Higgs Essay

Is It Really Higgs?

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Abstract

The discovery of a new spinless particle at LHC has dominated the discussions in physics blogs during last weeks. Quite many bloggers identify without hesitation the new particle as the long sought for Higgs although some aspects of data do not encourage the interpretation as standard model Higgs or possibly its SUSY variant. Maybe the reason is that it is rather imagine any other interpretation. In this article the TGD based interpretation as a pion-like state of scaled up variant of hadron physics is discussed explaining also why Higgs is not needed and why it cannot even perform the tasks posed for it in TGD framework. Essentially one assumption, the separate conservation of quark and lepton numbers realized in terms of 8-D chiral invariance, excludes Higgs like states as also standard $\mathcal{N}=1$ SUSY. This identification could explain the failure to find the decays to τ pairs and also the excess of two-gamma decays. The decays gauge boson pairs would be caused by the coupling of pion-like state to instanton density for electro-weak gauge fields. Also a connection with the dark matter researches reporting signal at 130 GeV and possibly also at 110 GeV suggests itself: maybe also these signals also correspond to pion-like states.

1 Background

The discovery of the new spinless particle at LHC [8, 9] is believed to be a turning point in physics, and for a full reason. Before discussing TGD based view about the discovery it is appropriate to discuss briefly the historical background to demonstrate that the answer to the question "Higgs or not Higgs?" indeed determines the path to be followed in future particle physics.

1.1 GUT paradigm

The leading thread in the story of particle physics is GUT paradigm, which emerged for four decades ago. It however has its problems besides the fact that not a single thread of evidence has accumulated to support it.

1. The basic idea of GUTs is to put all fermions and bosons to multiplets of some big gauge group extending the standard model gauge group. This idea is applied also in the generalization of gauge theories to supersymmetric gauge theories and in superstring models. Scalar fields developing vacuum expectations define a key element of this approach and give hopes of obtaining a realistic mass spectrum. This rather simple minded approach would make unification an easy job. There are however difficulties.

2. One of the basic implications is that baryon and lepton numbers are not conserved separately. Proton decays would make this non-conservation manifest. These decays have not been however observed, and one of the challenges of the GUT based models is fine-tuning of couplings so that proton is long-lived enough. This raises the question whether one could somehow understand the separate conservation of B and L from basic principles.

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3. Putting all fermions in the same multiplet would suggest that the mass ratios for fermions should be simple algebraic numbers not too far from unity. Fermion families have however widely differing mass scales and the ratio of top quark mass scale to neutrino mass scale is gigantic. This suggests that fermion generations and even different charge states of fermions of single generation are characterized by inherent mass scales and do not belong to a multiplet of a big gauge group. Standard model gauge group would be the fundamental gauge group and the challenge would be to deduce it from some fundamental principles. In TGD framework number theoretical vision indeed leads to an explanation for standard model gauge group [24].

   It is also an empirical fact that fermion generations are identical copies of each other apart from widely different masses. This suggests some non-group theoretic explanation for family replication phenomenon. In TGD framework 2-D wormhole throats characterized topological by their genus in orientable category are the fundamental particle like objects. This provides a possible explanation for the family replication phenomenon. One must of course explain why genera higher than $g = 2$ are heavy or absent from the spectrum, and one can indeed develop an argument for this based on the fact that $g \leq 2$ 2-surfaces allow always Z_2 as conformal symmetries unlike $g > 2$ 2-surfaces [16].

4. Particle massivation is in GUT framework is described by coupling the fermions and gauge bosons to a scalar field. The vacuum expectation values of the scalar fields define the mass scales. In the case of standard model one has only single scalar/Higgs field and by choosing the couplings to Higgs field to be proportional to fermion mass one can reproduce particle masses. Only a reproduction is in question and theory is certainly not microscopic. Vacuum expectation value (VEV) paradigm is central also for the inflationary cosmology - in fact for the entire theoretical particle physics developed during last decades. The no-existence of Higgs would force to return to the roots to the situation four decades ago. Therefore the new spinless particle could be a turning point in the history of physics, and it is easy to understand why the attitudes against or on behalf of Higgs interpretation are so passionate and why facts tend to be forgotten.

1.2 How to achieve separate conservation of B and L?

A possible manner to understand the separate conservation of both B and L would be via the identification of spinors as different chiralities of higher-dimensional spinors.

1. This would however require the identification of color quantum numbers as angular momentum like quantum numbers assignable to partial waves in internal space. This is indeed the identification performed in TGD framework and $H = M^4 \times CP_2$ is the unique choice of imbedding space coding for the standard model quantum numbers. In TGD approach quarks and leptons correspond to different imbedding space chiralities, and this excludes Higgs as a genuine imbedding space scalar since it would couple to quark-lepton pairs. To get the couplings correctly Higgs should correspond to imbedding space vector having components only the direction of CP_2 but it is rather difficult to imagine how gauge bosons could "eat" components of Higgs in this case. As a matter fact, Higgs components should be characterized by same charge matrices as weak bosons and would be a TGD counterpart for a mixture of scalar and pseudoscalar.

2. Chiral invariance is indeed essential for the renormalizability of 4-D gauge theories.The absence of 8-D scalars would allow also a generalization of chiral invariance from 4-D to 8-D context implying separate conservation of B and L. This is the case even in string model framework if separate conservation of B and L is assumed. It is worth of mentioning that the separate conservation of B and L is not consistent with the standard $\mathcal{N} = 1$ SUSY realized in terms of Majorana spinors. This is not a catastrophe since LHC has already excluded quite a considerable portion of parameter space for $\mathcal{N} = 1$ SUSY. $\mathcal{N} = 2$ SUSY however is and is generated in TGD framework by right-handed neutrino and its antiparticle.

There are however quite intricate delicacies involved discussed in detail in [28]. For instance, the modes of covariantly constant right-handed neutrino spinor of CP_2 generates 4-D generalization of super-conformal symmetry as modes delocalized into entire space-time surfaces whereas other modes are localized to 2-D surfaces and generate badly broken SUSY with very large value of $\mathcal{N}$. An open question is whether the ν_R covariantly constant also in M^4 degrees of freedom could generate $\mathcal{N} = 1$ SUSY analogous to the standard SUSY. In any case, TGD seems to be inconsistent with both scalar VEV paradigm and standard $\mathcal{N} = 1$ SUSY.

3. p-Adic physics and p-adic length scale hypothesis allow to understand the widely different mass scales of fermions and various gauge bosons since p-adic prime and the primary p-adic length scale defined by it become the characterizers of elementary particle. Also the secondary p-adic length and time scales are important: for electron secondary p-adic time scale is .1 seconds and quite intriguingly the fundamental time scale of biology. p-Adic thermodynamics provides the microscopic theory of particle massivation leading to highly successful predictions not only for particle mass scale ratios but also for the particle masses. p-Adic primes near powers of two - in particular Mersenne primes - pop up naturally and define positive integer characterizing given particle. Number theory becomes the tool of understanding the mystery number 10^{38} defined by the ratio of Planck mass and proton mass (this number is essentially the ratio of CP_2 mass to electron mass) [19].

If Higgs is needed in TGD framework at all, it might provide gauge bosons with longitudinal polarizations. Even this function seems to be un-necessary. Here so called zero energy ontology (ZEO) comes in rescue.

1.3 Particle massivation from p-adic thermodynamics

p-Adic thermodynamics defines a core element of p-adic mass calculations [16, 19, 22]. p-Adic thermodynamics is thermodynamics for the conformal scaling generator L_0 in the tensor product representation of super-conformal algebra and the masses are fixed one the p-adic prime characterizing the particle is fixed. p-Adic length scale hypothesis $p \simeq 2^k$, k integer, implies an exponential sensitivity of the particle mass scale on k so that a fitting of particle masses is not possible.

1. The first thing that one can get worried about relates to the extension of conformal symmetries. If the conformal symmetries for light-like surfaces and $\delta M^4_\pm \times CP_2$ generalize to $D = 4$, how can one take seriously the results of p-adic mass calculations based on 2-D conformal invariance? There is actually no reason to worry. The reduction of the conformal invariance to 2-D one for the solutions of modified Dirac equation takes care of this problem [28] This however requires that the fermionic contributions assignable to string world sheets and/or partonic 2-surfaces - Super- Kac-Moody contributions - dictate the elementary particle masses. For hadrons also super-symplectic contributions would be present and would give the dominating contribution to baryon masses.

   The modes of right handed neutrino are delocalized to a 4-D region of space-time surface and characterized by two integers. The absence of all standard model interactions suggests that no thermalization takes place for them. These modes are de-localized either to a region of Euclidian signature identifiable as 4-D line of generalized Feynman graph or to a region of Minkowskian signature. Since modified gamma matrices vanish identically for CP_2 type vacuum extremals one can ask whether the 4-D neutrino modes are associated only with Minkowskian regions. In this case the counterpart of $\mathcal{N} = 1$ SUSY would assign spartner to a many-particle state rather than to elementary particle. This could explain for why LHC has not seen the analog of standard SUSY.

2. ZEO suggests that the wormhole throats carrying many-fermion states with parallel momenta are massless: this applies even to virtual wormhole throats [26]. As a consequence, the twistor approach would work and the on mass shell kinematical constraints to the vertices would allow the cancellation of UV divergences. The 2-D Kac-Moody generators assignable to the boundaries of string world

sheets would generate Yangian algebra [27]. IR divergences would cancel because incoming and outgoing particles would be massive on mass shell particles as states involving several wormhole throats. The p-adic thermal expectation value is for the longitudinal M^2 momentum squared rather than for the four-momentum squared (the definition of CD selects $M^1 \subset M^2 \subset M^4$ as also does number theoretic vision). Also propagator would be determined by M^2 momentum. Lorentz invariance would be achieved by averaging over the moduli for CD including also Lorentz boosts of CD.

3. In the original approach states with arbitrary large values of L_0^{tot} were allowed as physical states. Usually one would require that the generator L_0^{tot} of conformal scaling annihilates the states. In the calculations however mass squared was assumed to be proportional L_0^{tot} apart from vacuum contribution. This is a questionable assumption. ZEO suggests that total mass squared vanishes and that one can decompose mass squared to a sum of longitudinal and transversal parts. If one can do the same decomposition for the longitudinal and transverse parts also for the Super Virasoro algebra, one can calculate longitudinal mass squared as a p-adic thermal expectation of L_0^{tr} in the transversal Super-Virasoro algebra and only states with $L_0^{tot} = 0$ would contribute and one would have conformal invariance in the standard sense. The decomposition is indeed possible since longitudinal parts correspond to pure gauge degrees of freedom.

   Thermodynamics - or rather, its square root - would become part of quantum theory in ZEO. M-matrix is indeed product of hermitian square root of density matrix multiplied by unitary S-matrix and defines the entanglement coefficients between positive and negative energy parts of zero energy state. Different M-matrices orthogonal to each other with respect to trace become rows of the unitary U-matrix.

4. The crucial constraint is that the number of super-conformal tensor factors is $N = 5$: this suggests that thermodynamics applied in Super-Kac-Moody degrees of freedom assignable to string world sheets is enough if one is interested in the masses of fermions and gauge bosons. Super-symplectic degrees of freedom can also contribute and determine the dominant contribution to baryon masses. Should also this contribution obey p-adic thermodynamics in the case when it is present? Or does the very fact that this contribution need not be present mean that it is not thermal? The symplectic contribution should correspond to hadronic p-adic length scale rather the much longer (!) p-adic length scale assignable to say u quark (this paradoxical looking result can be understood in terms of uncertainty principle and the assignment of quarks to the color magnetic body of hadron). Hadronic p-adic mass squared and partonic p-adic mass squared cannot be summed since primes are different. If one accepts the basic rules [22], longitudinal energy and momentum are additive as indeed assumed in perturbative QCD.

5. Calculations work if the vacuum expectation value of the mass squared must be assumed to be tachyonic. There are two options depending on whether one whether p-adic thermodynamics gives total mass squared or longitudinal mass squared.

   (a) One could argue that the total mass squared has naturally tachyonic ground state expectation since for massless extremals (MEs, topological light rays [15]) longitudinal momentum is light-like and transversal momentum squared is necessary present and non-vanishing by the localization to topological light ray of finite thickness of order p-adic length scale. Transversal degrees of freedom would be modeled with a particle in a box.

   (b) If longitudinal mass squared is what is calculated, the condition would require that transversal momentum squared is negative so that instead of plane wave like behavior exponential damping would be required. This would conform with the localization in transversal degrees of freedom.

This is the general picture. One crucially important implication is that gauge conditions in Lorentz gauge must be modified. Only longitudinal M^2 momentum appears in the propagators (recall that total mass squared vanishes and cannot appear in the propagator if virtual particles are massless). Therefore only M^2 momentum appears in gauge conditions: $p_L \cdot \epsilon = 0$ holds true and implies that also longitudinal polarization is allowed. Massivation is also unavoidable. The first guess for gauge boson state is as a wormhole contact containing fermion and anti-fermion at 3-D light-like wormhole throats. One must have spin 1 but since fermion and anti-fermion are massless they must have non-parallel 3-momenta in order to have parallel spins. For instance, they could have parallel and massive longitudinal momenta but non-parallel transverse momenta. The longitudinal mass squared would be in general non-vanishing and hence mass squared as the average over moduli of CD involving also integration over Lorentz boosts of CD. Higgs is not needed in TGD framework and its possible TGD counterpart seems also incapable of fulfilling its functions.

1.4 Could a TGD counterpart of scalar boson have useful functions in TGD Universe?

The social pressures tending to force the interpretation of the new resonance as Higgs are rather strong and most bloggers seem to take this interpretation as granted. In this kind of situation theoretician with visions deviating from the mainstream thinking of course feels excitement and stress. I am not an exception to this rule. What if the production rate and branching ratios are those predicted by standard model? Is my vision wrong in this case? How it could be wrong? Can I modify it without losing something essential?

Recall that standard model Higgs has two functions. Higgs VEV gives masses for fermions and weak gauge bosons and Higgs gives longitudinal components for massive gauge bosons. Could one have Higgs like states performing only one or none of these functions?

1. In TGD framework fermion massivation by Higgs vacuum expectation is replaced by p-adic thermodynamics giving the dominant contribution to the longitudinal mass squared p_L^2 (all particle states are massless at fundamental level). One cannot however exclude scalar vacuum expectations giving a small corrections to fermion masses. p-Adic thermodynamics as a microscopic mechanism of fermion massivation is so beautiful and predictive that it beats massivation based on Higgs expectation, which in TGD framework can be seen as a phenomenological parametrization at best.

2. In the case of weak gauge bosons p-adic temperature $T = 1/n$ would be probably smaller ($T \leq 1/2$ instead of $T = 1$ for fermions) and the analog of Higgs expectation could give a significant or even dominating contribution to weak gauge boson masses. There are however conceptual problems. What is the TGD counterpart of Higgs VEV? Does it characterize coherent state? Does this expectation have classical space-time correlate as gauge bosons have?

What about the second function of Higgs as a provider of longitudinal polarizations for massive gauge bosons?

1. TGD allows to imagine the existence of analogs of Higgs like states [20] (see the previous posting). They generalize the notions of scalar and pseudo-scalar in Minkowski space to vector and pseudo-vector in 8-D imbedding space with components only in CP_2 directions defining the analogs of polarizations. These states appear always as singlet and charged triplet and are very much analogous to 1+3 formed by electroweak gauge bosons.

2. In standard model the three components of standard model Higgs also provide the longitudinal components of weak bosons W and Z. ZEO allows to understand the massivation of spin 1 bosons as something unavoidable without the need for Higgs like particle and I do not have any elegant proposal how the possible scalar 1+3 could transform to longitudinal components of weak bosons and single neutral Higgs. Thus there is a tendency to conclude that if Higgs like states exist in TGD Universe they appear as full multiplets 1+3 containing also charged states as physical particles.

I could of course be wrong! Maybe Higgs could after all manage to serve as a provider of longitudinal polarizations. Could one imagine the classical counterparts of gauge bosons eating Higgs components in classical TGD? To get some perspective, consider modified Dirac equation for induced spinors at preferred extremals of Kähler action.

1. For the TGD counterparts of induced Dirac equation both gamma matrices and gauge potentials appearing in the modified Dirac equation are induced from those of imbedding space by simply projecting them to the space-time surface. This implies that induced gamma matrices contain also CP_2 part. This gives rise to new kind of couplings proportional to the contraction of gauge potential with CP_2 part of induced gamma matrices.

   Induced gamma matrices are actually replaced by modified gamma matrices defined by Kähler action to obtain supersymmetry and internal consistency of the theory but the conclusion remains the same. Modified gamma matrices are proportional to Maxwell energy momentum tensor expressible in terms of Einstein equations using Einstein tensor and metric for the proposed ansatz for preferred extremals. Could these couplings involving energy momentum tensor and thus mass mimic Higgs couplings? I do not regard this interpretation as plausible.

2. Quantum classical correspondence requires the existence of classical counterparts of quanta, also Higgs. My inability to imagine any convincing candidate has been one of the reasons for my skepticism concerning Higgs like states. While writing this I however decided to try once again. I failed but learned that em charge as isospin like quantum number for fermions should be conserved in TGD classically - something very non-trivial that I have taken as granted and shown to be true only for the octonionic representation of imbedding space gamma matrices [18].

Therefore it seems that the possibility to realize the longitudinal polarizations of weak gauge bosons using Higgs like states are rather meager.

1.5 Could the conservation of em charge allow to identify unitary gauge and from this classical Higgs field?

An important aspect of the standard model Higgs mechanism is that it respects em charge leaving photons massless. In standard model the conservation of em charge defined as isospin like quantum number is non-trivial since the presence of classical gauge fields induces transitions between different charge states of fermions. In second quantization this problem is circumvented by replacing classical gauge fields with quantized ones. The so called unitary gauge defined by a gauge transformation depending on Higgs fields allows to express the action in terms of physical (in general massive) fields and makes charge conservation explicit. How the conservation of em charge is obtained in TGD?

1. Doesn't one have the same problem but as a much worse variant since classical long range electroweak gauge fields are unavoidable in TGD and there is no path integral but preferred extremals? Could it make sense to speak about unitary gauge also in TGD framework? Could one turn around this idea to derive classical Higgs from the possibly existing gauge transformation to unitary gauge? The answer is negative. There is actually no need for the unitary gauge.

   As a matter fact, the conservation for em charge in spinorial sense leads to the earlier conjecture that the solutions of the modified Dirac equations are localized at 2-D surfaces whose ends define braid strands at space-like 3-surfaces at the ends of causal diamonds and at the light-like 3-surfaces connecting them and defining lines for generalized Feynman diagrams. This picture was earlier derived from the notion of finite measurement resolution implying discretization at the level of partonic 2-surfaces and also from number theoretical vision suggesting that basic objects correspond to 2-D commutative and co-commutative identifiable as sub-manifolds of 4-D associative and co-associated surfaces.

2. The point is that the Kähler form of CP_2 is covariantly constant and one can identify covariantly constant em charge as a matrix of form $Q = aI + bJ_{kl}\Sigma^{kl}$: the coefficients a and B are different for quarks and leptons (different chiralities of H-spinors). This matrix is covariantly constant also with respect to the induced spinor structure and commutes with Dirac operator (be it the TGD counterpart of the ordinary massless Dirac operator or modified Dirac operator). Therefore one should be able to choose the modes of induced spinor field to have a well-defined em charge at each point of space-time surface. The covariantly constant Kähler form of CP_2 is an important element in making possible the conservation of em charge and derives from the supersymmetry generated by covariantly constant right-handed neutrino. This is however not enough as it became clear.

3. Rather unexpectedly, the challenge of understanding the charge conservation in the spinorial sense led to a breakthrough in understanding of the modes of the modified Dirac equation. The condition for conservation leads to three separate analogs of Dirac equations and the two additional ones are satisfied if em charged projections of the generalized energy momentum currents defining components of modified gamma matrices vanish. If these components define Beltrami fields expressible as products $j = \Psi\nabla\Phi$ the conditions can be satisfied for $\Psi = 0$. Since Ψ is complex or hyper-complex, the conditions are satisfied for 2-dimensional surfaces of space-time surfaces identifiable as string world sheets and partonic 2-surfaces. This picture was earlier derived from various arguments. Em charge conservation does not there give rise to a counterpart of unitary gauge but leads to a bridge between modified Dirac equation and general view about quantum TGD based on generalization of super-conformal invariance.

Higgsteria had therefore at least one very positive impact in TGD framework! Note that only slightly earlier emerged the construction recipe for preferred extremals of Kähler action based on a generalization of minimal surface equations of string models to 4-D context and generalizing the 2-D conformal invariance to its four-dimensional analog. This had also a surprising and very pleasant outcome: Einstein's equations with cosmological term follow as consistency conditions for the reduction of field equations to purely algebraic conditions solved by assuming that Euclidian space-time region has hermitian structure and Minkowskian region its counterpart that I have christened Hamilton-Jacobi structure. This simplified considerably the vision about the representations of super-conformal symmetries [28].

2 M_{89} hadron physics instead of Higgs?

In TGD framework the most plausible interpretation for 125 GeV state would be as pion-like state of scaled up copy of hadron physics. Two-photon decay and also the decays to other weak bosons and perhaps even gluons would be due to axial anomaly and involve only gauge boson loops.

2.1 Scaled copies of hadron physics as a basic prediction of TGD

One of the most surprising "almost-predictions" of TGD is the possibility of scaled variants of hadron physics.

1. Ordinary hadron physics is characterized by Mersenne prime $M_n = 2^n - 1$, $n = 107$. There are also other physically interesting Mersenne primes. M_{127} corresponds to electron and has been tentatively assigned to electro-hadron physics for which color octet states of electron replace color triplet of quarks. Muon corresponds to Gaussian Mersenne $M_{G,n} = (1 + i)^n - 1$, $n = 113$, and τ to the hadronic Mersenne prime M_n, $n = 107$.

2. There is evidence for leptohadron physics associated with these charged leptons too [25].

3. The masses of current quarks are from QCD estimates in 10 MeV scale and there exists some evidence for Regge trajectories in 20 MeV string tension. The interpretation would be in terms

of magnetic flux tubes associated with the "magnetic body" of the hadron and the question. It however seems that M_{127} variant of hadron physics with characteristic mass scale of order .5 MeV cannot be in question.

4. In biologically relevant length scale range ranging from cell membrane thickness (10 nm) to the size scale of cell nucleus about 5 μm there are as many as four Gaussian Mersennes $M_{G,n}$ corresponding to $n = 151, 157, 163, 167$. Dark matter identified as phases with non-standard value of effective Planck constant coming as integer multiple of ordinary Planck constant is essential for what it is to be living in TGD Universe. The dark matter residing at magnetic flux quanta could correspond to quarks and gluons free in the size scale involved.

M_{89} corresponds to a candidate for a hadron physics with mass scale of hadron physics scaled up by a factor 512: this corresponds to TeV range. For instance, proton mass of order .94 GeV would be scaled up to about 500 GeV. General arguments suggests that some new physics must emerge at TeV energy scale. Could it be that M_{89} hadron physics is this new physics? If so then the identification of 125 GeV resonance as a pion-like state of the new hadron physics would be natural. It should be easy to kill this hypothesis at LHC since entire spectroscopy of hadron like states is predicted and the experience from QCD allows to predict the dynamics of these states. p-Adic mass calculations in turn allow to estimate the mass spectrum using simple scaling arguments.

2.2 Is it really Higgs?

After the first wave of Higgsteria the attitudes to the discovery at LHC have become more realistic and i "Higgs discovery" is indeed transforming to "discovery". I of course feel empathy for those who have spent their professional career by doing calculations with Higgs: it is not pleasant to find that something totally different might be in question. In the latest New Scientist [10] the problems are acknowledged and summarized.

For most decay channels the rates differ from standard model predictions considerably [2]. In particular, gamma gamma decay rate is about three times too high and tau lepton pairs are not produced at all. This is very alarming since Higgs should couple to leptons with coupling proportional to its mass. It is becoming clear that it is not standard model Higgs. People have begun to talk about "Higgs like" state since nothing else they do not have because technicolor scenario is experimentally excluded.

The most natural - albeit not the only possible - TGD identification is as a pion-like state. This would mean that it is pseudo-scalar: also SUSY predicts pseudo-scalar as one of the several Higgses.

The basic predictions of TGD scenario deserve to be summarized.

1. Also two charged and one neutral companion of the effective pseudo-scalar should exist. This is because pseudo-scalar must be replaced by imbedding space axial vector having only CP_2 components (4) forming electroweak triplet and singled just as ew gauge bosons do. The identification as CP_2 tangent space vector looks promising at first but it is difficult to imagine how charged components of Higgs could be eaten by weak bosons.

2. ATLAS and CMS see their Higgs candidates at slightly different masses: mass difference is about 1 GeV. Could this mean that the predicted two neutral states contribute and have been already observed? Could this also explain the too large decay rate to two gammas.

   One can however counter-argue that ordinary pion has no neutral companion of same mass. In hadronic sigma model it has scalar companion with which it forms 1+3 multiplet of SO(4), the tangent space group of CP_2 reducing to $SU(2)_L \times U(1)$ identifiable as $U(2) \subset SU(3$ in the concrete representation of pion states. Could one think that this is the case also now and sigma develops vacuum expectation analogous to that of Higgs determining most of the couplings just as in sigma model for ordinary hadrons? The problem is that the neutral component should be scalar.

Could one get rid of the additional sigma state? CP_2 allows two geodesic spheres and the homologically trivial one allows $SO(3)$ as isometries instead of $U(2)$. In this case one would have naturally $SO(3)$ triplet instead of 3+1 and no sigma boson. For the four kaon like states one would have 3+1 naturally. This could distinguish between pion-like and kaon-like multiplets also in the ordinary hadron physics [20]. What is genuinely new that strong isospin groups $U(2)$ and $SO(3)$ would reduce to subgroups of color group in spinor representation.

3. If there is pion-like state there, it is pseudo-scalar: this might become clear during this year. SUSY people would identify it as one of the SUSY Higgses.

4. Pion-like states consist of "scaled up" quarks of M_{89} hadron physics and they prefer to decay to hadrons. Lepton pairs are produced only in higher order via box diagrams with weak boson pair as vertical edges and quark line and lepton line as horizontal edges. This explains why tau pairs are not observed. The fastest decays could take place to two gluons of M_{89} hadron physics transforming to ordinary gluons in turn decaying to quarks and producing jets.

5. The simplest option is that effective action for decays to weak gauge bosons is instanton action assignable to axial current anomaly. WW production rate is consistent with standard Higgs and this fixes the coefficient of the instanton term if one assumes that electroweak symmetry is not broken so that γ, Z, and W would have different coefficients.

6. Associated production of $b\bar{b} + W$ has been observed as predicted. In TGD $b\bar{b}$ would correspond to decay to two gluons annihilating to quark pair. Light quark pairs would be produced much more than in Higgs decays where Higgs-quark coupling is proportional to quark mass.

7. What is intriguing that the plots for the ratio of observed cross section divided by standard model prediction as a function of Higgs mass show periodically occurring peaks as a function of Higgs mass with period of order 20 GeV. This might be of course a mere artifact related to the size of data bin and probably is and also to the character of the plot. There is however intriguing similarity with the reported existence of satellites of ordinary pion with period of order 20-40 MeV. By scaling 40 MeV by a factor 512 one obtains 20 GeV. Could the 145 GeV state reported earlier by CDF collaboration [1] correspond to this kind of state?

What experimenters have to say about these predictions after year is interesting. The discovery of charged partners, too low rate for the decays to lepton pairs, and too fast decays to light quark pairs would destroy the Higgs interpretation.

2.3 Connection with dark matter searches?

An additional fascinating thread to the story comes from the attempts to detect dark matter. The prediction of TGD approach is that dark matter resides at magnetic flux tubes as phases with large value of Planck constant and that dark energy corresponds to the magnetic energy of the flux tubes and is characterized by a gigantic value of (effective) Planck constant [17]. This leads to a rather detailed vision about cosmic evolution with magnetic energy replacing the vacuum energy assigned with inflaton fields. The decay of the magnetic flux tubes rather than vacuum expectation of inflaton field would create ordinary matter and dark matter [23].

The results of the dark matter searches are inconclusive. Some groups claim the detection of what they identify as dark matter [4, 7], some groups see nothing [5, 3]. The analysis is sensitive to the assumptions made and if the assumption that dark matter corresponds to WIMPs - say neutralino of standard SUSY- the analysis might fail. Second source of failure relates to the distribution of dark matter. For instance, the standard assumption about spherical halos around galaxies might be wrong and TGD indeed suggests that this particular form of dark matter is concentrate string like magnetic flux tubes containing galaxies around it like pearls in a necklace. It has been indeed reported that the nearby space around Earth does not contain dark matter [14]. On the other hand, evidence for string like magnetic flux tubes containing dark matter and connecting galactic clusters has been reported [13]. Even if dark matter candidates are detected, they could be fake since the particles in question could be created in atmosphere in the collisions of highly energetic cosmic rays creating hadrons of M_{89} hadron physics: certain mysterious cosmic ray events with ultra high energies could be indeed due to M_{89} hadron physics [21].

Independent positive reports come from groups studying the data from Fermi satellite in the hope of identifying particles of galactic dark matter. 3 sigma evidence has been represented for the claim that there is signal for dark particle with mass around 130 GeV [12]. Gamma pairs would be produced in the annihilation of particles with this mass. Another group [6] reports a signal at the same energy but argues that due to kinematical effects this signal actually corresponds to a particle with a mass of about 145 GeV: similar signal was earlier reported earlier by CDF at Fermilab [1]. Also some indications for a signal at 110 GeV is proposed by the latter group: direct extrapolation to take into account the kinematical effects would suggest a particle at 125 GeV. It has been also claimed that the signal is too strong to be interpreted as neutralino, the main candidate for a WIMP defining dark matter in the standard sense [11]. This is a further blow against standard SUSY. If the Higgs candidate is actually a pionlike state of scaled up variant of hadron physics, one can ask whether M_{89} hadron physics could be active in the extreme conditions of the galactic center and lead to a copious production of pionlike state of M_{89} physics annihilating and decaying to gamma pairs.

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