Intention, Cognition, and Time

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Abstract

Intentions involve time in an essential manner and this led to the idea that p-adic-to-real quantum jumps could correspond to a realization of intentions as actions. It however seems that this hypothesis posing strong additional mathematical challenges is not needed if one accepts adelic approach in which real space-time time and its p-adic variants are all present and quantum physics is adelic. I have already earlier developed the first formulation of p-adic space-time surfaces as cognitive charges of real space-time surfaces and also the ideas related to the adelic vision. The recent view involving strong form of holography would provide dramatically simplified view about how these representations are formed as continuations of representations of strings world sheets and partonic 2-surfaces in the intersection of real and p-adic variants of WCW ("World of Classical Worlds") in the sense that the parameters characterizing these representations are in the algebraic numbers in the algebraic extension of p-adic numbers involved.

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1 Introduction

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The recent view involving strong form of holography would provide dramatically simplified view about how these representations are formed as continuations of representations of strings world sheets and partonic 2-surfaces in the intersection of real and p-adic variants of WCW ("World of Classical Worlds") in the sense that the parameters characterizing these representations are in the algebraic numbers in the algebraic extension of p-adic numbers involved.

1.1 What intentions are?

One of the earlier ideas about the flow of subjective time was that it corresponds to a phase transition front representing a transformation of intentions to actions and propagating towards the geometric future quantum jump by quantum jump. The assumption about this front is un-necessary in the recent view inspired by ZEO.

Intentions should relate to active aspects of conscious experience. The question is what the quantum physical correlates of intentions are and what happens in the transformation of intention to action.

1. The old proposal that p-adic-to-real transition could correspond to the realization of intention as action. One can even consider the possibility that the sequence of state function reductions decomposes to pairs real-to-padic and p-adic-to-real transitons. This picture does not explain why and how intention gradually evolves stronger and stronger, and is finally realized. The identification of p-adic space-time sheets as correlates of cognition is however natural.

2. The newer proposal, which might be called adelic, is that real and p-adic space-time sheets form a larger sensory-cognitive structure: cognitive and sensory aspects would be simultaneously present. Real and p-adic space-time surfaces would form single coherent whole which could be called adelic space-time. All p-adic manifolds could be present and define kind of chart maps about real preferred extremals so that they would not be independent entities as for the

first option. The first objection is that the assignment of fermions separately to the every factor of adelic space-time does not make sense. This objection is circumvented if fermions belong to the intersection of realities and p-adicities.

This makes sense if string world sheets carrying the induced spinor fields define seats of cognitive representations in the intersection of reality and p-adicities. Cognition would be still associated with the p-adic space-time sheets and sensory experience with real ones. What can sensed and cognized would reside in the intersection.

Intention would be however something different for the adelic option. The intention to perform quantum jump at the opposite boundary would develop during the sequence of state function reductions at fixed boundary and eventually NMP would force the transformation of intention to action as first state function reduction at opposite boundary. NMP would guarantee that the urge to do something develops so strong that eventually something is done.

Intention involves two aspects. The plan for achieving something which corresponds to cognition and the will to achieve something which corresponds to emotional state. These aspects could correspond to p-adic and real aspects of intentionality.

1.2 p-Adic physics as physics of only cognition?

There are two views about p-adic-real correspondence corresponding to two views about p-adic physics. According to the first view p-adic physics defines correlates for both cognition and intentionality whereas second view states that it provides correlates for cognition only.

1. Option A: The older view is that p-adic -to-real transitions realize intentions as actions and opposite transitions generate cognitive representations. Quantum state would be either real or p-adic. This option raises hard mathematical challenges since scattering amplitudes between different number fields are needed and the needed mathematics might not exist at all.

2. Option B: Second view is that cognition and sensory aspects of experience are simultaneously present at all levels and means that real space-time surface and their real counterparts form a larger structure in the spirit of what might be called Adelic TGD. p-Adic space-time charts could be present for all primes. It is of course necessary to understand why it is possible to assign definite prime to a given elementary particle.

   This option could be developed by generalizing the existing mathematics of adeles by replacing number in given number field with a space-time surface in the imbedding space corresponding that number field. Therefore this option looks more promising. For this option also the development of intention can be also understood. The condition that the scattering amplitudes are in the intersection of reality and p-adicities is very powerful condition on the scattering amplitudes and would reduce the realization of number theoretical universality and p-adicization to that for string world sheets and partonic 2-surfaces.

For instance, the difficult problem of defining p-adic analogs of topological invariant would trivialie since these invariants (say genus) have algebraic representation for 2-D geometries. 2-dimensionality of cognitive representation would be perhaps basically due to the close correspondence between algebra and topology in dimension $D = 2$.

Most of the following considerations apply in both cases.

2 Some questions to ponder

The following questions are part of the list of question that one must ponder.

2.1 Do cognitive representations reside in the intersection of reality and p-adicities?

The idea that cognitive representation reside in the intersection of reality and various p-adicities is one of the key ideas of TGD inspired theory of consciousness.

1. All quantum states have vanishing total quantum numbers in ZEO, which now forms the basis of quantum TGD [K2]. In principle conservation laws do not pose any constraints on possibly occurring real–p-adic transitions (Option A) if they occur between zero energy states.

   On the other hand, there are good hopes about the definition of p-adic variants of conserved quantities by algebraic continuation since the stringy quantal Noether charges make sense in all number fields if string world sheets are in the real–p-adic intersection. This continuation is indeed needed if quantum states have adelic structure (Option B). In accordance with this quantum classical correspondence (QCC) demands that the classical conserved quantities in the Cartan algebra of symmetries are equal to the eigenvalues of the quantal charges.

2. The starting point is the interpretation of fermions as correlates for Boolean cognition and p-adic space-time sheets space-time correlates for cognitions [K5]. Induced spinor fields are localized at string world sheets, which suggests that string world sheets and partonic 2-surfaces define cognitive representations in the intersection of realities and p-adicities. The space-time adele would have a book-like structure with the back of the book defined by string world sheets.

3. At the level of partonic 2-surfaces common rational points (or more generally common points in algebraic extension of rationals) correspond to the real–p-adic intersection. It is natural to identify the set of these points as the intersection of string world sheets and partonic 2-surfaces at the boundaries of CDs. These points would also correspond to the ends of strings connecting partonic 2-surfaces and the ends of fermion lines at the orbits of partonic 2-surfaces (at these surfaces the signature of the induced 4-metric changes). This would give a direct connection with fermions and Boolean cognition.

(a) For option A the interpretation is simple. The larger the number of points is, the higher the probability for the transitions to occur. This because the transition amplitude must involve the sum of amplitudes determined by data from the common points.

(b) For option B the number of common points measures the goodness of the particular cognitive representation but does not tell anything about the probability of any quantum transition. It however allows to discriminate between different p-adic primes using the precision of the cognitive representation as a criterion. For instance, the non-determinism of Kähler action could resemble p-adic non-determinism for some algebraic extension of p-adic number field for some value of p. Also the entanglement assignable to density matrix which is n-dimensional projector would be negentropic only if the p-adic prime defining the number theoretic entropy is divisor of n. Therefore also entangled quantum state would give a strong suggestion about the value of the optimal p-adic cognitive representation as that associated with the largest power of p appearing in n.

2.2 Could cognitive resolution fix the measurement resolution?

For p-adic numbers the algebraic extension used (roots of unity fix the resolution in angle degrees of freredom and pinary cutoffs fix the resolution in "radial" variables which are naturally positive. Could the character of quantum state or perhaps quantum transition fix measurement resolution uniquely?

1. If transitions (state function reductions) can occur only between different number fields (Option A), discretization is un-avoidable and unique if maximal. For real-real transitions the discretization would be motivated only by finite measurement resolution and need be neither necessary nor unique. Discretization is required and unique also if one requires adelic structure for the state space (Option B). Therefore both options A and B are allowed by this criterion.

2. For both options cognition and intention (if p-adic) would be one half of existence and sensory perception and motor actions would be second half of existence at fundamental level. The first half would correspond to sensory experience and motor action as time reversals of each other. This would be true even at the level of elementary particles, which would explain the amazing success of p-adic mass calculations.

3. For option A the state function reduction sequence would correspond to a formation of p-adic maps about real maps and real maps about p-adic maps: real $\rightarrow$ p-adic $\rightarrow$ real $\rightarrow$ ..... For option B it would correspond the sequence adelic $\rightarrow$ adelic $\rightarrow$ adelic $\rightarrow$ .....

4. For both options p-adic and real physics would be unified to single coherent whole at the fundamental level but the adelic option would be much simpler.

This kind of unification is highly suggestive - consider only the success of p-adic mass calculations - but I have not really seriously considered what it could mean.

2.3 What selects the preferred p-adic prime?

What determines the p-adic prime or preferred p-adic prime assignable to the system considered? Is it unique? Can it change?

1. An attractive hypothesis is that the most favorable p-adic prime is a factor of the integer n defining the dimension of the $n \times n$ density matrix associated with the flux tubes/fermionic strings connecting partonic 2-surfaces: the presence of fermionic strings already implies at least two partonic 2-surfaces. During the sequence of reductions at same boundary of CD n receives additional factors so that p cannot change. If wormhole contacts behave as magnetic monopoles there must be at least two of them connected by monopole flux tubes. This would give a connection with negentropic entanglement and for $h_{eff}/h = n$ to quantum criticality, dark matterm and hierarchy of inclusions of HFFs.

2. Second possibility is that the classical non-determinism making itself visible via super-symplectic invariance acting as broken conformal gauge invariance has same character as p-adic non-determinism for some value of p-adic prime. This would mean that p-adic space-time surfaces would be especially good representations of real space-time sheets. At the lowest level of hierarchy this would mean large number of common points. At higher levels large number of common parameter values in the algebraic extension of rationals in question.

2.4 How finite measurement resolution relates to hyper-finite factors?

The connection with hyper-finite factors suggests itself.

1. Negentropic entanglement can be said to be stabilized by finite cognitive resolution if hyper-finite factors are associated with the hierarchy of Planck constants and cognitive resolutions. For HFFs the projection to single ray of state space in state function reduction is replaced with a projection to an infinite-dimensional sub-space whose von Neumann dimension is not larger than one.

2. This raises interesting question. Could infinite integers constructible from infinite primes correspond to these infinite dimensions so that prime p would appear as a factor of this kind of infinite integer? One can say that for inclusions of hyperfinite factors the ratio of dimensions for including and included factors is quantum dimension which is algebraic number expressible in terms of quantum phase $q = exp(i2\pi/n)$. Could n correspond to the integer ratio $n = n_f/n_i$ for the integers characterizing the sub-algebra of super-symplectic algebra acting as gauge transformations?

3 About space-time correlates of cognition

In the following the idea about p-adic space-time surfaces as correlates is discussed more thoroughly in light of the recent progress in the understanding of fundamental TGD. The key outcome is that string world sheets can be seen as intersections of matter and cognition.

3.1 Generalizing the notion of p-adic space-time surface

The notion of p-adic manifold [K9] is an attempt to formulate p-adic space-time surfaces identified as preferred extremal of p-adic variants of p-adic field equations as cognitive charts of real space-time sheets. Here the essential point is that p-adic variants of field equations make sense: this is due to the fact that induced metric and induced gauge fields make sense (differential geometry exists p-adically unlike global geometry involving notions of lengths, area, etc does not exist: in particular the notion of angle and conformal invariance make sense).

The second key element is finite resolution so that p-adic chart map is not unique. Same applies to the real counterpart of p-adic extremal and having representation as space-time correlate for an intention realized as action.

The discretization of the entire space-time surface proposed in the formulation of p-adic manifold concept [K9] looks too naive an approach. It is plausible that one has an abstraction hierarchy for discretizations at various abstraction levels.

1. The simplest discretization would occur at space-time level only at partonic 2-surfaces in terms of string ends identified as algebraic points in the extension of p-adics used. For the boundaries of string world sheets at the orbits of partonic 2-surface one would have discretization for the parameters defining the boundary curve. By field equations this curve is actually a segment of light-like geodesic line and characterized by initial light-like 8-velocity, which should be therefore a number in algebraic extension of rationals. The string world sheets should have similar parameterization in terms of algebraic numbers.

   By conformal invariance the finite-dimensional conformal moduli spaces and topological invariants would characterize string world sheets and partonic 2-surfaces. The p-adic variant of Teichmueller parameters was indeed introduced in p-adic mass calculations and corresponds to the dominating contribution to the particle mass [K3, K1].

2. What might be called co-dimension 2 rule for discretization suggests itself. Partonic 2-surface would be replaced with the ends of fermion lines at it or equivalently: with the ends of space-like strings connecting partonic 2-surfaces at it. 3-D partonic orbit would be replaced with the fermion lines at it. 4-D space-time surface would be replaced with 2-D string world sheets. Number theoretically this would mean that one has always commutative tangent space. Physically the condition that em charge is well-defined for the spinor modes would demand co-dimension 2 rule.

3. This rule would reduce the real-p-adic correspondence at space-time level to construction of real and p-adic space-time surfaces as pairs to that for string

world sheets and partonic 2-surfaces determining algebraically the corresponding space-time surfaces as preferred extremals of Kähler action. Strong form of holography indeed leads to the vision that these geometric objects can be extended to 4-D space-time surface representing preferred extremals.

4. In accordance with the generalization of AdS/CFT correspondence to TGD framework cognitive representations for physics would involve only partonic 2-surfaces and string world sheets. This would tell more about cognition rather than Universe. The 2-D objects in question would be in the intersection of reality and p-adicities and define cognitive representations of 4-D physics. Both classical and quantum physics would be adelic.

5. Space-time surfaces would not be unique but possess a degeneracy corresponding to a sub-algebra of the super-symplectic algebra isomorphic to it and and acting as conformal gauge symmetries giving rise to n conformal gauge invariance classes. The conformal weights for the sub-algebra would be n-multiples of those for the entire algebra and n would correspond to the effective Planck constant $h_{eff}/h = n$. The hierarchy of quantum criticalities labelled by n would correspond to a hierarchy of cognitive resolutions defining measurement resolutions.

Clearly, very many big ideas behind TGD and TGD inspired theory of consciousness would have this picture as a Boolean intersection.

3.2 Number theoretic universality for cognitive representations

Number theoretic universality is one of the key principles of quantum TGD [K4]. In the following this principle is discussed in the light of the newest results about quantum TGD.

1. By number theoretic universality p-adic zero energy states should be formally similar to their real counterparts for option B. For option A the states between which real–p-adic transitions are highly probable would be similar. The states would have as basic building bricks the elements of the Yangian of the super-symplectic algebra associated with these strings which one can hope to be algebraically universal [K10].

2. Finite measurement resolution demands that all scattering amplitudes representing zero energy states involve discretization. In purely p-adic context this is unavoidable because the notion of integral is highly problematic. Residue integral is p-adically well-defined if one can deal with π.

   p-Adic integral can be defined as the algebraic continuation of real integral made possible by the notion of p-adic manifold and this works at least in the real–p-adic intersection. String world sheets would belong to the intersection if they are cognitive representations as the interpretation of fermions as correlates of Boolean cognition suggests. In this case there are excellent hopes that all real integrals can be continued to various p-adic sectors (which can involve algebraic extensions of p-adic number fields). Quantum TGD would be adelic. There are of course potential problems with transcendentals like powers of π.

3. Discrete Fourier analysis allows to define integration in angle degrees of freedom represented in terms of algebraic extension involving roots of unity. In purely p-adic context the notion of angle does not make sense but trigonometric functions make sense: the reason is that only the local aspect of geometry generalize characterized by metric generalize. The global aspects such as line length involving integral do not. One can however introduce algebraic extensions of p-adic numbers containing roots of unity and this gives rise to a realistic notion of trigonometric function. One can also define the counterpart of integration as discrete Fourier analysis in discretized angle degrees of freedom.

4. Maybe the 2-dimensionality of cognition has something to do with the fact that quaternions and octonions do not have p-adic counterpart (the p-adic norm squared of quaternion/octonion can vanish). I have earlier proposed that life and cognitive representations resides in real-p-adic intersection. Stringy description of TGD could be seen as number theoretically universal cognitive representation of 4-D physics. The best that the limitations of cognition allow to obtain. This hypothesis would also guarantee that various conserved quantal charges make sense both in real and p-adic sense as p-adic mass calculations demand.

4 Why p-adic intentionality does not reduce to quantum randomness?

The basic argument against quantal free will is that quantum non-determinism is basically randomness of a particular kind so that one can apply statistical determinism to predict the behavior for an ensemble of systems. The crucial question is whether also intentionality in the proposed sense reduces to randomness so that statistical determinism applies. One can imagine several mutually consistent approaches to the problem.

1. The notion of randomness is based on the notion of probability, and it could happen that the notion of probability simply does not make sense at all for a system exhibiting an intentional behavior or that the probabilities do not exist in the real sense but only as p-adic probabilities. Thus abnormal statistics might serve as a signature of an intentional system.

2. Intentionality involves free will and unpredictability in short time scales but predictability in long time scales. This could serve as a signature of an intentional system. Quantum-classical correspondence states that the dynamics of space-time surface mimics quantum dynamics and therefore also the dynamics of consciousness and intentionality. If so the behavioral patterns of an intentional system characterized by p-adic prime p should obey p-adic topology, which is a strong and testable prediction.

3. Zero Energy Ontology and the notion of negentropic entanglement provide a further perspective to the problem. Intentionality means goal directed behavior. NMP implies that the increase of negentropy is the universal goal. Universe builds negentropic entanglement servings as kind of Akashic records. One could therefore say that it is NMP that intends and wants. The outcome of the state function reduction at the opposite boundary of CD is forced by NMP and the plan for making it and the will to do do it should characterize the contents of consciousness associated with the self defined by a sequences of state function reductions at given boundary of CD. NMP also implies that the outcome of state function reduction is not random since entanglement negentropy is preserved or even increases. Of course, negentropic entanglement can be transferred between different systems.

4.1 p-Adic topology for time series as a signature of intentionality

Intentional behavior means that there is unpredictability in short time scales but predictability in long time scales because system can realize its long term plans and use its partially free will to cope with the changing challenges of the everyday life.

p-Adic topology could realize this idea.

1. The rational values of real and p-adic imbedding space coordinates correspond to the same points of the generalized imbedding space (essentially union of real and p-adic imbedding spaces for various values of p with common rational points identified).
2. The points, which are p-adically close to each other can have arbitrarily long real distance since the points x and $x + kp^n$, $k \in \{0, p-1\}$, become arbitrarily near to each other p-adically and arbitrarily far way in real sense as n increases for the p-adic topology characterized by prime p.

Thus p-adic long range fractal correlations could simply result from p-adic continuity. The local unpredictability would be mimicked by a discontinuous behavior in the real topology resulting from the fact that time values close to each other in the real sense are far from each other in p-adic sense.

p-Adic non-determinism means that integration constants of p-adic differential equations having by definition vanishing derivatives, are functions of the pinary cutoffs x_N defined as $x = \sum_k x_k p^k \to x_N = \sum_{k<N} x_k p^k$ of the arguments of the function. Since the rational values of real and p-adic coordinates correspond to same points of imbedding space, this means that p-adic non-determinism realizes intentionality by fixing the solution of field equations at a finite number of points below some real time (length) scale defined by N. The choice of these pseudo constants would characterize p-adic intentionality, the future plan of the system relatively stable against quantum jumps and the range of intentional action would be finite, which could explain why the young person in the geometry youth now cannot make choices affecting dramatically the geometric now decades later.

There is an analogous non-determinism also in the real sector due to the dramatic failure of the complete non-determinism of the basic action principle determining the dynamics of space-time surfaces. This non-determinism justifies the characterization of the real space-time sheets by a p-adic primes.

Consider now a situation in which some observables of might -be intentional system are measured as a function of time. Suppose that measurements are carried out at moments $t_n = n\Delta T$, $\Delta T = T/N_m$, where T is the duration of the experiment and N_m is the number of measurements.

1. With respect to the real topology the behavior of the system would look random in short time scales with violent discontinuities independently how precise the time resolution is made: fluctuations would actually become more violent with the improving time resolution.

2. p-Adic fractality would predict long range correlations over arbitrarily long time scales p^n in this kind of situation. Time values t and $t + rp^k\Delta T$ would be near to each other p-adically so that the values of the observables measured at these time values would be near to each other. Long range temporal correlations would thus quantify the ideas that will is not completely free and that intentionality implies an approximate predictability in long time scales. The fact that p-adic pseudo constants allow intentional free will only below some time and length scales, justifies the idea that our life is in long time scales determined by what might be called fate although we can make freely decisions in short time scales. The stability of the p-adic pseudo constants and pinary cutoff N in quantum jumps would also mean that the realization of p-adic intentions occurring subjectively now in my geometric childhood would not have dramatic implications in the geometric now.

3. p-Adic fractality would also mean that similar behavioral time patterns could repeat themselves as temporally scaled-up versions. Person would react in a similar manner in different time scales, say in stressing situation lasting for few minutes or many years. What is used to call as personality might have something to do with these fractal behavioral patterns. There is indeed statistical evidence for the possibility to predict much about the life cycle of a person from the behavioral patterns in childhood. The child who wants all now tends to become an adult who does the same. Some aspects of personality would perhaps represent something not invariant under time translations but under p-adic time scalings.

4.2 How statistical behavior could exhibit intentionality?

Consider an ensemble of consisting of N_m measurements of some observables of a system during a fixed time interval T occurring at equally spaced moments of time $t_n = n \times \Delta T$, $\Delta T = T/N_m$. Classify the measurements by some equivalence relation so that there are I possible outcomes and estimate the probabilities for the outcomes as rational numbers $p_i = n_i/N_m$, $\sum n_i = N_m$. When N_m becomes large one should obtain estimates for the probabilities of various instances labelled by $i = 1, ..., I$. The standard frequency interpretation of probability theory relies on the assumption is that these estimates converge in real topology so that the estimates $p(i, N_m + k) = n_i/N_m + k$, $k << N_m$ and $p(i, N_m) = n_i/N_m$ do not differ much for large values of N_m.

It is however quite possible that $p(N_m)$ converges in some p-adic topology which would mean that in the real topology the estimates would fluctuate wildly without any convergence, in a typically fractal manner. The estimates for probabilities would however converge p-adically in which case the system would be intentional and characterized by some p-adic prime p. The quantum-classical correspondence suggests that the sequence of N_m measurements performed for an intentional system during time interval T can be modelled as a sequence of measurements performed for a p-adic space-time sheet serving as its correlate. With this assumption one can immediately conclude that the estimates for the probabilities do not converge since various observables are continuous functions with respect to p-adic rather than real topology and ΔT does not approach zero at the limit $N_m \to \infty$ but fluctuates wildly. Only for N_m and $N_m + kp^n$ p-adic continuity guarantees that probabilities estimated in this manner are near each other.

It must be emphasized that the notion of p-adic probability based on frequency interpretation satisfies the Kolmogorov axioms as demonstrated by [A1] [A1]. The notion of resolution $\Delta T = T/N_m$ defining what $N_m \to \infty$ limit really means is an absolutely essential additional element. If one defines $N_m \to N_m+1$ as an addition of one additional measurement to existing sequence of measurements, the frequencies convergence to ordinary real probabilities with a given resolution since only one of the numbers n_i changes in $N_m \to N_m + 1$. The notion of resolution makes sense also in spatial degrees of freedom.

The notion of resolution is unavoidable already in quantum field theories in order to reduce degrees of freedom which are not directly experimentally detectable since the that measurement resolution is always finite. The notion of renormalization group realizes mathematically the notion of finite resolution [B1]. Thus resolution dependent statistics is not anything new. What is new is p-adicity and the long range correlations reducing to the p-adic continuity because of different concept of nearness. Note also that p-adically small structures have real sizes which are astrophysical so that cognition and intentionality are naturally astrophysical phenomena in accordance with the notions of magnetic body and ME.

These considerations suggests how one could try to demonstrate p-adic intentionality experimentally.

1. One might hope of demonstrating that intentional systems behave apparently randomly in short time scales but that there are long range temporal correlations in time scales $t_n = p^n\Delta T$, $\Delta T = T/N_m$. Wild fluctuation of the probability estimates as function of N_m is a direct signature of intentionality. The approximate invariance of the frequencies under the transformations $N_m \to N_m + p^n\Delta T$ in turn allow to identify the value p. This approach could be used to prove the presence of the p-adic intentionality even at the molecular level or at level of say solar and planetary magnetospheres by studying the temporal behavior of the fluctuations of magnetic fields. For instance, it is known that solar magnetic field has what might be called memory [E1], which should not be there if it were really random. For tornadoes the presence of short range chaos and long range order in at at least spatial degrees of freedom

is obvious. Period doubling in the systems approaching chaos could be a signature for the appearance of 2-adic intentionality in increasingly longer time scales. Also $1/f$ noise, not really understood in standard physics framework, might be related to intentionality.

2. One could also test the number theoretic information measures suggested by the p-adic approach using preferred resolutions defined by $N_m = kp^n$. Number theoretic information measures make sense for rational valued probabilities, and are obtained from Shannon entropy by replacing ordinary logarithm with the p-adic logarithm $Log_p(x) = log(|x|_p) = log(p^k) = klog(p)$ to get $S_p = -\sum_n p_n Log_p(p_n)$. The number theoretic entropies can have also negative values in which case one can say that the ensemble contains genuine information.

4.3 How the p-adic primes involved with intentionality and ordinary physics are related?

In real physics the p-adic primes involved are very large, for instance, $p = 2^{127}-1$ for electron. These large primes however labels real space-time sheets and characterize their fractality and *effective* p-adic topology. p-Adic length scale hypothesis in its basic form predicts that primary and n-ary length/time scales correspond to powers of $\sqrt{2}$ of the fundamental p-adic length/time scales so that 2-adic fractality would indeed be realized in this sense. Besides the basic units for time and length also their integer multiples can take the role of the basic unit, this of course in accordance with the very notion of fractality.

Small primes would characterize p-adic space-time sheets serving as correlates of intentions. It seems that only relatively small values p, $p = 2$ being the simplest guess, are realized as far as intentionality is considered. The octaves in music realize 2-adic fractality and it might not be an accident that binary mathematics is mathematics of computation.

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