The Recent TGD Inspired View about Higgs

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Abstract

The existence of Higgs and its identification have been continual source of head ache in TGD framework. The vision which looks most plausible at this moment is rather conservative in the sense that it assumes that standard description of massivation using Higgs in QFT framework is the only possible one: if TGD has QFT limit, then Higgs provides a phenomenological parametrization of particle masses providing a mimicry for the microscopic description relying on p-adic thermodynamics. The anomalies related to Higgs are however still there. A new explanatory piece in the puzzle is M_{89} hadron physics. The gamma ray background from the decays of M_{89} pions could explain the anomalous decay rate to gamma pairs and the problemsrelated to the determination of Higgs mass. It could explain also the production of highly correlated charged particle pairs observed first at RHIC for colliding heavy ions and two years ago at LHC for proton heavy-ion collisions as decay products of string like objects of M_{89} hadron physics, the observations of Fermi satellite, and maybe even the latest Christmas rumour suggesting the

existence of charge 2 states decaying to lepton pairs by identifying them as leptomeson formed from two color octet muons and produced ivia intermediate parallel gluon pairs n the decay of M_{89} mesonic strings to ordinary hadrons and leptons.

1 Introduction

Higgs has been a stone in the toe of TGD. The theoretical problem has been the lack of classical space-time correlate for it. No wonder that in the case of Higgs I have developed a large number of alternative scenarios with and without Higgs like particle. I have indeed considered many alternatives [K8] such as no Higgs like state at all, Higgs as the pion of what I call M_{89} hadron physics, Higgs like state as pseudoscalar, and finally Higgs like state as a scalar plus M_{89} hadron physics. The observed too high rate for the decays of Higgs to gamma pairs has been a guiding line in these attempts.

At this moment it seems clear that Higgs like particle exists although it is far from clear whether it has standard model couplings. If TGD has QFT limit and if one believes that Higgs mechanism is the only manner to model the particle massivation in QFT context, then Higgs mechanism would provide a mimicry of p-adic massivation but not its fundamental description. p-Adic thermodynamics is required for a microscopic description. Higgs vacuum expectation could have space-time counterpart at microscopic level and correspond to CP_2 part for the trace of the second fundamental form assignable to string world sheet (if string world sheet is minimal surface in space-time as one might expect, it is not minimal surface in imbedding space (meaning vanishing Higgs expectation) except under very special conditions).

The following sections describe first the basic ideas behind p-adic mass calculations. After that I describe the evolution of the vision about Higgs like state in TGD framework during last months as blog postings reflect it so that some repetitions are unavoidable. Also the recent observations providing support for M_{89} hadron physics are discussed.

2 About the basic assumptions behind p-adic mass calculations

The motivation for this piece of text was the basic horror experience of theoretician waking him up at early morning hours. Is s there something wrong with basic assumptions of some particular piece of theory? At this time it was p-adic thermodynamics. Theoretician tries to figure this out in a drowsy state between wake-up and sleep, fails repeatedly, and blames the mighties of the Universe for his miserable fate as eternal doubter. Eventually merciful sleep arrives and theoretician wakes up in the morning, recalls the problem and feels that nothing is wrong. But theoretician knows that it is better to check everything once again.

So that this is what I am doing in the sequel: listing and challenging the basic assumptions and philosophy behind p-adic mass calculations. As always in this kind of situation, I prefer to think it allover again rather than finding what I have written earlier: reader can check whether the recent me agrees with the earlier me. This list is not the only one that I have made during these years and other, possibly different, lists can be found in the chapters of various books. Although the results of calculations are unique and involve only very general assumptions, the guessing of the detailed physical picture behind them is difficult.

I hope that this piece of text would also help to understand better how p-adic mass calculations as a microscopic theory and the standard description of Higgs mechanism as a phenomenological low energy parameterization relate to each other.

2.1 Why p-adic thermodynamics?

p-Adic thermodynamics is a fundamental assumption behind the p-adic mass calculations [K3]: p-adic mass squared is identified as a thermal average of mass squared for super-conformal representation with p-adic mass squared given essentially by the conformal weight.

Zero energy ontology (ZEO) has gradually gained a status of second fundamental assumption. In fact, ZEO strongly suggests the replacement of p-adic thermodynamics with its "complex square root" so that one would be actually considering genuine quantum states squaring to thermodynamical states. This idea looks highly satisfactory for anyone used to think that elementary particles cannot be thermodynamical objects. The square root of p-adic thermodynamics raises delicate number theoretical issues [K6] since the p-adic square root of the conformal weight having value p does not exist without a proper algebraic extension of p-adic numbers leading to algebraic integers and generalized notion of primeness.

Q: Why p-adic thermodynamics, which predicts the thermal expectation of p-adic mass squared and requires the mapping of p-adic valued mass squared to real mass squared by some variant of canonical identification?

A: Number theoretical universality requires fusion of real and p-adic number based physics for various primes so that p-adic thermodynamics becomes natural.

1. The answer inspired by TGD inspired theory of consciousness would be that the interaction of p-adic space-time sheets serving as correlates of cognition with real space-time sheets representing matter makes p-adic topology effective topology in some length scale range also for real space-time sheets (as an effective topology for discretization). One could even speak about cognitive representations of elementary particles using the rational or algebraic intersections of real and p-adic space-time sheets. These cognitive representations are very simple in p-adic topology and it is easy to calculate the masses of the particles using p-adic thermodynamics. Since representation is in question, the result should characterize also real particle.

2. The pragmatic answer would be that p-adic thermodynamics gives extremely powerful number theoretical constraints leading to the quantization of mass scales and masses with p-adic temperature $T = 1/n$ and p-adic prime appearing as free parameters. Also conformal invariance is strongly favored since the counterpart of Hamiltonian must be integer valued as the super-conformal scaling generator indeed is.

3. By number theoretical universality one can require that the p-adic mass thermodynamics is equivalent with real thermodynamics for real mass squared. This is the case if partition function has cutoff so that conformal weights only up to some maximum value N are allowed. This has no practical consequences since the real-valued contribution from the conformal weight n is proportional to $p^{-n+1/2}$ and for $n > 2$ is completely negligible since the primes involved are so large ($p = M_{127} = 2^{127} - 1$ for electron for instance).

Q: Is the canonical identification mapping the p-adic mass squared to real mass squared unique? This is not the case. One can imagine a family of identification for which integers $n < p^N$, $N = 1, 2, ...$ are mapped to itself. This however has no practical implications for the calculations since the values of primes involved are so large.

The calculations themselves assume only p-adic thermodynamics and super-conformal invariance. The most important thing that matters is the number of tensor factors in the tensor product of representations of conformal algebra, which must be *five*.

Q: What are the fundamental conformal algebras giving rise to the super conformal symmetries?

A: There are two conformal algebras involved.

1. The symplectic algebra of $\delta M^4_\pm \times CP_2$ has the formal structure of Kac-Moody algebra with the light-like radial coordinate r of the light-cone boundary $\delta M^4_\pm$ taking the role of complex coordinate z. It has symplectic algebras of CP_2 and sphere S^2 of light-cone boundary as building blocks taking the role of the finite-dimensional Lie group defining Kac-Moody algebra. This algebra has not in string models.

2. There is also the Kac-Moody algebra assignable to the light-like wormhole throats and assignable to the isometries of the imbedding space having M^4 and CP_2 isometries as factors. There are also electroweak symmetries acting on spinor fields. In fact, the construction of the solutions of the modified Dirac equation [K9] suggests that electroweak and color gauge symmetries become Kac-Moody symmetries in TGD framework. In practice this means that only the generators with positive conformal weight annihilate the physical states. For gauge symmetry also those with negative conformal weight annihilate the physical states.

   One can of course ask whether also $SU(2)$ sub-algebra of SL(2,C) acting on spinors should be counted. One could argue that this is not the case since spin does correspond to gauge or Kac-Moody symmetry as electroweak quantum numbers do.

Q: One must have five tensor factors. How should one count the number of tensor factors, in other words what is the basic building brick to which one identifieds as a tensor factor of Super-Virasoro algebra?

A: One can imagine two options.

1. The most general option is that one takes the CP_2 and S^2 symplectic algebras as factors in the symplectic sector. In Kac-Moody sector one has $E^2 \subset M^4$ isometries (longitudinal degrees of freedom of string world sheet carrying induce spinors fields are not physical) and $SU(3)$. Besides this one has electroweak algebra $U(2)$, which almost but quite not decomposes to $SU(2)_L \times U(1)$ (there are correlations between $SU(2)_L$ and $U(1)$ quantum numbers and the existence of spinor structure of CP_2 makes also these correlations manifest). This would give 5 tensor factors as required.

2. I have also considered Cartan algebras as separate tensor factors. I must confess, that at this moment I am unable to rediscover what my motivation for this actually has been. This would give a larger number of tensor factors: 1+2 factors in symplectic sector from Cartan algebras of $SO(3) \times SU(3)$ defining subgroup of symplectic group, 2+2 for isometries in Kac-Moody sector from E^2 and $SU(3)$, and 1+1 in the electroweak sector with spin giving a possible further factor. This means 9 (or possibly 10) factors so that thermalization is not possible for all Cartan algebra factors. Symplectic sectors are certainly a natural candidate in this respect so that one would have 5 as required (or 6 if spin is allowed to have Kac-Moody structure) sectors.

The first option looks more convincing to me.

2.2 How to understand the conformal weight of the ground state?

Ground state conformal weight which is non-positive can receives various contributions. One contribution is negative and therefore corresponds to a tachyonic mass squared, second contribution corresponds to CP_2 cm degrees of freedom and together with the momentum squared boils down to an eigenvalue of the square of spinor d'Alembertian for $H = M^4 \times CP_2$ (by bosonic emergence). Third one comes from the conformal moduli of the partonic 2-surface at the end of the space-time sheet at light-like boundary of causal diamond and distinguishes between different fermion families.

Q: Tachyonic ground state mass does not look physical and is quite generally seen as a serious - if not lethal - problem also in string models. What is the origin of the tachyonic contribution to the mass squared in TGD framework?

A: The recent picture about elementary particles is as lines of generalized Feynman diagram identified as space-time regions with Euclidian signature of the induced metric. In this regions mass squared is naturally negative and it is natural to think that ground state mass squared receives contributions from both Euclidian and Mionkowskian regions. If so, the necessary tachyonic contribution would be a direct signal for the presence of the Euclidian regions, which have actually turned out to define a generalization of blackhole interior and be assignable to any system as a space-time sheet characterizing the system geometrically [L2]. For instance, my own body as I experience it would correspond to my personal Euclidian space-time seet as a line of generalized Feynman diagram.

Q: Where does the $H = M^4 \times CP_2$ contribution to the scaling generator L_0 assignable to spinor partial waves in H come from?

A: Zero energy ontology (ZEO) allows to assign to each particle a causal diamond CD and according to the recent view [K1] emerging from the analysis of the relationship between subjective (experienced) time and geometric time, particle is characterized by a quantum superposition of CDs. Every state function reduction means localization of the upper of lower tip of all CDs in the superposition and delocalization of the other tip. The position of the upper tip has wave function in $H_\pm = M^4_\pm \times CP_2$ and there is a great temptation to identify the wave function as being induced from a partial wave in $H = M^4 \times CP_2$. As a matter fact, number theoretic arguments and arguments related to finite measurement resolution strongly suggest discretization of $H_\pm$. $M^4_\pm$ would be replaced with a union of hyperboloids with a distance from the tip of $M^4_\pm$ which is quantized as a multiple of CP_2 radius. Furthermore at each hyperboloid the allowed points would correspond to the orbit of some discrete subgroup of $SL(2,C)$. CP_2 would be also discretized.

2.3 What about Lorentz invariance?

The square root of p-adic thermodynamics implies quantum superposition of states with different values of mass squared and hence four-momenta. In ZEO this does not mean obvious breaking of Lorentz invariance since physical states have vanishing total energy. Note that coherent states of Cooper pairs, which in ordinary ontology would have both ill-defined energy and fermion number, have a natural interpretation in ZEO.

1. A natural assumption is that the state in the rest system involves only a superposition of states with vanishing three-momentum. For Lorentz boosts the state would be a superposition of states with different three-momenta but same velocity. Classically the assumption about same 3-velocity is natural.

   Q: Could Lorentz invariance break down by the presence of the superposition of different momenta?

   A: This is not the case if only the average four-momentum is observable. The reason is that average four-momentum transforms linearly under Lorentz boosts. I have earlier considered the possibility of replacing momentum squared with conformal weight but this option looks somewhat artificial and even wrong to me now.

2. The decomposition $M^4 = M^2 \times E^2$ is fundamental in the formulation of quantum TGD, in the number theoretical vision about TGD, in the construction of preferred extremals, and for the vision about generalized Feynman diagrams. It is also fundamental in the decomposition of the degrees of string to longitudinal and transversal ones. An additional item to the list is that also the states appearing in thermodynamical ensemble in p-adic thermodynamics correspond to four-momenta in M^2 fixed by the direction of the Lorentz boost.

   Q: Can one find a concrete identification for $M^2 \times E^2$ decomposition at the level of preferred extremals? Could these preferred extremals be interpreted as the internal lines of generalized Feynman diagrams carrying massless momenta? Could one identify the mass of particle predicted by p-adic thermodynamics with the sum of massless classical momenta assignable to two preferred extremals of this kind connected by wormhole contacts defining the elementary particle?

   A: Candidates for this kind of preferred extremals indeed exist. Local $M^2 \times E^2$ decomposition and light-like longitudinal massless momentum assignable to M^2 characterizes "massless extremals" (MEs, "topological light rays"). The simplest MEs correspond to single space-time sheet carrying a conserved light-like M^2 momentum. For several MEs connected by wormhole contacts the longitudinal massless momenta are not conserved anymore but their sum defines a time-like conserved four-momentum: one has a bound states of massless MEs. The stable wormhole contacts binding MEs together possess Kähler magnetic charge and serve as building bricks of elementary particles. Particles are necessary closed magnetic flux tubes having two wormhole contacts at their ends and connecting the two MEs. The sum of the classical massless momenta assignable to the pair of MEs is conserved even when they exchange momentum. Quantum classical correspondence suggests that the conserved classical rest energy of the particle equals to to the prediction of p-adic mass calculations. The massless momenta assignable to MEs would naturally correspond to the massless momenta propagating along the internal lines of generalized Feynman diagrams assumed in zero energy ontology. Note that massless-ness of virtual particles makes also possible twistor approach.

   Q: In parton model of hadrons it is assumed that the partons have a distribution with respect to longitudinal momentum, which means that the velocities of partons are same along the direction of motion of hadron. Could one have p-adic thermodynamics for hadrons?

   A: For hadronic p-adic thermodynamics the value of the string tension parameter would be much smaller and the thermal contributions from $n > 0$ states would be completely negligible so that the idea does not look good. In p-adic thermodynamics for elementary particles one would have distribution coming from different values of p-adic mass squared which is integer valued apart from ground state configuration.

2.4 What are the fundamental dynamical objects?

The original assumption was that elementary particles correspond to wormhole throats. With the discovery of the weak form of electric-magnetic duality came the realization that wormhole throat is homological magnetic monopole (rather than Dirac monopole) and must therefore have (Kähler) magnetic charge. Magnetic flux lines must be however closed so that the wormhole throat must be associated with closed flux loop.

The most natural assumption is that this loop connects two wormhole throats at the first space-time sheet, that the flux goes through a second wormhole contact to another sheet, returns back along second flux tube, and eventually is transferred to the original throat along the first wormhole contact.

The solutions of the Modified Dirac equation [K9] assign to this flux tube string like curve as a boundary of string world sheet carrying the induced fermion field. This closed string has "short" portions assignable to wormhole contacts and "long" portions corresponding to the flux tubes connecting the two wormhole contacts. One can assign a string tension defined by CP_2 scale with the "short" portions of the string and string tension defined by the primary or perhaps secondary p-adic length scale to the "long" portions of the closed string.

Also the "long" portion of the string can contribute to the mass of the elementary particle as a contribution to the vacuum conformal weight. In the case of weak gauge bosons this would be the case and since the contribution is naturally proportional to gauge couplings strength of W/Z boson one could understand Q/Z mass ratio if the p-adic thermodynamics gives a very small contribution from the "short" piece of string (also photon would receive this small contributionin ZEO): this is the case if one must have $T = 1/2$ for gauge bosons. Note that "long" portion of string can contribute also to fermion masses a small shift. Hence no Higgs vacuum expectation value or coherent state of Higgs would be needed although Higgs expectation could parametrize this contribution phenomenologically.

There are two options for the interpretation of Higgs like state after the results of Kyoto conference to be discussed below.

1. For option I Higgs vacuum expectation identifiable in terms of coherent state gives a dominating contribution to gauge boson masses besides the small contribution of p-adic thermodynamics whereas fermionic masses are predicted by p-adic mass calculations alone.

2. For option II p-adic thermodynamics describes the situation microscopically for both fermions and bosons and Higgs mechanism emerges as an ffective description of particle massivation at QFT limit of the theory and both gauge fields and Higgs fields and its vacuum expectation exist only as constructs making sense at QFT limit. Higgs like particles do of course exist. Also Higgs vacuum expectation has space-time correlate: a possible identification is as CP_2 part of the trace of the second fundamental form for string world sheets regarded as 2-surfaces in imbedding space. At WCW limit various fields are replaced by WCW spinor fields as fundamental object.

Q: One can consider several identifications of the fundamental dynamical object of p-adic mass calculations. Either as a wormhole throat (in the case of fermions for which either wormhole throat carries the fermion quantum number this looks natural), as entire wormhole contact, or as the entire flux tube having two wormhole contacts. Which one of these options is correct?

A: The strong analogy with string model implied by the presence of fermionic string world sheet would support that the identification as entire flux tube in which case the large masses for higher conformal excitations could be interpreted in terms of string tension. Note that this is the only possibility in case of gauge bosons.

Q: What about p-adic thermodynamics or its square root in hadronic scale?

A: As noticed the contributions from $n > 0$ conformal excitations would be extremely small in p-adic thermodynamics for "long" portions. It would seem that this contribution is non-thermal and comes from each value of n labelling states in Regge trajectory separately just as in old-fashioned string model. Even weak bosons would have Regge trajectories. The dominant contribution to the hadron mass can be assigned to the magnetic body of the hadron consisting of Kähler magnetic flux tubes. The Kähler-magnetic (or equivalently color-magnetic) flux tubes connecting valence quarks can contribute to the mass squared of hadron. I have also considered the possibility that symplectic conformal symmetries distinguishing between TGD and superstring models could be responsible for a contribution identifiable as color magnetic energy of hadron classically.

3 Two options for Higgs like states in TGD framework

HCP2012 conference (Hadron Collider Physics Symposium) at Kyoto will provide new data about Higgs candidate at next Wednesday. Resonaances [C4] has summarized the basic problem related to the interpretation as standard model Higgs: two high yield of gamma pairs and too low yield of $\tau\overline{\tau}$ and and $b\overline{b}$ pairs. It is of course possible that higher statistics changes the situation.

3.1 Two options concerning the interpretation of Higgs like particle in TGD framework

Theoretically the situation quite intricate. The basic starting point is that the original p-adic mass calculations provided excellent predictions for fermion masses. For the gauge bosons the situation was different: a natural prediction for the W/Z mass ratio in terms of Weinberg angle is the fundamental prediction of Higgs mechanism and this prediction did not follow automatically from the p-adic mass calculation in the original form. Classical Higgs field does not seem to have any natural counterpart in the geometry of space-time surface (the trace of the second fundamental form does not work since it vanishes for preferred extremals which are also minimal surfaces). This raised the question whether there is any Higgs boson in TGD Universe and for some time I took seriously the interpretation of the Higgs like state observed by LHC as a pion of M_{89}. To sum up, the evolution of ideas about TGD counterpart of Higgs mechanism [K8] has been full of twists and turns. This summary is warmly recommended for a seriously interested reader.

p-Adic mass calculations and the results from LHC leave two options under consideration.

1. Option I: Only fermions get the dominating contribution to their masses from p-adic thermodynamics and in the case of gauge bosons the dominating contribution is due to the standard Higgs mechanism. p-Adic thermodynamics would contribute also to the boson masses, in particular photon mass but the contribution would be extremely small and correspond to p-adic temperature $T = 1/n$, $n \geq 2$. For this option only gauge bosons would have standard model couplings to Higgs whereas fermionic couplings could be small. Of course, standard model couplings proportional to fermion mass are also possible. One can criticize this option because fermions and bosons are in an asymmetric position. The beautiful feature is that one could get rid of the hierarchy problem due to the couplings of Higgs to heavy fermions.

2. Option II: p-Adic mass calculations explain also the masses of gauge bosons and Higgs like particle. If Higgs like state develops a coherent state describable in terms of vacuum expectation value as M^4 QFT limit, this expectation value is determined by the mass spectrum determine by the p-adic mass calculations. The mass spectrum of particles determines Higgs expectation and the couplings of Higgs rather than vice versa! For this option Weinberg angle would be *defined* by the ratio of W and Z boson mass as $cos^2(\theta_W) = m_W^2/m_Z^2$ and these masses should be given by p-adic mass calculations.

   The recent view about particles as Kähler magnetic loops carrying monopole flux is forced by the assumption that the corresponding partonic 2-surfaces are Kähler magnetic monopoles (implied by the weak form of electric-magnetic duality). The loop proceeds from wormhole throat to another one, then traverses along wormhole contact to another space-time sheet and returns back and eventually is transferred to the first sheet via wormhole contact. The mass squared assignable to this flux loop could give the contribution usually assigned to Higgs vacuum expectation. If this picture is correct, then the reduction of the W/Z mass ratio to Weinberg angle might be much easier to understand. As a matter fact, I have proposed that the flux loop gives rise to a stringy spectrum of states with string tension determined by p-adic length scale associated with M_{89}.

   This option is attractive because fermions and bosons are in an exactly same position. Hierarchy problem is possible problem of this approach: note however that the considerations in the sequel imply that standard model action is predicted to be an effective action giving only tree diagrams so that there are no radiative corrections at M^4 QFT limit.

The original interpretation of Higgs like state was oas M_{89} pion. The recent observations from Fermi telescope [C12, C11] suggest the existence of a boson with mass 135 GeV. It would be a good candidate for M_{89} pion. One can test the hypothesis by scaling the mass of ordinary neutral pion, which corresponds to M_{107}. The scaling gives mass 69.11 GeV. p-Adic length scale however allows also octaves of the minimum mass (they appear for leptopions) and scaling by two gives mass equal to 138.22 GeV not too far from 135 GeV.

There is also second encouraging numerical co-incidence. It is probably not an accident that Higgs vacuum expectation value corresponds to the minimum mass for $p = M_{89}$ if the p-adic counterpart of Higgs expectation squared is of order $O(p)$ in other words one has $\mu^2/m^2_{CP_2} = p = M_{89}$.

My sincere hope is that the results of HCP2012 would allow to distinguish between these two options.

3.2 Microscopic description of gauge bosons and Higgs like and meson like states

Under the pressures from LHC it has become gradually clear that the understanding of whether TGD has M^4 QFT limit or not, and how this limit can be defined, is essential for the understanding also the role of Higgs. In the following a first attempt to understand this limit is made. I find it somewhat surprising that I am making this attempt only now but the understanding of the proper role of the classical gauge potentials has been quite a challenge.

1. If one believes that M^4 QFT is a good approximation to TGD at low energy limit then the standard description of Higgs mechanism seems to be the only possibility: this just on purely mathematical grounds. The interpretation would however be that the masses of the particles determine Higgs vacuum expectation value and Higgs couplings rather than vice versa. This would of course be nothing unheard in the history of physics: the emergence of a microscopic theory - in the recent case p-adic thermodynamics - would force to change the direction of the causal arrow in "Higgs makes particles massive" to that in "Higgs expectation is determined by particle masses".

2. The existence of M^4 QFT limit is an intricate issue. In TGD Universe baryon and lepton number correspond to different chiralities of $H = M^4 \times CP_2$ spinors and this means that Higgs like state cannot be H scalar (it would be lepto-quark in this case). Rather, Higgs like state must be a vector in CP_2 tangent space degrees of freedom. One can indeed construct a candidate for a Higgs like state as an Euclidian pion or its scalar counterpart: both are possible and one can even consider the mixture of them. The H-counterpart of Higgs like state is therefore CP_2 axial vector or CP_2 vector or mixture of them.

   Euclidian pion or scalar carries fermion and anti-fermion at opposite throat of the wormhole contact. It is easy to imagine that a coherent state of Euclidian pseudo-scalars or scalars or their mixture having Higgs expectation as M^4 QFT correlate is formed. This state transforms as $2 \oplus \overline{2}$ under $U(2 \subset SU(3)$ identifiable as weak gauge group. This representation is natural in Euclidian regions Higgs as a tangent space vector of CP_2 has naturally $2 \oplus \overline{2}$ decomposition in tangent space of CP_2 allowing an interpretation as Lie algebra complement of $u(2) \subset su(3)$.

   In Minkowskian regions CP_2 projection is 3-D and a natural counterpart of Higgs would be pseudo-scalar (or scalar) transforming as $3 \oplus 1$ and $U(2 \subset SU(3)$ identifiable now as strong U(2). The 3-dimensionality of the M^4 projection suggests that one obtains only the triplet state.

3. By bosonic emergence also gauge bosons correspond at microscopic level to fermion and anti-fermion at opposite throats of wormhole contacts. Meson like states in turn correspond to fermion and anti-fermion at the ends of a flux tube connecting throats of two different wormhole contacts so that both Higgs, gauge bosons, and meson-like states are obtained using similar construction recipe.

4. The popular statement "gauge bosons eat almost all Higgs components" makes sense at the M^4 QFT limit.: just a transition to the unitary gauge effectively eliminates all but one of the components of the Higgs like state and gauge bosons get third polarization. This means gauge boson massivation but for option II it would take place already in p-adic thermodynamics in ZEO (zero energy ontology).

3.3 To deeper waters

Higgs issue seems to divide theoreticians to two classes: the simple-minded pragmatists and real thinkers.

For pragmatists the existence of Higgs and Higgs mechanism is something absolute: Higgs exists of not and one can make a bet about it. Most bloggers and most phenomenologists applying numerical models belong to this group. In particular, bloggers have had heated discussions and have made bets pro and and co, mostly pro.

Thinkers see the situation in a wider perspective. The real issue is the status of quantum field theory as a description of fundamental forces. Is QFT something fundamental or is it only a low energy limit of a more fundamental microscopic theory? Could it even happen that QFT limit fails in some respects and could the description of particle massivation represent such an aspect?

Already string models taught (or at least should have taught) to see quantum field theory as an effective description of a microscopic theory working at low energy limit. Since string theorists have not been able cook up any convincing answer to the layman's innocent question "How would you describe atom using these tiny strings which are so awe inspiring?", QFT limits have become what string models actually are at the phenomenological level. AdS-CFT correspondence actually equates string theory with a conformal quantum field theory in Minkowski space so that hopes about genuine microscopic theory are lost. This is disappointing but not surprising since strings are still too simple: they are either open or closed, there is no interesting internal topology.

In TGD framework string world sheets are replaced with 4-D space-time surfaces. One ends up with a very concrete vision about matter based on the notion of many-sheeted space-time and the implications are highly non-trivial in all scales. For instance, blackhole interior is replaced with a space-time region with Euclidian signature of the induced metric characterizing any physical system be it elementary particle, condensed matter system, or astrophysical object. Therefore the key question becomes the following. Does TGD have QFT in M^4 as low energy limit or rather - as a limit holding true in a given scale in the infinite length scale hierarchies predicted by theory (p-adic length scale hierarchy and hierarchy of effective Planck constants and hierarchy of causal diamonds)?

3.3.1 Deeper question: Does QFT limit of the fundamental theory exist?

Could the QFT limit defined as QFT in M^4 fail to exist? After this question one cannot avoid questions about the character of Higgs and Higgs mechanism.

1. It is quite possible that in QFT framework Higgs mechanism is the only description of particle massivation. But this is just a mimicry, not a predictive description. QFT limit can only reproduce the spectrum of elementary particles masses or rather - mass ratios. The ratio of Planck mass (also an ad hoc concept) to proton mass remains a complete mystery.

   This failure has been convincingly demonstrated by a huge amount of work in particle phenomenology. First came the GUT theorists. They applied every imaginable gauge group with elementary particles put in all imaginable group representations to reproduce the known part of the particle spectrum. They have reproduced standard model gauge symmetries at low energy limit. They have also done the necessary fine-tuning to make proton long-lived enough, to give large enough masses for the exotics, and to make beta functions sensical.

   The same procedures have been repeated in SUSY framework and finally super string phenomenology has produced QFT limits with Higgs mechanism, and are now doing intense fine tuning to save poor SUSY from the aggressive attacks by LHC. During these 40 years of busy modeling practically nothing has been achieved but the work goes on since theoreticians have their methods and they must produce highly technical papers to preserve the illusion of hard science.

2. Higgs mechanism is also plagued by profound problems. The hierarchy problem means that the Higgs mechanism with mass of about 125 GeV is just at the border of stability. The problem is that the sign of mass squared term in Higgs potential can change by radiative corrections so that the vacuum with a vanishing Higgs expectation value becomes stable. SUSY was hoped to solve the hierarchy problem but LHC has made SUSY in standard sense implausible. Even if it exists cannot help in this issue. Another problem is that the coefficients of the fourth power

in the Higgs potential can become negative so that vacuum becomes unstable: the bottom of a valley becomes top of a hill. The value of Higgs mass is such that also this seems to happen: see the posting of Resonaances [C7]!

Quite generally, fine tuning problems are the characteristic issues of the QFT limit. Proton must be long-lived enough, baryon and lepton number violating decay rates cannot be too high, the predicted exotic particles implied by the extension of the standard model gauge group must be massive enough, and so on... This requires a lot of fine tunng. Theory has transformed from a healer to a patient: the efforts of theoreticians reduce to attempts to resuscitate the patient. All this becomes understandable as one realizes that QFT is just a mimicry, not the fundamental theory.

One could also see these two problems of the Higgs mechanism as the last attempt of the frustrated Nature to signal to the busy mainstream career builders something very profound about reality by using paradox as its last means. From TGD vantage point the intended message of Nature looks quite obvious.

3.3.2 Trying to understand the QFT limit of TGD

The counterparts of gauge potentials and Higgs field are not needed in the microscopic description if p-adic thermodynamics gives the masses so that the gauge potentials and Higgs field should emerge only at M^4 QFT limit. It is not even necessary to speak about Higgs and YM parts of the action at the microscopic level. The functional integral defined by the vacuum function expressed as exponent of Kähler action for preferred extremals to which couplings of microscopic expressions of particles in terms of fermions coupled to the effective fields describing them at QFT limit should define the effective action at QFT limit.

The basic recipe is simple.

1. Start from the vacuum functional which is exponent of Kähler action for preferred extremals with Euclidian regions giving real exponent and Minkowskian regions imaginary exponent.
2. Add to this action terms which are bilinear in the microscopic expression for the particle state and the corresponding effective field appearing in the effective action.
3. Perform the functional integration over WCW ("world of classical worlds") and take vacuum expectation value in fermionic degrees of freedom.
4. This gives an effective field theory in $M^4 \times CP_2$. To get M^4 QFT integrate over CP_2 degrees of freedom in the action. This dimensional reduction is similar to what occurs in Kaluza-Klein theories.

The functional integration of WCW induces also integration of induced spinor fields which apart from right-handed neutrino are restricted to the string world sheets. In principle induced spinor fields could be non-vanishing also at partonic 2-surfaces but simple physical considerations suggest that they are restricted to the intersection points of partonic 2-surfaces and string world sheets defining the ends of braid strands. Therefore the effective spinor fields Ψ_{eff} would appear only at braid ends in the integration over WCW and one has good hopes of performing the functional integral.

1. One can assign to the induced spinor fields Ψ imbedding space spinor fields Ψ_{eff} appearing in the effective action. The dimensions of Ψ and Ψ_{eff} are $1/L^{3/2}$. A dimensionally correct guess is the term $\int d^2x\sqrt{g_2}\overline{\Psi_{eff}}(P)D^{-1}\Psi + h.c$, where Γ^α denotes the induced gamma matrices, P denotes the end point of a braid strand at the wormhole throat, and D denotes the "ordinary" massless Dirac operator $\Gamma^\alpha D_\alpha$ for the induced gamma matrices. Propagator contributes dimension L and is well-defined since Ψ is not annihilated by D but by the modified Dirac operator in which modified gamma matrices defined by the modified Dirac action appear. Note that internal consistency does not allow the replacement of Kähler action with four-volume. Integral over the second wormhole throat contributes dimension L^2. Therefore the outcome is a dimensionless finite quantity, which reduces to the value of integrand at the intersection of partonic 2-surface and string world sheet - that is at ends of braid strand since induced spinors are localized at string world sheets unless right-handed neutrinos are in question. The fact that induced spinor fields are proportional to a delta function restricting them to string world sheets does not lead to problems since the modified Dirac action itself vanishes by modified Dirac equation.

2. Both Higgs and gauge bosons correspond to bi-local objects consisting of fermion and anti-fermion at opposite throats of wormhole contact and restricted to braid ends. The are connected by the analog of non-integrable phase factor defined by classical gauge potentials. These bilinear fermionic objects should correspond to Higgs and gauge potentials at QFT limit. The two integrations over the partonic 2-surfaces contribute L^2 both, whereas the dimension of the quantity defining the gauge boson or Higgs like state is $1/L^3$ from the dimensions of spinor fields and from the dimension of generalized polarization vector compensated by that of gamma matrices. Hence the dimensions of the bi-local quantities are L for both gauge bosons and Higgs like particles. They must be coupled to their effective QFT counterparts so that a dimensionless term in action results. Note that delta functions associated with the induced spinor fields reduce them to the end points of braid strand connecting wormhole throats and finite result is obtained.

3. How to identify these dimensional bilinear terms defining the QFT limit? The basic problem is that the microscopic representation of the particle is bi-local and the effective field at QFT limit should be local. The only possibility is to consider an average of the effective field over the stringy curve connecting the points at two throats. The resulting quantities must have dimensions $1/L$ in accordance with naive scaling dimensions of gauge bosons and Higgs to compensate the dimension L of the microscopic representation of bosons. For gauge bosons having zero dimension as 1-forms the average $\int A_\mu dx^\mu/l$ along a unique stringy curve of length l connecting wormhole throats defines a quantity with dimension $1/L$. For Higgs components having dimension $1/L$ the quantities $\int H_A\sqrt{g_1}dx/l$, where g_1 corresponds to the induced metric at the stringy curve, has also dimension $1/L$. The presence of the induced metric depending on CP_2 metric guarantees that the effective action contains dimensional parameters so that the breaking of scale invariance results.

To sum up, for option II the parameters for the counterpart of Higgs action emerging at QFT limit must be determined by the p-adic mass calculations in TGD framework and the flux tube structure of particles would in the case of gauge bosons should give the standard contribution to gauge boson masses. For option I fermionic masses would emerge as mass parameters of the effective action. The presence of Euclidian regions of space-time having interpretation as lines of generalized Feynman diagrams is absolutely crucial in making possible Higgs like states. One must however emphasize that at this stage both option I and II must be considered.

4 Higgs-like state according to TGD after HCP2012

As both Phil Gibbs [C2] and Tommaso Dorigo [C3] have already told, ATLAS and CMS reported new Higgs results at LHC in Kyoto. From TGD perspective these results are of special interest since - as explained in previous postings (see this and this), they could allow to distinguish between two options suggested by TGD for the interpretation of the Higgs like particle. Before continuing it must be made clear that the road to these options has been long and tortuous [K8]. I have christened the basic options as Option I and II.

4.1 The two options

In the following I summarize briefly the options I and II mentioned above.

1. Option I assumes that Higgs like state cannot explain fermion masses so that the couplings of Higgs to fermions can even vanish. Gauge boson masses are however assumed to result by the counterpart of Higgs mechanism which would be formation of a coherent state assignable to the Higgs like particle identified a M^4 scalar formed from fermion and antifermion at opposite throats of wormhole contacts (just like gauge bosons). Note that Higgs like state is actually CP_2 vector.

    (a) One can wonder why not allow coherent states of Higgs like particle also for option II at the microscopic level. p-Adic thermodynamics does not tolerate this. Fhe conclusion that these coherent states explain also fermion masses is difficult to avoid. For me it would mean return 17 years back to the times before p-adic mass calculations without a slightest idea why fermion masses are what they are.

(b) Both scalar and pseudoscalar identification is possible for Higgs like state in TGD as it is now. Somewhat misleadingly I have referred to the Higgs like state as Euclidian pion. "Pion" is a misleading terminological mammoth bone from my original identification of 125 GeV state as pion of M_{89} hadron physics. M_{89} hadrons is one of the most important new physics (almost)-predictions of TGD. The 135 GeV particle for which Fermi telescope has provided considerable evidence could correspond to M_{89} pion. It is a pity that the experimentalist are testing only the mainstream theories such as standard SUSY, whose state after HCP2012 is so critical that journalists have rumored that SUSY is now at hospital.

The reason for "Euclidian" is that the space-time regions assignable to the (thickened) lines of generalized Feynman diagrams have Euclidian signature of induced metric. The Minkowskian parts of the flux tubes would be much longer, of the order of Compton length of particle, and could be identified as counterparts of hadronic strings if both ends carry fermion number. This means a unification of elementary particles and hadron like states: they are both string like objects but with widely differing typical lengths and string tensions. The string tension assignable to the long strings/flux tubes would give the dominant contribution to hadron masses.

2. Option II is conservative in the sense that apparently Higgs would make both bosons and fermions massive: aesthetically this is of course very nice feature. This conservative character is only apparent since p-adic thermodynamics would determine both fermion and boson masses - also the mass of Higgs.

   (a) Both gauge boson fields and Higgs field would be constructs of QFT limit for the microscopic physical objects not describable as fields and obtained by making 3-surfaces assigned with particles to point like objects. In the earlier posting I described how standard model like theory would result as a QFT limit of TGD by using a modification of a standard construction for the effective action.

   (b) "Apparent" would mean that Higgs vacuum expectation value is a purely fictive notion for this option. It would apparently explain masses for gauge bosons and fermions if the coupling of fermions to the scalar state mapped to Higgs field corresponds to gradient coupling $\overline{\Psi}\gamma^\mu\partial\mu\Phi\Psi/\mu$, μ the Higgs vacuum expectation value reproducing the fermion mass from this coupling. In the case of gauge bosons the standard gauge coupling to Higgs would reproduce the gauge boson mass in same manner. This is however only a mimicry of the mass spectrum, not its prediction. QFT limit cannot do better. The crucial ratio of W and Z boson masses expressible in terms of Weinberg angle would become a definition of Weinberg angle.

   (c) The identification of elementary particles in terms of monopole flux loops allows also to consider gauge boson masses as contributions to the conformal weight of the gauge boson ground state so that it would not result from the p-adic thermodynamics proper. Is this contribution present also in fermionic ground states and does it give only a small shift to fermion mass squared from the value determined by p-adic thermodynamics?

   For gauge bosons this contribution is of order $O(p^2)$: the coefficient would be large so that the contribution would not be much below the smallest possible $O(p)$ contribution. Assuming this for fermions this contribution would induce only a small upwards shift of fermion masses whose relative size would be largest for lowest fermion families. For this option the parameter $\mu \simeq 246$ GeV, which actually corresponds to the smallest possible value of p-adic mass squared of order $O(p)$: clearly W and Z boson masses are below this but not much and this would require p-adic temperature $T = 1/2$ in p-adic thermodynamics. The proportionality of the mass of long string to the square of appropriate gauge coupling constant appearing in the gauge boson masses would be also natural and predict W/Z mass ratio correctly.

4.2 Option I or Option II?

What do the results of the data released by ATLAS and CMS groups allow to conclude? Option I or Option II?

1. Perhaps the most important piece of data is the production rate for $\tau^+\tau^-$ pairs by Higgs decays. CMS reports excess of $.72 \pm .52$ and ATLAS $.72 \pm .64$. Earlier Tevatron reported evidence excess in bb channel. Together these results are quite strong and if taken at face value (note however the large error margins) then Option II survives in TGD framework.

2. The crucial diphoton channels, where gamma pair excess has been reported hitherto have not been updated by either group. This is a pity since for Option I the development of coherent state of Euclidian scalar serving as a counterpart for the Higgs expectation would be due to a coupling of pseudoscalar (scalar) to instanton density (YM action density) - call it just X - slashed between Higgs like state and its conjugate in QFT description. The addition of a quantized piece to X would give rise to a term giving rise to anomalous decays to photon pairs/gauge boson pairs.

   For the pseudoscalar Higgs the coefficient of the interaction term would be dictated by anomaly considerations. For a scalar Higgs the ad hoc guess would that the coefficient is same. CP_2 type vacuum extremal represents the extreme case of Euclidian space-time region and for this induced Kähler form is self dual. Could this be used to justify this adhoc assumption?

   Many explanations for diphoton excess have been proposed and I cannot avoid the temptation to add an additional contribution to the soup. There have been rumors that the state around 125 GeV splits into two: ATLAS and CMS have indeed reported slightly different masses. Could this be a real effect and explain the diphoton excess - and also why nothing was reported in Kyoto? The believer on M_{89} physics could argue as follows.

   (a) The pion like state corresponds to $3 \oplus 1$ representation for strong isospin group U(2) realized using sub-algebra SU(2) of SU(3) playing the role of strong isospin group in TGD. Pion realizes only "3". Could "1" correspond to the sigma meson of M_{89} hadron physics and have mass around 125 GeV and thus explain two-photon anomaly? Unfortunately, the status of sigma even in ordinary hadron physics has turned out to be very problematic.

   (b) One can also play with a second idea. There is recent evidence that ordinary pion has what might be called an infrared Regge trajectory with the mass splitting about 20 MeV or 40 MeV between different states (see this [C8]). This pion would have satellites also below its usual mass: the first reported one around 100 MeV. If also M_{89} pion has similar IR Regge trajectory then by scaling by a factor 512 the splitting of 20 (40) MeV would scale up to a splitting of 10 (20) GeV. This would map 100 MeV pion to a copy of 135 GeV M_{89} pion with mass around 115 GeV (for which ATLAS found evidence for a couple of years ago!). This state is unfortunately 10 GeV too low! 20 MeV splitting would suggest a satellite of pion around 120 MeV, and its M_{89} variant would be around 125 GeV! In this case the different parities of Euclidian scalar and scaled down copy of Euclidian pion would allow to distinguish between them. This copy of pion would have also charged companions.

3. Tommaso Dorigo [C3] tells that also the first determination of the spin parity of the state has been made. 0_+ is slightly favored so that scalar Higgs would be in question. TGD indeed allows both options but for the scalar option the coupling of Higgs like state to YM action density remains the ad hoc guess mentioned above.

To sum up, the challenge of understanding Higgs like states in TGD framework seems to be now to be accomplished to high extent. The outcome is a formulation for the QFT limit of TGD which allows to understand how TGD implies standard model like theory as its QFT limit and rather precise view about limitations of QFT approximation.

4.3 The situation after ATLAS

The newest twist in the process was the report of ATLAS discussed by Resonaances [C6] about Higgs like state. The too high decay rate of Higgs like state to gamma pairs was still reported, and the mass of Higgs seems to depend slightly on whether it is determined from the production of gamma pairs or Z pairs. This suggests that also something else than Higgs is there. TGD candidate for this something else would be the pion of M_{89} hadron physics to be discussed below: the original proposal was the identification of Higgs like state as M_{89} pion. By a naive scaling estimate for its width as $\Gamma \sim \alpha_s M$ one would obtain for the width at a lower bound of order 20 GeV.

The identification as the 135 GeV particle for which Fermi telescope finds evidence as M_{89} pion is rather suggestive. This suggests that the anomalously high rate for the production of gamma pairs could be due to the decays of M_{89} pion providing an additional background. Due to this background also the determination of the mass of the Higgs like state could lead to different results for gamma pairs and Z pairs in ATLAS.

The rate for the production of gamma pairs is somewhat too high up to cm energy of gamma pair of order 200 GeV. A single wide resonance with width below 100 GeV identified as M_{89} pion is a possible explanation. May be this effect could be also understood in terms of satellites of M_{89} pion with mass difference of order 20 GeV. These satellites would be scaled up variants of satellites of ordinary pion [C8] and of also other hadrons for which evidence has been found recently and explained in TGD framework in terms of infared Regge trajectories. Of course, not a single particle physicist in CERN takes this kind of idea seriously since ordinary low energy hadron physics is regarded as a closed chapter of particle physics in higher energy circles.

5 Experimental evidence for M_{89} hadron physics

M_{89} hadron physics is one of the most far-reaching almost-predictions of p-adic mass calculations. The general prediction is that both ordinary and Gaussian Mersenne primes define p-adic length scales for various copies of hadron physics: what is fascinating is that in the biologically most interesting length scale range 10 nm-2.5 μm there are as many as four Gaussian Mersennes. Also leptohadron physics are possible if the predicted color octet excitations of leptons are light, and there is indeed evidence for leptohadron physics [K7] for all leptons. I suggested already more than decade ago that M_{89} hadron physics [K2] could explain exotic ultra high energy cosmic rays events. During last years it has become clear that M_{89} hadron physics might also serve as a common denominator for the anomalous events observed at RHIC and LHC and challenging QCD as an ultimate theory of strong interactions. The 135 GeV bump observed by Fermi satellite could correspond to M_{89} pion rather than any standard dark matter candidate.

5.1 LHC might have produced new matter: are M_{89} hadrons in question?

Large Hadron Collider May Have Produced New Matter is the title of popular article explaining briefly the surprising findings of LHC [C10] made for the first time September 2010. A fascinating possibility is that these events could be seen as a direct signature of brand new hadron physics. I distinguish this new hadron physics using the attribute M_{89} to distinguish it from ordinary hadron physics assigned to Mersenne prime $M_{107} = 2^{107} - 1$.

5.1.1 Some background

Quark gluon plasma is expected to be generated in high energy heavy ion collisions if QCD is *the* theory of strong interactions. This would mean that quarks and gluons are de-confined and form a gas of free partons. Something different was however observed already at RHIC: the surprise was the presence of highly correlated pairs of charged particles. The members of pairs tended to move in parallel: either in same or opposite directions.

This forced to give up the description in terms of quark gluon plasma and to introduce what was called color glass condensate. The proposal was that so called color glass condensate, which is liquid with strong correlations between the velocities of nearby particles rather than gas like state in which these correlations are absent, is created: one can imagine that a kind of thin wall of gluons is generated as the highly Lorentz contracted nuclei collide. The liquid like character would explain why pairs tend to move in parallel manner. Why they can move also in antiparallel manner is not obvious to me although I have considered the TGD based view about color glass condensate inspired by the fact that the field equations for preferred extremals are hydrodynamical and it might be possible to model this phase of collision using scaled version of critical cosmology which is unique apart from scaling of the parameter characterizing the duration of this critical period. Later LHC found a similar behavior in heavy ion collisions. The theoretical understanding of the phenomenon is however far from complete.

The real surprise was the observation of similar events in proton proton collisions at LHC: for the first time already at 2010. Lubos Motl wrote a nice posting about this observation. Also I wrote a short comment about the finding. Now the findings have been published: preprint can be found in arXiv [C10]. Below is the abstract of the preprint.

Results on two-particle angular correlations for charged particles emitted in pPb collisions at a nucleon-nucleon center-of-mass energy of 5.02 TeV are presented. The analysis uses two million collisions collected with the CMS detector at the LHC. The correlations are studied over a broad range of pseudorapidity η, and full azimuth ϕ, as a function of charged particle multiplicity and particle transverse momentum, p_T. In high-multiplicity events, a long-range ($2 < |(\Delta\eta| < 4$), near-side $\Delta\phi$ approximately 0) structure emerges in the two-particle $\Delta\eta - \Delta\phi$ correlation functions. This is the first observation of such correlations in proton-nucleus collisions, resembling the ridge-like correlations seen in high-multiplicity pp collisions at $s^{1/2} = 7$ TeV and in A on A collisions over a broad range of center-of-mass energies. The correlation strength exhibits a pronounced maximum in the range of $p_T =$ 1-1.5 GeV and an approximately linear increase with charged particle multiplicity for high-multiplicity events. These observations are qualitatively similar to those in pp collisions when selecting the same observed particle multiplicity, while the overall strength of the correlations is significantly larger in pPb collisions.

5.1.2 Could M_{89} hadrons give rise to the events?

Second highly attractive explanation discussed by Lubos [C5]is in terms of production of string like objects. In this case the momenta of the decay products tend to be parallel to the strings since the constituents giving rise to ultimate decay products are confined inside 1-dimensional string like object. In this case it is easy to understand the presence of both parallel and antiparallel pairs. If the string is very heavy, a large number of particles would move in collinear manner in opposite directions. Color quark condensate would explain this in terms of hydrodynamical flow.

In TGD framework these string like objects would correspond to color magnetic flux tubes. These flux tubes carrying quark and antiquark at their ends should however make them manifest only in low energy hadron physics serving as a model for hadrons, not at ultrahigh collision energies for protons. Could this mean that these flux tubes correspond to hadrons of M_{89} hadron physics? M_{89} hadron physics would be low energy hadron physics since the scaled counterpart of QCD Λ around 200 MeV is about 100 GeV and the scaled counterpart of proton mass is around .5 TeV (scaling is by factor is 512 as ratio of square roots of $M_{89} = 2^{89} - 1$, and M_{107}). What would happen in the collision would be the formation of p-adically hot spot at p-adic temperature $T = 1$ for M_{89}.

For instance, the resulting M_{89} pion would have mass around 67.5 GeV if a naive scaling of ordinary pion mass holds true. p-Adic length scale hypothesis allows power of $2^{1/2}$ as a multiplicative factor and one would obtain something like 135 GeV for factor 2: Fermi telescope has provided evidence for this kind particle although it might be that systematic error is involved (see the nice posting of Resonaances [C1]). The signal has been also observed by Fermi telescope for the Earth limb data where there should be none if dark matter in galactic center is the source of the events. I have proposed that M_{89} hadrons - in particular M_{89} pions - are also produced in the collisions of ultrahigh energy cosmic rays with the nuclei of the atmosphere: maybe this could explain also the Earth limb data. Recall that my first erratic interpretation for 125 GeV Higgs like state was as M_{89} pion and only later emerged the interpretation of Fermi events in terms of M_{89} pion.

What about the explanation in terms of M_{89} color spin glass? It does not make sense. First of all, both color spin glass and quark gluon plasma would be higher energy phenomena in QCD like theory. Now low energy M_{89} hadron physics would be in question. Secondly, for the color spin glass of ordinary hadron physics the temperature would be about 1 GeV, the mass of proton in good approximation. For M_{89} color spin glass the temperature would be by a factor 512 higher, that is .5 TeV: this cannot make sense since the model based on temperature 1 GeV works satisfactorily.

5.1.3 How this picture relates to earlier ideas?

I have made three earlier proposals relating to the unexpected correlations just discussed. The earlier picture is consistent with the recent one.

1. I have already earlier proposed a realization of the color glass condensate in terms of color magnetic flux tubes confining partons to move along string like objects. This indeed explains

why charged particle pairs tend to move in parallel or antiparallel manner. Amusingly, I did not realize that ordinary hadronic strings (low energy phenomenon) cannot be in question, and therefore failed to make the obvious conclusion that M_{89} hadrons could be in question. Direct signals of M_{89} hadron physics have been in front of our eyes since the findings of RHIC around 2005 but our prejudices - in particular, the stubborn belief that QCD is a final theory of strong interactions - have prevented us to see them! Instead of this we try desperately to see superstrings and standard SUSY!

2. One basic question is how the hadrons and quarks of M_{89} hadron physics decay to ordinary hadrons. I proposed the basic idea for about fifteen years ago - soon after the discovery of p-adic physics. The idea was that the hadrons of M_{89} physics are p-adic hot spots created in the collisions of hadrons. Also quarks get heated so that corresponding p-adic prime increases and the mass of the quark increases by some power of $\sqrt{2}$ meaning a reduction in size by the same power. The cooling of these hot spots is a sequence of phase transitions increasing the p-adic prime of the appropriate (hadronic or partonic) space-time sheet so that the eventual outcome consists of ordinary hadrons. p-Adic length scale hypothesis suggests that only primes near powers of 2 (or their subset) appear in the sequence of phase transitions. For instance, M_{89} hadronic space-time sheet would end up to an ordinary hadronic space-time sheets consisting of at most 18 steps from $M_{107}/M_{89} \simeq 2^{18}$. If only powers of 2 are allowed as scalings (the analog of period doubling) there are 9 steps at most.

   Each step scales the size of the space-time sheet in question so that the process is highly analogous to cosmic expansion leading from very short and thin M_{89} flux tube to M_{107} flux tube with scaled up dimensions. Since a critical phenomenon is in question and TGD Universe is fractal, a rough macroscopic description would be in terms of scaled variant of critical cosmology, which is unique apart from its finite duration and describes accelerated cosmic expansion. The almost uniqueness of the critical cosmology [K5] follows from the imbeddability to $M^4 \times CP_2$. Cosmic expansion would take place only during these periods. Both the cosmic expansion expansion associated with the cooling of hadronic and partonic space-time sheets would take via jerks followed by stationary periods with no expansion. The size of the scale of the hadronic or partonic space-time sheet would increase by a power of $\sqrt{2}$ during a single jerk.

   By the fractality of the TGD Universe this model of cosmic expansion based on p-adic phase transitions should apply in all scales. In particular, it should apply to stars and planetary systems. The fact that various astrophysical objects do not seem to participate in cosmic expansion supports the view that the expansion takes place in jerks identifiable as phase transitions increasing the p-adic prime of particular space-time sheet so that in the average sense a continuous smooth expansion is obtained. For instance, I have proposed a variant of expanding Earth model [K4] explaining the strange observation that the continents would nicely cover the entire surface of Earth if the radius of Earth were one half of its recent radius. The assumed relatively rapid phase transition doubling the radius of Earth explains several strange findings in the thermal, geological, and biological history of Earth.

   This approach also explains also how the magnetic energy of primordial cosmic strings identifiable as dark energy has gradually transformed to dark or ordinary matter [L1]. In this model the vacuum energy density of inflation field is replaced with that of Kähler magnetic field assignable to the flux tubes originating from primordial cosmic strings with a 2-D M^4 projection. The model explains also the magnetic fields filling the Universe in all scales: in standard Big Bang cosmology their origin remains a mystery.

3. What about the energetics of the process? If the jerk induces an overall scaling, the Kähler magnetic energy of the magnetic flux tubes decreases since - by the conservation of magnetic flux giving $B \propto 1/S$ - the energy is proportional to L/S scaling like $1/\sqrt{p}$ (L and S denote the length and the transversal area of the flux tube). Therefore magnetic energy is liberated in the process and by p-adic length scale hypothesis the total rest energy liberated is $\Delta E = E_i(1-2^{(k_i-k_f)/2})$, where i and f refer to initial and final values of the p-adic prime $p \simeq 2^k$. Similar consideration applies to partons. The natural assumption is that the Kähler magnetic (equivalently color magnetic) energy is liberated as partons. These partons would eventually transform to ordinary partons and materialize to ordinary hadrons. The scaling of the flux tube would preserve its size would force the observed correlations.

To conclude, the brave conjecture would be that a production of M_{89} hadrons could explain the observations. There would be no quark gluon plasma nor color spin glass (a highly questionable notion in high energy QCD). Instead of this new hadron physics would emerge by the confinement of quarks (or their scaled up variants) in shorter length scale as collision energies become high enough, and already RHIC would have observed M_{89} hadron physics!

5.2 Anomalous like sign dimuons at LHC?

We are not protected against particle physics rumors even during Christmas. This time the rumor was launched from the comment section of Peter Woit's blog and soon propagated to the blogs of Lubos and Phil Gibbs.

The rumor says that ATLAS has observed 5 sigma excess of like sign di-muon events. This would suggests a resonance with charge $Q = \pm 2$ and muon number two. In the 3-triplet SUSY model there is a Higgs with charge 2 but the lower limit for its mass is already now around 300-400 GeV. Rumors are usually just rumors and at this time the most plausible interpretation is as a nasty joke intended to spoil the Christmas of phenomenologists. Lubos however represents a graph from a publication of ATLAS [C9] based on 2011 data giving a slight support for the rumor. The experiences during last years give strong reasons to believe that statistical fluctuation is in question. Despite this the temptation to find some explanation is irresistible.

5.2.1 TGD view about color allows doubly charged leptomesons

TGD color differs from that of other unified theories in the sense that colored states correspond to color partial waves in CP_2. Most of these states are extremely massive but I have proposed that light color octet leptons are possible [K7], and there is indeed some evidence for pion like states with mass very near to $m = 2m_L$ for all charged lepton generations decaying to lepton-antilepton pairs and gamma pairs also p-adically scaled up variant having masses coming as octaves of the lowest state have been reported for the tau-pion.

Since leptons move in triality zero color partial waves, color does not distinguish between lepton and anti-lepton so that also leptons with the same charge can in principle form a pion-like color singlet with charge $Q = \pm 2$. This is of course not possible for quarks. In the recent case the p-adic prime should be such that the mass for the color octet muon is 105/2 GeV which is about $2^9 m(\mu)$, where $m(\mu) = 105.6$ MeV is the mass of muon. Therefore the color octet muons would correspond to $p \simeq 2^k$, $k = k(\mu) - 2\times 9 = 113 - 18 = 95$, which not prime but is allowed by the p-adic length scale hypothesis.

But why just $k = 95$? Is it an accident that the scaling factor is same as between the mass scales of the ordinary hadron physics characterized by M_{107} and M_{89} hadron physics? If one applies the same argument to tau leptons characterized by M_{107}, one finds that like sign tau pairs should result from pairs of M_{89} τ leptons having mass $m = 512 \times 1.776 GeV = 909$ GeV. The mass of resonance would be twice this. For electron one has $m = 512 \times .51$ MeV= 261.6 MeV with resonance mass equal to 523.2 MeV. Skeptic would argue that this kind of states should have been observed for long time ago if they really exist.

5.2.2 Production of parallel gluon pairs from the decay of strings of M_{89} hadron physics as source of the leptomesons?

The production mechanism would be via two-gluon intermediate states. Both gluons would decay to unbound colored lepton-antilepton pair such that the two colored leptons and two antileptons would fuse to form two like sign lepton pairs. This process favors gluons moving in parallel. The required presence of also other like sign lepton pair in the state might allow to kill the hypothesis easily.

The presence of parallel gluons could relate to the TGD inspired explanation [K2] for the correlated charged particle pairs observed in proton proton collisions (QCD predicts quark gluon plasma and the absence of correlations) in terms of M_{89} hadron physics. The decay of M_{89} string like objects is expected to produce not only correlated charged pairs but also correlated gluon pairs with members moving in parallel or antiparallel manner. Parallel gluons could produce like sign di-muons and di-electrons and even pairs of like sign μ and e. In the case of ordinary hadron physics this mechanism would not be at work so that one could understand why resonances with electron number two and mass 523 MeV have not been observed earlier.

Even leptons belonging to different generations could in principle form this kind of states and Phil Gibbs has represented a graph which he interprets as providing indications for a state with mass around 105 GeV decaying to like sign μ e pairs. In this case one would however expect that mass is roughly 105/2 GeV since electron is considerably lighter than muon in given p-adic length scale.

To sum up, if the rumor is true, then M_{89} hadron physics would have begun to demonstrate its explanatory power. The new hadron physics would explain the correlated charged particle pairs not possible to understand in high energy QCD. The additional gamma pair background resulting from the decays of M_{89} pions could explain the two-gamma anomaly of Higgs decays, and also the failure to get same mass for the Higgs from ZZ and gamma-gamma decays. One should not forget that M_{89} pion explains the Fermi bump around 135 GeV. And it would also explain the anomalous like sign lepton pairs if one accepts TGD view about color.

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[C2] Higgs at HCP2012. `http://blog.vixra.org/2012/11/14/higgs-at-hcp2011/`.

[C3] Higgs: New ATLAS And CMS Results. `http://www.science20.com/quantum_diaries_survivor/higgs_new_atlas_and_cms_results-96412`.

[C4] Higgs: New Deal. `http://resonaances.blogspot.fi/2012/10/higgs-new-deal.html`.

[C5] LHC: CMS probably sees quark-gluon plasma or dual QCD string or something better. `http://motls.blogspot.fi/2010/09/lhc-probably-sees-new-shocking-physics.html`.

[C6] Twin peaks in ATLAS. `http://resonaances.blogspot.fi/2012/12/twin-peaks-in-atlas.html`.

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