement of $n = h_{eff}$ implied by the measurement of the extension of the rationals defining the adeles. The statistical increase of n follows automatically and implies statistical increase of maximal entanglement negentropy. Entanglement negentropy increases in statistical sense.

The resulting world would not be the best possible one unlike for a strong form of NMP demanding that negentropy does increase in “big” state function reductions. n also decrease temporarily and they seem to be needed. In TGD inspired model of bio-catalysis the phase transition reducing the value of n for the magnetic flux tubes connecting reacting bio-molecules allows them to find each other in the molecular soup. This would be crucial for understanding processes like DNA replication and transcription.

3. State function reduction corresponding to the measurement of density matrix could occur to an eigenstate/eigenspace of density matrix only if the corresponding eigenvalue and eigenstate/eigenspace is expressible using numbers in the extension of rationals defining the adèle considered. In the generic case these numbers belong to N -dimensional extension of the original extension. This can make the entanglement stable with respect to state the measurements of density matrix.

A phase transition to an extension of an extension containing these coefficients would be required to make possible reduction. A step in number theoretic evolution would occur. Also an entanglement of measured state pairs with those of measuring system in containing the extension of extension would make possible the reduction. Negentropy could be reduced but higher-D extension would provide potential for more negentropic entanglement and NMP would hold true in the statistical sense.

4. If one has higher-D eigen space of density matrix, p-adic negentropy is largest for the entire subspace and the sum of real and p-adic negentropies vanishes for all of them. For negentropy identified as total p-adic negentropy SNMP would select the entire sub-space and NMP would indeed say something explicit about negentropy.

3.3 Or is NMP needed as a separate principle?

Hitherto I have postulated NMP as a separate principle [K2]. Strong form of NMP (SNMP) states that Negentropy does not decrease in “big” state function reductions corresponding to death and re-incarnations of self.

One can however argue that SNMP is not realistic. SNMP would force the Universe to be the best possible one, and this does not seem to be the case. Also ethically responsible free will would be very restricted since self would be forced always to do the best deed that is increase maximally the negentropy serving as information resources of the Universe. Giving up separate NMP altogether would allow to have also “Good” and “Evil”.

This forces to consider what I christened weak form of NMP (WNMP). Instead of maximal dimension corresponding to N -dimensional projector self can choose also lower-dimensional sub-spaces and 1-D sub-space corresponds to the vanishing entanglement and negentropy assumed in standard quantum measurement theory. As a matter fact, this can also lead to larger negentropy gain since negentropy depends strongly on what is the large power of p in the dimension of the resulting eigen sub-space of density matrix. This could apply also to the purely number theoretical reduction of NMP.

WNMP suggests how to understand the notions of Good and Evil. Various choices in the state function reduction would correspond to Boolean algebra, which suggests an interpretation in terms of what might be called emotional intelligence [K3]. Also it turns out that one can understand how p-adic length scale hypothesis - actually its generalization - emerges from WNMP [K4].

1. One can start from ordinary quantum entanglement. It corresponds to a superposition of pairs of states. Second state corresponds to the internal state of the self and second state

to a state of external world or biological body of self. In negentropic quantum entanglement each is replaced with a pair of sub-spaces of state spaces of self and external world. The dimension of the sub-space depends on which pair is in question. In state function reduction one of these pairs is selected and deed is done. How to make some of these deeds good and some bad? Recall that WNMP allows only the possibility to generate NNE but does not force it. WNMP would be like God allowing the possibility to do good but not forcing good deeds.

Self can choose any sub-space of the subspace defined by $k \leq N$ -dimensional projector and 1-D subspace corresponds to the standard quantum measurement. For $k = 1$ the state function reduction leads to vanishing negentropy, and separation of self and the target of the action. Negentropy does not increase in this action and self is isolated from the target: kind of price for sin.

For the maximal dimension of this sub-space the negentropy gain is maximal. This deed would be good and by the proposed criterion NE corresponds to conscious experience with positive emotional coloring. Interestingly, there are $2^k - 1$ possible choices, which is almost the dimension of Boolean algebra consisting of k independent bits. The excluded option corresponds to 0-dimensional sub-space - empty set in set theoretic realization of Boolean algebra. This could relate directly to fermionic oscillator operators defining basis of Boolean algebra - here Fock vacuum would be the excluded state. The deed in this sense would be a choice of how loving the attention towards system of external world is.

2. A map of different choices of k -dimensional sub-spaces to k -fermion states is suggestive. The realization of logic in terms of emotions of different degrees of positivity would be mapped to many-fermion states - perhaps zero energy states with vanishing total fermion number. State function reductions to k -dimensional spaces would be mapped to k -fermion states: quantum jumps to quantum states!

The problem brings in mind quantum classical correspondence in quantum measurement theory. The direction of the pointer of the measurement apparatus (in very metaphorical sense) corresponds to the outcome of state function reduction, which is now 1-D subspace. For ordinary measurement the pointer has k positions. Now it must have $2^k - 1$ positions. To the discrete space of k pointer positions one must assign fermionic Clifford algebra of second quantized fermionic oscillator operators. The hierarchy of Planck constants and dark matter suggests the realization. Replace the pointer with its space-time k -sheeted covering and consider zero energy energy states made of pairs of k -fermion states at the sheets of the n -sheeted covering? Dark matter would be therefore necessary for cognition. The role of fermions would be to “mark” the k space-time sheets in the covering.

The cautious conclusion is that NMP as a separate principle is not necessary and follows in statistical sense from the unavoidable increase of $n = h_{eff}/h$ identified as dimension of extension of rationals define the adeles if this extension or at least the dimension of its Galois group is observable.

4 p-Adic physics as correlate of cognition and imagination

The items in the following list give motivations for the proposal that p-adic physics could serve as a correlate for cognition and imagination.

1. By the total disconnectedness of the p-adic topology, p-adic world decomposes naturally into blobs, objects. This happens also in sensory perception. The binary digits of p-adic number can be assigned to a p -tree. Parisi proposed in the model of spin glass [B1] that p-adic numbers could relate to the mathematical description of cognition and also Khrennikov [J1] has developed this idea. In TGD framework that idea is taken to space-time level: p-adic space-time sheets represent thought bubbles and they correlate with the real ones since they form cognitive representations of the real world. SH allows a concrete realization of this.

2. p-Adic non-determinism due to p-adic pseudo constants suggests interpretation in terms of imagination. Given 2-surfaces could allow completion to p-adic preferred extremal but not to a real one so that pure “non-realizable” imagination is in question.
3. Number theoretic negentropy has interpretation as negentropy characterizing information content of entanglement. The superposition of state pairs could be interpreted as a quantum representation for a rule or abstracted association containing its instances as state pairs. Number theoretical negentropy characterizes the relationship of two systems and should not be confused with thermodynamical entropy, which characterizes the uncertainty about the state of single system.

The original vision was that p-adic non-determinism could serve as a correlate for cognition, imagination, and intention. The recent view is much more cautious. Imagination need not completely reduce to p-adic non-determinism since it has also real physics correlates - maybe as partial realizations of SH as in nerve pulse pattern, which does not propagate down to muscles.

A possible interpretation for the solutions of the p-adic field equations would be as geometric correlates of cognition, imagination, and perhaps even intentionality. Plans, intentions, expectations, dreams, and possibly also cognition as imagination in general could have p-adic cognitive space-time sheets as their geometric correlates. A deep principle seems to be involved: incompleteness is the characteristic feature of p-adic physics but the flexibility made possible by this incompleteness is absolutely essential for imagination and cognitive consciousness in general.

The most feasible view is that the intersections of p-adic and real space-time surfaces define cognitive representations of real space-time surfaces (PEs, [K1, K5, K6]). One could also say that real space-time surface represents sensory aspects of conscious experience and p-adic space-time surfaces its cognitive aspects. Both real and p-adics rather than real or p-adics.

The identification of p-adic pseudo constants as correlates of imagination at space-time level is indeed a further natural idea.

1. The construction of PEs by SH from the data at 2-surfaces is like boundary value problem with number theoretic discretization of space-time surface as additional data. PE property in real context implies strong correlations between string world sheets and partonic 2-surfaces by boundary conditions a them. One cannot choose these 2-surfaces completely independently in real context.
2. In p-adic sectors the integration constants are replaced with pseudo-constants depending on finite number of binary digits of variables depending on coordinates normal to string world sheets and partonic 2-surfaces. The fixing of the discretization of space-time surface would allow to fix the p-adic pseudo-constants. Once the number theoretic discretization of space-time surface is fixed, the p-adic pseudo-constants can be fixed. Pseudo-constant could allow a large number of p-adic configurations involving string world sheets, partonic 2-surfaces, and number theoretic discretization but not allowed in real context.

Could these p-adic PEs correspond to imaginations, which in general are not realizable? Could the realizable intentional actions belong to the intersection of real and p-adic WCWs? Could one identify non-realistic imaginations as the modes of WCW spinor fields for which 2-surfaces are not extendable to real space-time surfaces and are localized to 2-surfaces? Could they allow only a partial continuation to real space-time surface. Could nerve pulse pattern representing imagined motor action and not proceeding to the level of muscles correspond to a partially real PE?

Could imagination and problem solving be search for those collections of string world sheets and partonic 2-surfaces, which allow extension to (realization as) real PEs? If so, p-adic physics would be there as an independent aspect of existence and this is just the original idea. Imagination could be realized in state function reduction, which always selects only those 2-surfaces, which allow continuation to real space-time surfaces. The distinction between only imaginable and also realizable would be the extendability by using strong form of holography.

3. An interesting question is why elementary particles are characterized by preferred p-adic primes (primes near powers of 2, in particular Mersenne primes). Could the number of realizable imaginations for these primes be especially large? Quite generally, those extensions

for which the number of realizable imaginations is maximal would be the fittest in number theoretic fight for survival. The ramified primes assigned to these extensions would in turn define the preferred p-adic primes. An open question is what are the fittest extensions and whether the p-adic primes coming as powers of two or of small primes are associated with these extensions.

I have the feeling that this view allows respectable mathematical realization of imagination in terms of adelic quantum physics. It is remarkable that SH derivable from - you can guess, strong form of General Coordinate Invariance (Einstein again!), plays an absolutely central role in it.

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