About the number theoretic aspects of zero energy ontology

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Abstract

The interaction between number theoretic vision, ZEO, and the TGD view DNA enriches all of them. In this article the recent view about quantum measurements is discussed in light of the recent progress in the understanding of the number theoretic aspects of TGD.

By $M^8 - H$ duality space-time regions would be determined by polynomials whose roots define in $M^4 \subset M^8$ 3-D mass shells providing the data for holography fixing the space-time surfaces. Whether product polynomials besides irreducible polynomials should be allowed has been an open question. The product polynomials could naturally correspond to free states unable to entangle. The functional composition was earlier interpreted as formation of many-particle states but perhaps a more natural interpretation is as a generation of sheets of the many-sheeted space-time with interactions having wormhole contacts as geometric correlates.

This modified picture leads to a re-analysis of state function reduction (SFR), in particular the notions of "big" SFR and "small" SFR from a number theoretic perspective. This leads to a more precise view about the notion of time and time evolution. The emerging picture can be applied to TGD inspired theory of consciousness, in particular various aspects related to the notion of time and memory.

Contents

1 Introduction

The interaction between number theoretic vision, ZEO, and the TGD view DNA enriches all of them. In this article the recent view about quantum measurements is discussed in light of the recent progress in the understanding of the number theoretic aspects of TGD [L6, L7].

1.1 $M^8 - H$ duality and classical non-determinism

The progress in the understanding of $M^8 - H$ duality serves as a strong motivation for looking ZEO from the number theoretic perspective.

$M^8 - H$ duality [L6, L7] is a central piece of the number theoretic picture. $M^8 - H$ duality involves the map of a 4-D surface of M^8 to H determininming holography in terms of the associativity of the normal space of the space-time surface. The realization of holography determine the 4-surface of M^8 by using the 3-D mass shells of $H^3 \subset M^4_c \subset M^8_c$ determined as roots of a polynomial serve as holographic data.

$M^8 - H$ duality is not a mere geometric map. Uncertainty Principle requires that the counterpart of CD in M^8 is mapped to a superposition of CDs as a plane wave for which the role of position coordinate is taken by the center of CD in M^4.

1. The CDs involved have the same center and the roots correspond to mass shells and their H-images to proper time $a = constant$ hyperboloids of M^4 such that proper time coordinate is essentially $a = h_{eff}/m$ for a Galois singlet with integer value momentum and integer value mass squared using as unit the p-adic length scale defined by the largest ramified prime.

   Octonionic associativity condition leads to a selection of a unique origin for the pair of positive and negative energy light-cones in M^8 mapped to pairs of half-cones of CD.

2. The intuitive picture is that also the Poincare transforms of CDs should be allowed. Is this physically acceptable and how could one realize this?

   M^8 corresponds to momentum space so that origin is a special point and coordinates are naturally unique. In M^8 Lorentz transformations are rotations and translations do not act on momenta but multiply Fourier components by phases.

   The $M^8 - H$ duality could map the half-light cones of M^8 with opposite sign of energy to the half-cones of CD. $M^8 - H$ duality is essentially an inversion thye level of momentum space. The value of $h_{eff} = nh_0$ in the inversion would be determined by the polynomial P in question as the order of its Galois group.

   Any point of $M^4 \subset H$ conserve as the origin defining the point of inversion. All choices are possible. The solution of the problem is a quantum superposition of all possible choices that is a plane wave in M^4 for the center of CD. The momentum would be defined by the total momentum assignable to either half-cone of the CD. $M^8 - H$ duality would be between states rather than being purely geometric.

Holography applies also to string worlds sheets, which intersect the mass shells at 1-D curves. The reconnections of string world sheets correspond to self-intersections of the space-time surface and occur at discrete points deterministically for space-time surfaces as preferred extremals (PEs). At the intersection points there is nondeterminism since AC+BD can go to AC+BD or AD+BC. The reconnection gives rise to the basic braiding operation of strings as space-like braid strands.

If $M^8 - H$ duality holds true, polynomials determine space-time regions and the Galois groups define fundamental symmetries of physics. The key questions relate to the interpretation of the

functional composition of polynomials. Second question is whether one can allow product polynomials.

1. Product polynomials are allowed and give a direct connection to particle physics and an intuitive picture about free many-particle states. Fundamental particles would correspond to irreducible monic polynomials with a simple Galois group.

2. The idea that functional decomposition gives many particle states in the usual sense is given up. The functional composition of polynomials would give rise to many-sheeted space-time as a hierarchical structure and connect the number theoretic view concretely with the view involving MBs. Also a connection with the notion of infinite prime emerges.

1.2 ZEO based quantum measurement theory from number theoretic perspective

The view about TGD based quantum measurement theory relies on zero energy ontology (ZEO) and its interpretation as consciousness theory involves several ad hoc elements. The notion of state function reduction (SFR) is the key notion. One can distinguish between "big" SFR (BSFR) as counterpart of ordinary SFR and "small" SFR (SSFR) as counterpart of weak measurement. What happens in SSFR and BSFR from a number theoretic point of view, is the key question.

The view about SSFRs is simplified.

1. SSFR is assumed to occur after BSFR, which leads to a complete localization of the WCW spinor field to a space-time surface represented by fixed polynomial P at the level of M^8: localization would be in the resolution defined by the resolution defined by the cognitive representation defined by the polynomial.

   The localization to single P has operational interpretation. One says that the localization occurs to single $P = P_1 \circ ... \circ P$ if the $P = ... \circ P_1 \circ ... \circ P$ if only the mass shells correspond to the roots of polynomials P_1 contain quarks. The higher mass shells are not activated.

   Note that the states of quarks considered are associated with either half-cone. In other half-cone there is delocalization forced by the fact that the observables associated with the two half-cones do not commute.

2. SSFR(s?) occurs for a fixed polynomial P. SSFR involves cognitive measurement cascade decomposing an irreducible representation of Galois group to a tensor product of irreps of relative Galous groups. There are also measurements in quark spin degrees of freedom for representations of relative Galois groups as well as measurements in the degrees of freedom related to the failure of strict classical determinism for the dynamic of the space-time surface.

3. Hitherto it has been assumed that there is a sequence of SSFRs followed by the counterpart of unitary time evolution. The TGD counterparts for the unitary evolutions would correspond quite generally to scalings and scalings could represent approximately time translations of the second tip of CD.

   The situation could be however considerably simpler: there could be only a single SSFR so that the question of when BSFR does occur would become obsolete. The time evolution by the scalings could be assigned to the fermionic degrees of freedom and to the mass shells defined by the roots of P.

One can also consider BSFR from a number theoretic point of view.

1. Suppose that the state is described by a polynomial P and that the many-quark state corresponding to, say, the lower half-cone of the CD is known. The state in the upper half-cone is not known. The state after BSFR corresponds to the state defined by $Q \circ P$ assignable to the upper half-cone of CD. This state must contain the mass shells assignable to P but with an opposite sign of energy for the Galois singlet states so that a lot of information is preserved. P would represent kinds of Akashic records and each BSFR would add to these records new records and the information content of the Universe would increase.

2. BSFR must be preceded by the analog of a unitary time evolution in which a superposition of space-time surfaces involving polynomials $Q \circ P$ are present. Note that the information related to P would be conserved. Since Q represents a higher abstraction level in the hierarchy of polynomials the process would mean emergence of larger space-time sheets modelled in terms of magnetic body (MB). Operationally this means that quarks must be transferred to the space-time sheet assignable to the roots of Q. One could also say that the entire state is a superposition of states associated with $Q \cdot P$, for arbitrary choices of Q but that quarks in the lower half-cone are associated with the mass shells of P only.

3. Here we have considered only the entire state. The intuitive picture has been that BSFRs can occur rather independently: the BSFRs at higher level however induce BSFRs at lower levels: somewhat like the decision of the boss induces decisions at the lower levels of the hierarchy.

   When SSFR has taken place and Galois degrees of freedom in the product of relative Galois groups are unentangled, also BSFRs replacing individual polynomials P_i in $P = P_1 ... \circ .. P_n$ with $Q_i \circ P_i$ can occur: without this assumption the highest level would act like a dictator.

4. When does BSFR occur? If only a single SSFR occurs, there is no problem. If single SSFR involves a sequence of SFRs as measurements for the quark quantum numbers associated with the mass shells characterized by p-adic length scales, one obtains a sequence of scalings giving rise to a subjective time evolution having the increasing CD size as a correlate of geometric time.

   If several SSFRs take place, the situation changes. Could NMP force BSFR in the case that there is a sequence of SFRs? Could the CD in the beginning of the SSFR sequence correspond to a sub-CD assignable to P. The spotlight of consciousness would not be large enough. As the size of the CD increases, additional particles become visible and eventually the CD as a perceptive field reaches the size of the entire CD. After this BSFR occurs. As a matter of fact, single SFR in the proposed sense is also consistent with this interpretation.

1.3 The notion of time from number theoretic perspective

There are also questions related to the notion of time.

1. The model for various time related aspects of conscious experience involves ad hoc elements and here an attempt is made to get rid of these elements. How the SSFR involving besides cognitive cascade also other measurements or a sequence of SSFR could correspond to a steady increase of geometric time determined in terms of CD size is the basic question.

2. Does the position of CD shift to the direction of future in the sequence of BSFRs and if it does so, what could be the natural mechanism causing this? This is one of the key questions.

   The existence of stars older than the Universe suggests that the center of mass of CD need not shift to the future. The system would evolve forth and back in time.

   On the other hand, the phenomenon of after images and the sleep-awake cycle could be understood also in terms of the shifting of CD to which mental images is assigned. Time crystal like phenomenon at the level of conscious experience implied by the existence of space-time surfaces, which are approximately periodic minimal surfaces, suggests an alternative explanation.

   Understanding what happens in memory recall is one of the key challenges and one both classical and quantal aspects of memory recall must be considered. The recent model is considerably simpler than the earlier one and the earlier picture follows without ad hoc assumptions.

2 State function reduction from number theoretic point of view

The only way to make progress is to challenge the existing views. The view about how ZEO [L4, L14] [K13] gives rise to a theory of consciousness as a generalization of quantum measurement

theory involves several assumptions, which might be challenged as un-necessary and possibly wrong at the level of details. Occam's razor might be needed.

Consider the basic assumptions involved.

1. The recent picture is based on the general TGD view about physics, which involves the dual views about physics as geometry and physics as generalized number theory. This part of theory seems rather stable.

2. In the number theoretic vision [L6, L7] functional composition of polynomials plays a key role. A tentative interpretation has been that it corresponds to the formation of many particle states in the case that polynomials appearing as factors of composition are prime polynomials with simple Galois groups. One must challenge this assumption.

   Functional composition could also correspond to topological condensation, whose number theoretic interpretation has remained hitherto open. As a matter of fact, free many-particle states could correspond to a products $P = \prod P_i$of irreducible polynomials with simple Galois groups and the functional composition $Q \circ P$ could correspond to a formation of interacting state formed by a topological condensation to a larger space-time sheets. P could also represent the magnetic body of the system as a many-sheeted structure.

ZEO is a crucially important piece of the theory.

1. The notion of BSFR as a counterpart of ordinary state function reduction (SFR) changing the arrow of time, and SSFR as a counterpart of weak measurement preserving the arrow, are central but there are still considerable uncertainties concerning the details of the picture.

2. The basic notions such as hierarchy of CDs, zero energy states, and the necessity of both BSFR and SSFR seem to be well-motivated. Also the cascade of cognitive measurements decomposing wave functions for the representations of the Galois group to entangled products of wave functions in relative Galois groups looks convincing. The special feature of Galois entanglement is its directedness which brings in mind attention. The localization of the nondeterminism as failure of strict determinism at space-time level to the frames of space-time surface as analog of soap film (minimal surface) seems also well-motivated. The reconnections indeed involve a failure of determinism naturally as a choice between two options.

2.1 What could happen in SSFRs?

Concerning the details of SSFR the situation is less clear.

1. The assumption has been that each SSFR as a counterpart of weak measurement is preceded and followed by a unitary time evolution increasing the size of the CD in statistical sense. These unitary evolutions could correspond to scalings of CD with the passive boundary fixed. In spin glass systems they would be realized [L15]. The exponential law for the relaxation of magnetization in spin glass would be replaced with a power law so that time would be a logarithm of the linear M^4 time. The scaling operator defining the unitary scaling would be determined by the super-symplectic symmetry in the same way as the conformal scaling operator in string models.

2. Each SSFR would correspond to an SFR selecting a unique space-time surface among possible holographic alternatives (perhaps selection of braiding distinguished by reconnections) plus a cascade of cognitive SFRs in the Galois group of the space-time surface reducing the wave function to a product of wave functions in its decomposition to relative Galois groups in question. The consciousness theoretic interpretation would be as an analysis. In the opposite time direction it would correspond to a generation of an idea, to a kind of heureka moment as BSFR.

   The sequence of SSFRs has been interpreted as a sequence of moments of consciousness defined by the life cycle of self as a conscious entity. BSFR would be a universal counterpart for death followed by a reincarnation with an opposite arrow of time.

3. Does one really need a sequence of unitary evolutions followed by SSFRs?Could single SSFR as a cascade of cognitive SFRs be enough? This would solve the problem of when BSFR occurs.

   For single SSFR, the life cycle of self would be essentially a cascade of cognitive SFRs, a process of cognitive analysis leading to a reduction of quantum coherence. One might argue that this is indeed what aging is at the highest level [L22], and would also conform with the second law of thermodynamics [L13]. The occurrence of SSFRs implies the reduction of the number of choices and this is what seems to take place in aging.

   On the other hand, we also have eureka moments and our mental images are born and die, which suggests a hierarchy of subselves realized in terms of function composition for which the cognitive cascades take place. We sleep and this could mean BSFR at some level of our personal self hierarchy. It would seem that the sub-CDs should be able to make several BSFRs during a single SSFR at the higher level. As found, this is possible.

4. The cognitive measurement cascade as such leads only to an unentangled tensor product of irreducible representations of the relative Galois groups. After this, the observables associated with the Galois representations, with spins of quarks, and non-deterministic classical degrees of freedom must be measured.

2.1.1 Does the sequence of SSFRS correspond to a sequence of scalings of a CD?

The increase of CD in the sequence of SSFRs would give a correlation between the flow of the subjective time as the sequence of SSFRs and geometric time as the size of CD. Is the sequence of SSFRs is really required or whether SSFR naturally decomposes into a sequence of scalings.

The following argument suggests that it is possible to obtain a sequence of scalings of a CD in a natural way in SSFR.

1. The light-cone proper time a constant hyperboloids correspond to cognitive representations consisting of all algebraic integers in the extension of rationals defined by P. Therefore they correspond to "very special moments in the life of self" as cognitive explosions. The presence of a quark at the point with momentum satisfying this condition is needed to activate it so that cognitive representations are finite. M^8 picture predicts also preferred moments t_n with respect to Minkoski time and also these correspond to the roots of P and define infinite cognitive representations which reduce to finite ones, when quark is required to activate the points of the representation. These preferred moments are naturally associated with massless particles.

   As a matter offact, if one requires super-Virasoro symmetry and identifies mass squared with a scaling generator, one can argue that only massless states are possible since the scaling generator must annihilate these states. This leads to a concrete interpretation of the massivation in p-adic thermodynamics. It would be due to an entangling interaction of the massless sub-system with the environment exciting states of sub-system with non-vanishing mass squared: the excited states of the entire system would be massless [L20].

2. The earlier intuitive picture was that the sequence of SSFRs as a cognitive cascade plus SFRs implied by the failure of the classical determinism increases the size of CD by scalings and makes gradually the roots of the polynomial P visible. This assumption does not look plausible if the size of the CD is determined from the beginning by the largest ramified prime for P.

   One can however argue that the perceptive field of the waking up self expands gradually and this correspond to the increase of CD from a size, which is determined by a ramified prime smaller than the maximal, presumably the smallest one so that the increase of the size CD would occur as emergence of increasing p-adic length scales.

   Note that the ramified primes appear as divisors for the discriminant which is product for the roots of P. An open question is whether the p-adic primes associated with the masses of Galois singlets can correspond to ramified primes.

3. Intuitively, the p-adic length scales would naturally correspond to the emergence of mass shells with decreasing mass, and therefore an increasing momentum resolution. Masses are defined by the roots of P or by emergence of Galois confined states at $a = constant$ hyperboloid, which satisfy Galois confinement. Each mass value would correspond to a p-adic mass scale and if the large mass scales emerge first with respect to experienced time, the size of the CD indeed increases.

   Note that the cognitive measurement cascade would proceed in the reverse order if the polynomial if Q in $Q \circ P$ corresponds to a larger space-time sheet. Cascades would proceed in opposite orders. This brings in mind the development of sensory perception followed by a motor reaction.

4. When all mass scales have emerged, the size of the CD is maximal and the BSFR can naturally occur since no information can be gained and NMP [K5] [L13] cannot be satisfied.

5. In this picture the cognitive state function reduction in the Galois group would occur first. This would give an unentangled tensor product of representations of relative Galois groups. After that measurement of the quantum numbers in the representations of relative Galois groups for the corresponding mass shells would take place in the proposed order.

2.1.2 Could the space-time surface determined by $P_1 \circ ... \circ P_n$ be replaced with that determined by $P_1 \times ... \times P_n$ in the cognitive cascade?

One of the fleeting ideas encountered during the development of the ideas about cognitive measurements was that it could also affect the space-time surface itself rather than only the wave functions in Galois degrees of freedom.

1. The simplest assumption is that it is just a sequence of SFRs in the the group algebra of the Galois group which has decomposition to a a product of relative Galois groups. The wave function in Galois group would be reduced to a product of wave functions in the relative Galois groups. Nothing would happen to the space-time surface itself.

2. Could the cognitive reduction sequence proceed as $P_1 \circ P_2 \circ ... \circ P_n \to P_1 \times P_2 \circ ... \circ P_n ... \to P_1 \times .... \times P_n$? If so, the space-time surface would be replaced with a union of space-time surfaces associated with P_i. Note that multiple roots can occur reducing the dimension of extension and order of Galois group so that it is a sum of orders rather than product.

   I have considered this possibility but it seems artificial and ad hoc. I have also considered the possibility that P_i could be replaced with the composite of characteristic polynomial of the density matrix characterizing the entanglement between P_i and $P_{i-1} \circ ...P_n$ so that the measured eigenvalues would be stored in the space-time geometry [L17, L16].

   The simplest elegant option is that nothing happens for the space-time surface in the cognitive measurement cascade. Only the Galois entanglement in quark degrees of freedom assignable to quark momenta as points at the mass shells defined by the roots of P and to quark spins would be reduced.

This idea however led to the realization that the surfaces defined by the product polynomials are natural correlates for free many particle states. This will be discussed later.

2.1.3 What kind of polynomials are allowed?

Mathematician's answer to the question of what kind of polynomials should be allowed, could be "irreducible ones". This was also my own first guess.

1. The original assumption was that only irreducible polynomials are physically acceptable. Irreducible polynomials P with simple Galois groups, and therefore having no product decomposition to polynomials with a lower degree polynomials P_i, are analogous to elementary particles and could define space-time regions assignable to elementary particles.

   Irreducible polynomials have reducible polynomials as a limiting case. It is difficult to think of throwing them away and one can wonder what physical interpretation they could have.

2. The product polynomial $P_1 \times ... P_n$ would naturally represent a non-interacting many-particle state consisting of disjoint 4-surfaces. A concrete number theoretic and geometric counterpart for the absence of entanglement could also be in question. A weaker assumption is that this kind of state cannot generate entanglement by interactions.

   The surface defined by the product $\prod P_i$ would be singular in the sense that it would not be irreducible polynomial and would be localized at "boundary" of discretized WCW as a union of 3-surfaces in half-cones of CDs associated with P_i defining union of 4-surfaces and correspond to a superposition of space-time surfaces restricting to these 3-D surfaces at lower half-cones.

   Therefore the intuition of particle physicists suggests that one should allow product polynomials.

The idea that unentangled free many-particle states have product polynomials as correlates is attractive. One can indeed consider a hierarchy of functional composisites involving also product polynomials.

1. The lowest level in the functional hierarchy could correspond as a free many-particle state to a product of irreducible polynomials with a simple Galois group as counterparts of elementary particles. For $P(0) = 0$ in $P \circ (\prod P_i)$ the roots of P_i would be roots of P giving rise to the analog of conserved genes. Functional composition with a polynomial would give an interacting many-particle state. P would characterize the interaction with particles and represent a space-time sheet at which the particles represented by P_i have topologically condensed.

   It should be noticed that the assumption $h_{eff} = n_0 h_0$, $n_0 = (7!)^2$, is satisfied if there is a ground state polynomial with Galois group corresponding to a product or to functional composite of two polynomials with simple Galois group A_7 and two simple Galois groups Z_2.

2. Arbitrarily high function composites are possible. The products of polynomials $Q_j \circ (\prod P_i)$ for these interacting states would in turn define higher level many-particle states and one would have a hierarchy analogous to abstraction hierarchy defined by a repeated function composition giving rise to increasingly complex functions. The hierarchy of space-time sheets of many-sheeted space-time would serve as a geometric counterpart. Also more general states can be constructed by allowing products of polynomials belonging to different levels in the hierarchy.

3. What could be the interpretation of the emerging geometric structures? The roots of Q_j correspond to n mass-shells and their inverse images define $m \times n$ mass shells, where $m = \sum m_i$ holds true. The space-time regions associated with P_i has been replaced with its n-fold covering. The n sheets would define the magnetic body.

   If $Q_j(0) = 0$ is true the roots of P_i are roots of the composite: this serves as the analog of conserved genes. If P_i corresponds to an irreducible monic polynomial and has a simple Galois group, one can talk about the analog of an elementary particle. The conservation of genes is approximate if Q_j has a root very small root. If a gene corresponds to a Galois group rather than roots, conservation does not require even this.

4. An interesting situation is obtained when the ground state consists of a single irreducible polynomial P. For $Q_j(0) = 0$ in the hierarchy, one would obtain MBs associated with P with arbitrary many levels. Could one say that also elementary particles evolve and these MBs correspond to different evolutionary levels of the particle with increasingly complex cognition. Lenin would have been right about elementary particles after all! p-Adic prime characterizing the mass of the particle in p-adic thermodynamics would correspond to the largest ramified prime for the extension considered.

   Second interesting situation corresponds to iteration of a single polynomial as $Q \circ P \to Q \circ Q \circ P \to ...$ with $Q(0) = 0$. These roots would correspond to a situation familiar from chaos theory and the inverse roots would approach the boundary of the full Julia set.

5. The hierarchy of infinite primes [K10] is one of the speculative mathematical ideas inspired by TGD. A geometric interpretation could be in terms of many-sheeted space-time. Number theoretic interpretationin terms of functional composites of polynomials of .... of polynomials suggests that the hierarchy described above gives a connection with the realization as many-sheeted space-time. The primes in the hierarchy of infinite primes could be generalized and correspond to simple Galois groups as analogs of primes.

6. Whether the phenomenology of the many-sheeted space-time is consistent with this proposal, is an open question. For instance, does the $M^8 - H$ duality predict at the level of H wormhole contacts connecting space-time sheets at different levels of hierarchy. Wormhole contacts have an Euclidean signature of induced metric and could correspond to the roots of P for which the real part is negative and could correspond as Galois confinened states to negative values of mass squared. Also tachyons can appear in the decomposition of Galois singlets to virtual quarks having momenta, which are algebraic integers of the extension of rationals at mass shells determined by the roots of P.

2.2 What could happen in BSFRs?

BSFRs correspond to the ordinary SFRs and the new element is that the arrow of time changes. The findings of Minev et al [L1], discussed in [L1], provide empirical support for this. The proposal also solves the question about how the world which can be quantum coherent in arbitrarily long scales can look classical in long scales. The findings of Libet about active aspects of conscious experience [J1] provide an additional support for the notion of BSFR.

2.2.1 Some facts about BSFRs

What do observations say about BSFRs?

1. The findings of Libet about active aspects of consciousness [J1] find a nice explanation in terms of BSFR as also the findings of Minev et al [L1] in atomic physics scales [L1].

2. On can argue that if time reversed systems exist they would have been observed a long time ago. This is not the true. According to the standard physics view, time reversed systems send classical signals only to the direction of the geometric past with respect to us. The classical signals from the time reversed systems in the geometric past do not reach us. The time reversed signals from the geometric future do this only if we can detect them and our claimed ability to anticipate future events and precognize suggests that this is possible [L21]. TGD suggests a classical mechanism of memory and anticipations involving time reflection of a signal in BSFR for a subsystem [K6]. Earthquakes are one and candidate for a macroscopic BSFRd discussed in [L2]

3. There exist stars older than the Universe [E1] discussed from TGD pointmofview in [K9]. This could be understood if the stars evolve by a sequence of BSFRs and the cm time coordinate for the star remains stationary.

2.2.2 The WCW state before BSFR

To understand what could happen in BSFR [L4, L14] [K13] one must first consider the state before the BSFR.

1. In ZEO the 3-surfaces (mass shells) associated with P_i would define the parts of 4-surfaces in a lower half of the corresponding CD. The proposal has been that they form a Russian doll structure with a common center as origin. Each CD has either of its tips as natural origins but the non-associativity of octonions forced them to select either tip and thus either half-cone of the CD. This means the selection of the arrow of time. The states at the passive tip, the selected one, are passive and correspond to the initial, prepared state of particle reaction. Galois reduction and selection of branches of minimal surface at frames corresponds to a preparation.

2. The 4-surfaces associated with P_i in $P = P_1 \circ ... \circ P_i ... \circ P_n$ would be topologically condensed on the portion of the larger space-time surface by wormhole contacts in the lower half of its CD. The wormhole contacts would correspond to tachyon-like mass shells predicted as roots. Galois confinement for physical states would allow only non-negative mass squared. This would give content to the nebulous idea of many-sheeted space-time. In the QFT picture, tachyonic mass squared values would correspond to virtual particle exchanges. One can say that in TGD virtual particle momentum spectrum is discrete and even finite so that one gets rid of divergences.

3. The state before BSFR would be a state of WCW spinor field localized to, say, the lower half-cone CD_- of CD. All polynomials in the superposition would effectively reduce in CD_- to that associated with P since for $Q \circ P$ there would be no quarks at the mass shells of Q in CD_-. The state in the lower half-cone, determined by P alone, does not provide the information to deduce it. In the operational sense, only a single state determined by P exists.

   The proposal is that the analogs of Kac-Moody and Super Virasoro conditions for the super-symplectic algebra [L3] determine the entire superposition over $Q \circ P$:s. The holography at the level of WCW [L6, L7] could fix the state as a WCW spinor field from the holographic data provided by the roots of P. The superposition of ver $Q \circ P$ would correspond to a discretization of a WCW spinor field satisfying the super symplectic gauge conditions [L3].

4. If the condition $Q(0) = 0$ is satisfied, the roots of $Q \circ P$ consist of the roots of P and the inverse images of the roots of Q by P^{-1}. After BSFR the WCW state is localized to the space-time surface determined holographically by the mass shells for single $Q \circ P$. BSFR can be said to occur in the space of polynomials and conserve the existing roots so that information is not lost.

5. The space-time surface inside CD_- is fixed by holography determined by mass shells H^3 with positive or negative energy depending on which half-cone is in question. Only one of choice for the sign is possible since otherwise the PE does not exist since the holography is overdetermined.

2.2.3 What could happen in BSFR?

What could happen in BSFR?

1. In BSFR the state in CD_+ is localized in the same way but becomes physically undetermined in CD_-. The roles of future and past are changed and BSFR would therefore reverse the arrow of time.

2. BSFR would correspond to a localization to a single polynomial defining proper time $a = constant$ hyperboloids in the positive/negative half cone of the CD, whose size would correspond to the largest ramified prime of the polynomial. The arrow of time changes. The time evolution by BSFRs would be a kind of flip-flop sequence between opposite arrows of time and half-cones of CD.

   In TGD inspired theory of consciousness, BSFR would be interpreted as the counterpart of death followed by a reincarnation (these terms are of course understood in a universal sense).

3. Since the polynomial surface gives rise to a unique discretization defined by the extension of rationals determined by P interpreted as cognitive representation [K8] [L11, L9, L8], one can argue that the localization to a single polynomial in BSFR should be interpreted as a localization only modulo finite measurement resolution. One can ask whether the localization could occur first to a single Galois group and only after that to a single polynomial. The state after the Galois localization would involve a large number of polynomials with the same Galois group and different ramified primes.

4. Is the opposite process $Q \circ P \to P$ in which some levels disappear and information is lost , possible. Number theoretic evolution inevitably leads to an increasing cognitive complexity as polynomials with an increasing degree emerge. One cannot however exclude these transitions.

What can one say about the state associated with the polynomial $Q \circ P$ defining the final state. The mass shells of P but with opposite energies can contain quarks besides the mass shells of Q. The Galois confined groups with integer valued momenta are in general different and BSFR could be interpreted as SFR occurring in particle reactions. The conservation of momentum which is true at the limit of infinitely large CD poses constraints on the momenta and masses. Some quarks at lower mass shells must be moved to the mass shells associated with Q. Kind of ionization transferring quarks from the lower levels of the hierarchy to the new level should take place.

2.2.4 Can different levels in polynomial hierarchy make BSFRs independently?

The proposed first guess about BSFRs is not general enough. The point is that the BSFR would occur for all factors P_i defining levels of the hierarchy of MBs simultaneously. The existing picture is that BSFRs are not simultaneous but can occur separately but not completely independently. A BSFR at higher level induces BSFRs at lower levels just like the decision of "boss" at higher level induces decisions at the lower levels. A more general picture would look as follows.

1. BSFR for $P = P_1 \circ ... \circ P_n$ involves a localization in the space of polynomials which are extensions of type $P \to Q \circ P$. After this a cognitive cascade occurs unentangling relative Galois groups associated with P_i. This process need of course not be complete.

   Cognitive cascade is followed by SFRs in quark degrees of freedom and in the degrees of freedom related to classical non-determinism.

2. After this a particular unentangled P_i could be replaced with $P_i \to Q_i \circ P_i$ in BSFR. This would mean that a CD associated with P_i increases in size. Sub-selves would correspond to P_is and this particular sub-self would thus die and reincarnate. At the level of P this would mean the replacement $P = P_1 ... \circ P_i \circ ....P_n \to P = P_1 ... \circ (Q_i \circ P_i) \circ .... \circ P_n$. In this picture the CD:s associated with P_i could have different arrows of time.

   This raises however the question whether Galois groups of P_i:s with different arrows of time entangle in the next BSFR. This could make sense for the same arrow of time only.

3 Questions related to the TGD inspired theory of consciousness

TGD inspired theory of consciousness could be seen as an interpretation of the ZEO based quantum measurement theory [L4] [K13]. The physical correlates for the phenomena of consciousness should have a simple description in the proposed framework.

3.1 About the notion of time

The basic motivation behind ZEO is that it could provide a solution to the problems related to the difference between experienced time and geometric time, which are usually identified although this is in a striking conflict with basic empirical facts.

1. One should understand the arrow of time and why the time increases in one direction, at least in a statistical sense. There are two natural geometric times: light-cone proper time a, which is naturally associated with CD and the linear time coordinate t associated with the $M^4 \subset H$.

   These two times would correspond to two different views about time evolution already briefly discussed [L20]. Light-cone proper time would be assignable to particles with thermal mass determined by p-adic thermodynamics [K3] and linear Minkowski time to massless particles for which translations must replace scalings. The first one is with respect to scalings and the second one with respect to time translations. Note that scalings and translations do not commute.

   Number theoretically both times are very special. For a given extension of rationals all points with algebraic Minkowski coordinates for M^8 can belong to the cognitive representations. A kind of cognitive explosion takes place. Quark momenta are naturally algebraic integers and

the actual cognitive representation is determined by the momenta of quarks present in the state and is finite.

2. The analog of the unitary evolution associated with a should correspond to scaling rather than time translation. If the pairs of unitary processes followed by SSFRs, the unitary process could correspond to the scaling as in super string models.

   Super symplectic transformations, acting as symmetries of the "world of classical worlds" (WCW), involve a scaling generator, which would have a representation in terms of super-symplectic algebra and scale the size of the CD. If the p-adic scale corresponds to the largest ramified prime for P, this should mean the increase of the largest ramified prime during time evolution by scalings.

3. This leads to ask whether the increase of experienced time in SFR, or in the cascade of SFRs associated with it, the polynomial P should be replaced with $Q \circ P$ such that Q has maximal ramified prime larger than that for P. Here one must be however cautious. For a fixed sub-CD, the flow of the experienced time could correspond to the increase of a as a characterizer of the size of the CD

   How the possibility of two times might reflect itself as a character of conscious experience? For instance, could everyday experience and some altered states of consciousness such as DMT experiences correspond to different geometric times for the perceptive field. DMT experiences could correspond to experience in which hyperbolic geometry of $a = constant$ surface is projected to $t = constant$ the hyper-plane [L18].

   For large values of a, the local curvature of H^3 decreases and at the limit of large values of a H^3 becomes t in a good approximation. The everyday experience could therefore correspond to large a and therefore in a good approximation to $t$whereas the DMT induced states of consciousness would correspond to small a [L18].

Momentum eigenstates and time translations can be considered at 3 levels: corresponding to space-time level, embedding space level and WCW level.

1. Could ZEO make it possible to talk about wave packets for sub-CDs, or rather, for the state associated with either half-cone of sub-CD. Could one assume that the wave packets of sub-CDs are localized within the largest CD involved? This is the view proposed in [L6, L7].

   Sub-CD would correspond to a sector of WCW and define the decomposition of WCW. WCW would also have decompositions according to Galoism group of the polynomial, the degree of the polynomial P, and the number of levels its its functional composition.

2. Could one define M^4 time evolution at the space-time level as a flow in which the flow lines of time translation as isometry in M^4 are projected to the space-time surface and define a "subjective" space-time view about time translation? H view would be the second view, in which the 3-surface would be a particle-like entity rather than the arena of physics. The notion of the quantum group [A1, A2] could catch this notion. Gravitational and inertial charges could correspond to space-time and embedding space views about conservation laws [K12]. Gravitational time translation could have a representation as a quantum group transformation at the level of X^4.

S-matrix is a fundamental notion in the standard QFT.

1. The TGD counterpart of S-matrix relating the states assignable to the half-cones of CD identified as Galois singlets made of quarks at fundamental level would correspond to the S-matrix as the particle physicist understands it. This transition would be associated with BSFR. The size of the largest CD would characterize the duration of transition [K12].

   TGD suggests that the unitary matrix of QFTs could be replaced with the fermionic counterpart of Kähler metric and therefore as a property fermionic states space [L10] and highly uniquely determined by the infinite-D character of the fermionic state space as also the Kähler metric of WCW [K2, K1, K7].

2. One has two times, linear time t and light-cone proper time a. For both of them the roots of P correspond to very special moments of time. The time evolutions with respect to t and a would naturally correspond to translations and scalings respectively. I already proposed that these two times could correspond to perceptive fields defined by $t = constant$ hyperplane appropriate for massless states and $a = constant$ hyperboloid appropriate for massive states.

   Should one speak about separate time evolutions for a and t. p-Adic particle massivation suggests that a is the correct time. For large values of a when the curvature of H^3 approaches zero, $a \simeq t$ is a good approximation. Therefore the counterparts of the unitary evolutions could always correspond to scalings.

3. Typically, the number of unstable particles decreases exponentially on M^4 time t. As already noticed, this kind of time evolution should correspond to a sequence of BSFRs and to perceptive fields which correspond to $t = t_n$ hyperplanes. For the relaxation of magnetization in spin glass the exponential law is replaced with a power law [L15] so that time would be a logarithm of the linear M^4 time. This would naturally correspond to a and scalings. For small values of a, the large curvature of H^3 would imply a strong deviation from the behavior with respect to linear time t. Spin glass systems would therefore correspond to small value of a.

4. For large values of a the time evolution by scalings associated with BSFRs or SSFRs should have an approximate interpretation as time translations for short enough times Δt. The earlier view has been that the shift of the active boundary of CD takes place in time evolution by SSFRs forcing the scaling of the CD.

   Could approximate counterparts of the time translations be induced as scalings of CD leaving the state at the passive boundary invariant and only increasing its size? If so, the time translations by Δt for the other tip of CD would reduce to scalings for which Δt corresponds to the scaling $\Lambda = 1 + \Delta t/T(CD)$ for CD having $T(CD)$ as the temporal distance between its tips? Note that the scalings would be different for the sub-CDs of the hierarchy rather than affecting all sub-CDs in the same way.

   For small values of $\Delta t/T(CD)$ this assumption would indeed transform the power law $\Lambda^k = exp(kln(+\Delta T/T(CD)$ with the rate k to and exponential decay $\Lambda^k \simeq exp(-k\Delta T/T_(CD))$ with rate $k/T_C D$.

3.2 The notion of memory mental image

The notion of memory mental image [K11, K6, K13] [L4, L5, L12] is one particular test for the ZEO based theory of consciousness. One can criticize the recent ZEO based view for having several ad hoc elements.

1. Mental images of self correspond to sub-selves of self having sub-CDs as correlates [K4].

2. Mental image wakes up when SSFR changes its state. The quantal non-determinism, which does not change CD, should correspond to the failure of the classical determinism assignable to the lower-D frames defining the space-time surface as a minimal surface analogous to soap film. At frames the field equations for the full action, which includes besides the volume term also Kähler action, are satisfied so that conservation laws hold true. In other regions the field equations for volume term and Kähler action hold true separately.

   Also the reconnections of flux tubes and string world sheets associated with the flux tube involve non-determinism since the strands AC and BD can transform to AC+BD or AD+BC in reconnection.

   These transitions could wake up mental images scattered around the space-time surface so that memory mental images would be where the original non-deterministic event occured. The formation of copies of mental images is also expected in the memory recall.

3. A possible interpretation for the classical non-determinism is in terms of intentional aspects of conscious experience. The superposition of different options could correspond to experience about having not yet chosen from a finite number of options. The non-determinism of SSFRs would in turn correspond to sensory experience.

4. The spatial braidings of nodes of a network induced by the motion of nodes defining time-like braiding store the information of time like braiding to memory as kinds of Akashic records [L20]. The reconnections, which are possible and unavoidable by the 4-dimensionality of the space-time surface, induce basic braidings even with the motion of the ends of braid strands. This is because the reconnection AC+BC $\rightarrow$ $AD + BC$ generates basic braiding operation as the braided counterpart of a permutation of neighboring braid strands known as SWAP in topological quantum computation.

5. The earlier view involved some assumptions, which in the recent view look un-necessary. In particular, the former picture led to an un-intuitive idea that the mental images about geometric past are stored in the geometric future. The idea was as follows. As the size of the CD increases, there are moments at which a new $t = t_n$ hyper-plane emerges. The question was whether the emergence of this plane in the sequence of scalings of the CD is accompanied by a generation of mental images in the future half-cone of the CD.

   This assumption is unnecessary in the recent picture and also in conflict with it since the upper half of CD remains unconscious to self. If the space-time surface in the interior of the new CD emerging in BSFR contains the same hyperbolic spaces H^3 as $a = a_n$ sections besides the new ones, the new space-time surface contains a lot of information about the previous space-time surface. This could explain why we can remember, perhaps unconsciously, something about the period of sleep if it corresponds to the reversed arrow of time.

   The fact that the BSFR conserves information about the earlier polynomial decomposition explains why we can remember something about yesterday even if falling asleep would correspond to BSFR.

6. After images is one aspect of the memory and since approximately periodic minimal surfaces as analogs of time crystals are possible. The frames and reconnections as singularities and loci of non-determinism and mental can appear in this case repeatedly so that after images could be understood of being due the increase of CD in the sequence of SSFRs.

3.3 More questions related to the relationship between subjective and geometric time

The growth of the geometric time should be associated with the sequence of SFRs defining quantum jumps in the sense that some kind of time value assigned to the content of the perceptive field grows in the sequence of SFRs in a statistical sense at least.

What does this statement really mean? Does this statement hold true for the sequences of SSFRs or BSFRs or both? This question was already considered for SSFRs and it was suggests that the sequence of time values defined by light-cone proper time a assignable to the mass hyperboloids associated with Galois confined states could provide this time is the SFRs occur in the order of decreasing mass squared and thus increasing a.

3.3.1 Could the position of CD shift to the direction of future in BSFR?

The flow of time assignable to BSFRS would have a pair of BSFRs establishing the original time direction as a basic step. A physical interpretation could be quantum tunneling. The first guess is that both BSFRs could increase the size of CD by replacing the polynomial P with $Q \circ P$. This is however not true if the largest ramified prime associated with Q is not larger than that associated with P.

One must be careful with the ramified prime conjecture, which is just a guess. Ramified primes are divisors of discriminant of P defined as the product for the squares of root differences. The roots could be larger than the largest ramified prime. Therefore one can challenge the ramified prime hypothesis and consider the possibility that the mass squared values of the physical states satisfying Galois confinement assign to the quantum state a collection of p-adic primes defining p-adic length scales.

The size of the CDs can increase and geometric time defined by the distance from the center of the CD to its tip would increase. Also the size of sub-CDs can increase in BSFRs. Evolution

in this manner would mean increase of complexity and emergence of new larger space-time sheets. NMP would force negentropy increase and as a byproduct increase of entropy [L13].

It is however difficult to understand whether and how the center of CD could shift in either time direction unless T violation at the fundamental level induces this. Could the correlation between subjective and geometric be associated only with the SFR sequences assignable to SSFRs?

3.3.2 Periodically appearing mental images and sleep-awake cycle

Consider first periodically appearing mental images and the sleep-awake cycle.

1. Our mental images typically die and are reborn again. After images represent a basic example of this. Could it be that this process is a sequence of birth and death of a mental image as subself?

   We are mental images of a higher level self. Could the wake-up period and sleep period be related by a BSFR and time reversal? Are we after images of this higher level self? Sleep would be a small death. This could explain why we do not remember anything about the period of sleep.

2. The neuroscience based objection against the necessity of BSFRs is that the disappearance of mental images is caused by the loss of the nerve pulse activity: the neurons in some parts of the brain and CNS become hyperpolarized so that nerve pulse activity relevant to our cognitive consciousness and memory ceases [L19]. I could be conscious but would not remember anything about this period. However, the BSFR for MB associated with the part of CNS in question could induce the loss of the nerve pulse activity.

   During the wake-up period the metabolic energy feed effectively increases the values of h_{eff} particles and activates higher levels to self-hierarchy. Perhaps this activates BSFRs inducing additional polynomial factors for polynomials $\circ P_i \circ ...$ corresponding to subselves. The size of the CD increases if BSFR occurs and the tip of the CD is in the future of the self that died. Could the tip correspond to the geometric time for the moment of wake-up of time reversed self?

3. After the second BSFR the geometric time for the self in the original time direction is determined most naturally by the center of the CD. It would not be shifted unless there is some mechanism causing a shift. If the shift occurs its direction could be fixed by the arrow of time for higher level self in the hierarchy.

   Why would the center of the CD to which the geometric time is naturally assigned shift towards a preferred time direction in H? If the scaling is the basic transformation associated with BSFR, the scalings would define time evolutions as approximate translations for linear time if the hyperboloid in question has small enough curvature. There would be no reason for the shift of the cm of CD. The idea about time evolution as shift of the cm of the CD would not make sense.

4. One can indeed image another explanation for after images and sleep-awake cycle would involve a time crystal like system. In TGD this kind of system would correspond to MB as a minimal surface with an approximately periodic structure. After images and our sleep-awake cycle would reflect this kind of periodicity for subselves.

   One can imagine that there is a time-like lattice of sub-CDs assignable to the periodic structure of classical nondeterminism (say reconnections appearing periodically). The sub-CDs do not shift but there would be a kind of wave which wakes up the sub-CDs, and is shifted in a preferred time direction. The time direction assignable to a larger CD representing the environment could define the preferred time direction. Time-like braids could provide a realization for these waves. Their reconnections involve classical and quantum non-determinism and if the reconnections appear periodically, their wake-up could induce a sequence of mental images of self. Note that this explanation can confirm with the explanation in terms of BSFR for the sub-CDs.

5. Directed attention is one basic aspect of consciousness. The structure of Galois entanglement is hierarchical directed downwards in the tower of relative Galois groups. This direction

would be from larger to smaller p-adic length scales. Also SFRS at quark level related to the non-determinism at the frames of space-time surface as a minimal surface and at braids is involved. Could the attention shift from sub-CD to sub-CD in the preferred time direction and in this way give rise to a temporal sequence of wake-ups of sub-CDs?

3.3.3 How to understand memory recall?

There is also the problem of memory recall as active process rather than a spontaneous emergence of memory. Both classical and quantum description for memory recall is suggested by quantum-classical correspondence.

1. In the classical picture, memory recall/anticipation would involve communication with the geometric past/future. Time reflection involving BSFR for the signal as a sub-self would take place.

2. A lot of information is preserved almost as such in BSFR $P \to Q \circ P$ since for $Q(0) = 0$ mass spectrum is preserved. Note that the mass shells as roots of P in the half-cones of CD have only a different sign of energy. Therefore a lot of information about previous time reversed incarnations preserved and therefore also about previous lives in the same time direction. One could speak of Akashic records. Akashic records would be also realized in the dynamical braiding with nodes connected by flux tubes.

3. One could also understand memory recall as a wake-up of memory mental images during the period associated with a single SFR. If this is due to the finite classical non-determinism at frames and reconnection points, this would change the entire space-time surface but possibly only after the singular point. This change would have interpretation as classical communication and time reflection if BSFR occurs at the singular region.

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