Some comments about $\tau - \mu$ anomaly of Higgs decays and anomalies of B meson decays

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Abstract

In this article possible TGD based explanation for the observed decays of Higgs to $\mu - \tau$ pairs not allowed by standard model is proposed as being due to neutrino mixing: the model introduces no new parameters or particles and should be lowest order prediction of any extension of standard model taking neutrino massivation and mixing as a starting point. M_{89} hadron physics in turn suggests a simple explanation for the anomalies observed the semileptonic and and hadronic decays of neutral B meson. The radiatively generated vertex representing the decay of W to a pair of ordinary M_{107} quark and M_{89} quark would make possible the presence of exchanged M_{89} quark in the box diagrams involved with the decays and this could explain the anomalies.

1 Introduction

Lubos (http://motls.blogspot.fi/2015/01/a-model-that-agrees-with-tau-mu-higgs.html?m=1) mentions a 2.5 sigma anomaly (http://cds.cern.ch/record/1740976/files/HIG-14-005-pas.pdf) [C1] observed in the decay of Higgs to $\tau - \mu$ pair or its charge conjugate not allowed by standard model. Lubos mentions a model http://arxiv.org/abs/1501.00993) explaining the anomaly and also other anomalies related to semileptonic decays of neutral B meson in terms of double Higgs sector and gauged $L_\mu - L_\tau$ symmetry. In a more recent posting http://motls.blogspot.fi/2015/01/a-new-paper-connecting-heterotic.html Lubos mentions another paper (http://arxiv.org/abs/1501.04815) explaining the anomaly in terms of a frightingly complex E_6 gauge model inspired by heterotic strings.

TGD suggests however an amazingly simple explanation of the $\tau - \mu$ anomaly in terms of neutrino mixing. As a matter fact, after writing the first hasty summary of the childishly simple idea discussed below but still managing to make mistakes, I became skeptic. Perhaps I have misunderstood what is meant by anomaly. Perhaps the production of $\tau - \mu$ pairs is not the anomaly after all. Perhaps the anomaly is the deviation from the prediction based on the model below. It however seems that my hasty interpretation was correct.

1.0.1 The relationship between topological mixing and CKM mixing

It is good to explain first the TGD based model for CKM mixing in terms of topological mixing for partonic topologies. Cabibbo-Kobayashi-Maskawa (CKM) matrix (see `http://tinyurl.com/zxay2f5`) is 3×3 unitary matrix describing the mixing of D type quarks in the couplings of W bosons to a pair of U and D type quarks. For 3 quarks it can involve phase factors implying CP breaking. The origin of the CKM matrix is a mystery in standard model.

In TGD framework CKM mixing is induced by the mixing of the topologies of 2-D partonic surfaces characterized by genus $g = 0, 1, 2$ (the number handles added to sphere to obtain topology of partonic 2-surface) assignable to quarks and also leptons [K2, K7].The first three genera are special since they allow a global conformal symmetry always whereas higher genera allow it only for special values of conformal moduli. This suggests that handles behave like free particles in many particle state that for higher genera and for three lowest genera the analog of bound state is in question.

The mixing is in general different for different charge states of quark or lepton so that for quarks the unitary mixing matrices for U and type quarks - call them simply U and D - are different. Same applies in leptonic sector. CKM mixing matrix is determined by the topological mixing being of form $CKM = UD^\dagger$ for quarks and of similar form for charged leptons and neutrinos.

The usual time-dependent neutrino mixing would correspond to the topological mixing. The time constancy assumed for CKM matrix for quarks must be consistent with the time dependence of U and D. Therefore one should have $U = U_1X(t)$ and $D = D_1X(t)$, where U_1 and D_1 are time independent unitary matrices.

In the adelic approach to TGD [K10] [?] fusing real and various p-adic physics (correlates for cognition) would have elements in some algebraic extension of rationals inducing extensions of various p-adic number fields. The number theoretical universality of U_1 and D_1 matrices is very powerful constraint. U_1 and D_1 would be expressible in terms of roots of unity and e (e^p is ordinary p-adic number so that p-adic extension is finite-dimensional) and would not allow exponential representation. These matrices would be constant for given algebraic extension of rationals.

It must be emphasized that the model for quark mixing developed for about 2 decades ago treats quarks as constituent quarks with rather larger masses determining hadron mass (constituent quark is identified as current valence quark plus its color magnetic body carrying most of the mass). The number theoretic assumptions about the mixing matrices are not consistent with the recent view: instead of roots of unity trigonometric functions reducing to rational numbers (Pythagorean triangles) were taken as the number theoretic ideal.

$X(t)$ would be a matrix with real number/p-adic valued coefficients and in p-adic context it would be an imaginary exponential $exp(itH)$ of a Hermitian generator H with the p-adic norm $t<1$ to guarantee the existence of the p-adic exponential. CKM would be time independent for $X_U = X_D$. TGD view about what happens in state function reduction [K4, K1, K11] implies that the time parameter t in time evolution operator is discretized and this would allow also $X(t_n)$ to belong to the algebraic extension.

For quarks $X_U = X_D = Id$ is consistent with what is known experimentally:

of course, the time dependent topological mixing of U or D type quarks would be seen in the behavior of proton. One also expects that the time dependent mixing is very small for charged leptons whereas the non-triviality of $X_\nu(t)$ is suggested by neutrino mixing. Therefore the assumption $X_L = X_\nu$ is not consistent with the experimental facts and $X_L(t) = Id$ seems to be true a good approximation so that only $X_\nu(t)$ would be non-trivial? Could the vanishing em charge of neutrinos and/or the vanishing weak couplings of right-handed neutrinos have something to do with this? If the $\mu - e$ anomaly in the decays of Higgs persists, it could be seen as a direct evidence for CKM mixing in leptonic sector.

CP breaking is also possible. As a matter fact, one day after mentioning the CP breaking in leptonic sector I learned about indications for (see `http://tinyurl.com/zr8xm26`leptonic CP breaking) emerging from T2K experiment performed in Japan: the rate for the muon-to-electron neutrino conversions is found to be higher than that for antineutrinos. Also the NOvA experiment in USA reports similar results. The statistical significance of the findings is rather low and the findings might suffer the usual fate. The topological breaking of CP symmetry would in turn induce the CP breaking the CKM matrix in both leptonic and quark sectors. Amusingly, it has never occurred to me whether topological mixing could provide the first principle explanation for CP breaking!

2 Model for the $h \to \mu - \tau_c$ anomaly in terms of neutrino mixing

To my humble opinion both models mentioned by Lubos are highly artificial and bring in a lot of new parameters since new particles are introduced. Also a direct Yukawa coupling of Higgs to $\tau - \mu$ pair is assumed. This would however break the universality since lepton numbers for charged lepton generations would not be conserved. This does not look attractive and one can ask whether the allowance of transformation of neutrinos to each other by mixing known to occur could be enough to explain the findings assuming that there are no primary flavor changing currents and without introducing any new particles or new parameters. In the hadronic sector the mixing for quarks D type quarks indeed explains this kind of decays producing charged quark pair of say type cu_c. In TGD framework, where CKM mixing reduces to topological mixing of topologies of partonic 2-surfaces, this option is especially attractive.

1. In standard model neutrinos are massless and have no direct coupling to Higgs. Neutrinos are however known to have non-vanishing masses and neutrino mixing analogous to CKM mixing is also known to occur. Neutrino mixing is enough to induce the anomalous decays and the rate is predicted completely in terms of neutrino mixing parameters and known standard physics parameters so that for a professional it should be easy to made the little computer calculations to kill the model.

2. In absence of flavor changing currents only $WL_i\nu_i$ vertices can produce the anomaly. The $h \to \mu - \tau_c$ or its charge conjugate would proceed by several

diagrams but the lowest order diagram comes from the decay of Higgs to W pair. If Higgs vacuum expectation value is non-vanishing as in standard model then Higgs could decay to a virtual W^+W^- pair decaying to $\tau\mu$ pair by neutrino exchange. Decay to Z^0 pair does not produce the desired final state in accordance with the absence of flavor changing neutral currents in standard model. Triangle diagram would describe the decay. Any lepton pair is possible as final state. Neutrino mixing would occur in either W emission vertex. The rates for the decays to different lepton pairs differ due to different mass values of leptons which are however rather small using Higgs mass as as scale. Therefore decays to all lepton pairs are expected.

3. In higher order Higgs could decay lepton pair to lepton pair decaying by neutrino exchange to W pair in turn decaying by neutrino exchange to lepton pair. As as special case one obtains diagrams Higgs decays $\tau - \mu$ pair with final state preferentially ν_τ exchange to W^+W^- pair decaying by ν_τ exchange to $\mu - \tau$ pair. The CKM mixing parameter for neutrino mixing would in either the upper vertices of the box. Note that Z^0 pair as intermediate state does not contribute since neutral flavor changing currents are absent.

The proposed mechanism should be at work in *any* generalization of standard model claiming to explain neutrino masses and their mixing without flavor changing neutral currents. If the observed anomaly is different from this prediction, one can start to search for new physics explanations but before this brane constructions in multiverse are not perhaps the best possible strategy.

3 What about the anomalies related to B meson decays?

The model (http://arxiv.org/abs/1501.00993) that Lubos refers to tries to explain also the anomalies related to semileptonic decays of neutral B meson. Neutrino mixing is certainly not a natural candidate if one wants to explain the 2.5 sigma anomalies reported for the decays of B meson to K meson plus muon pair. Lubos (http://motls.blogspot.fi/2013/07/lhcb-3-or-4-sigma-excess-of-b-mesons.html) has a nice posting about surprisingly many anomalies related to the leptonic and pion and kaon decays of neutral B meson. Tommaso Dorigo (http://www.science20.com/quantum_diaries_survivor/foursigma_evidence_new_physics_rare_b_decays_found_lhcb_and_its_interpretation-117058) tells about 4-sigma evidence for new physics in rare B meson decays. There is also an anomaly related to the decay of neutral B meson to muon pair reported by Jester (http://resonaances.blogspot.fi/2014/12/weekend-plot-bs-and-more.html).

TGD predicts M_{89} hadron physics as a p-adically scaled up variant of ordinary M_{107} hadron physics with hadron mass scale scaled up by factor 512 which corresponds to LHC energies. Could it be that the box diagrams containing W pair and two quark exchanges involve also quarks of M_{89} hadron physics? A quantitative modelling would require precise formulation for the phase transition changing the p-adic prime characterizing quarks and gluons.

One can however ask whether one might understand these anomalies qualitatively in a simple manner in TGD framework. Since both leptons and quarks are involved, the anomaly must related to W-quark couplings. If M_{89} physics is there, there must be radiatively generated couplings representing the decay of W to a pair of ordinary M_{107} quark and M_{89} quark. A quark of M_{89} hadron physics appearing as a quark exchange between W^+ and W^- in box diagram would affect the rates of B meson to kaon and pion. This would affect also the semileptonic decays since the the photon or Z^0 decaying to a lepton pair could be emitted from M_{89} quark.

4 But doesn't Higgs vacuum expectation vanish in TGD?

While polishing this posting I discovered an objection against TGD approach that I have not noticed earlier. This objection allows to clarify TGD based view about elementary particles [K9] and particle massivation in particular [K3, K8, K5, K6] so that I will discuss it here.

1. In standard model the decay of Higgs decays to gauge bosons is described quite well by the lowest order diagrams and the decay amplitude is proportional to Higgs vacuum expectation. In TGD p-adic mass calculations [**?**] describe fermion massivation and Higgs vacuum expectation vanishes at the fundamental level but must make sense at the QFT limit of TGD involving the replacement of many-sheeted space-time with single slightly curved region of Minkowski space defining GRT space-time. Various gauge fields are sums of induced gauge fields at the sheets.

2. Note that the decays of Higgs to W pairs with a rate predicted in good approximation by the lowest order diagrams involving Higgs vacuum expectation have been observed. Hence Higgs vacuum expectation must appear as a calculable parameter in the TGD approach based on generalized Feynman diagrams. In this approach the vertices of Feynman diagrams are replaced with 3-D vertices describing splitting of 3-D surface, in particular that of partonic 2-surfaces associated with it and carrying elementary particle quantum numbers by strong form of holography. The condition that em charge is well-defined requires that the modes of the induced spinor fields are localized at string world sheets at which induced W fields vanish. Also induced Z^0 fields should vanish above weak scale at string world sheets. Thus the description of the decays reduces at microscopic level to string model with strings moving in space-time. String world sheets would have boundaries at parton orbits and interpreted as world lines of fundamental point-like fermions.

3. Elementary particles are constructed as pairs of wormhole contacts with throats carrying effective Kähler magnetic charge. Monopole flux runs along first space-time sheet, flows to another space-time sheet along contact and returns back along second space-time sheet and through the first wormhole contact so that closed magnetic flux tube is obtains. Both sheets carry string world

sheets and their ends at the light-like orbits of wormhole throats are carriers of fermion number.

4. This description gives non-vanishing amplitudes for the decays of Higgs to gauge boson pairs and fermion pairs. Also the couplings of gauge bosons to fermions can be calculated from this description so that both the gauge coupling strengths and Weinberg angle are predicted. The non-vanishing value of the coupling of Higgs to gauge boson defines the Higgs vacuum expectation which can be used in gauge theory limit. The breaking of weak gauge symmetry reflects the fact that weak gauge group acts as holonomies of CP_2 and is not a genuine symmetry of the action. Since weak gauge bosons correspond classical to gauge potentials, the natural conjecture is that the couplings are consistent with gauge symmetry.

5. Massivation of particles follows from the fact that physical particles are composites of massless fundamental fermions whose light-like momenta are in general non-parallel. It seems however possible to regarded particles as massless in 8-D sense. At classical level this is realized rather elegantly: Minkowskian and Euclidian regions give both a contribution to four-momentum and the contribution from the lines of generalized Feynman diagrams is imaginary due to the Euclidian signature of the induced metric. This gives rise to complex momenta and twistor approach suggests that these momenta are light-like allow real mass squared to be non-vanishing. Also the massivation of light particles could be described in this manner.

   This description would conform with M^8-H duality [K10] at momentum space level: at imbedding space level one would have color representations and at space-time level representations of SO(4) associated with mass squared=constant sphere in Euclidian three space: this would correspond to the $SU(2)_L \times SU(2)_R$ dynamical symmetry group of low energy hadronic physics.

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In the first part of the talk I will review the status of flavor physics after the first run of the LHC and in particular I will discuss recent results from the LHCb experiment suggesting possible deviations from the SM predictions in semileptonic B-meson decays. In the second part of the talk I will give an interpretation of the these anomalies via a composite Higgs model, in which both the Higgs and a triplet leptoquarks arise as pseudo-Goldstone bosons of the strong dynamics. See all Particle Physics Theory seminars Subscribe to the Particle Physics Theory seminars calendar More Physics and B decay anomalies at LHCb. Arantza Oyanguren1 (on behalf of the LHCb collaboration), 1Instituto de FÃsica Corpuscular (IFIC), Centro mixto CSIC - Universidad de Valencia.Â Several types of B hadron decays can be given, some exaples are shown in Figure 1. The dom-. inant decay processes are the tree level b â†' c (Cabibbo favored) and b â†' u (Cabibbo suppressed) transitions.Â Since both mesons, the Ï† â†' K+Kâˆ' and the Kâˆ—0 â†' K+Ï€âˆ' decay into two charged hadrons, and the Kâˆ—0 decay is avour specic (no eect from new physics is expected), the B0 â†' Kâˆ—0Î³ decay channel can be used to control reconstruction eects. Figure 14 shows the mass distribution of the B0 â†' Kâˆ—0Î³. Candidates / (25 MeV/c2) Candidates / (25 MeV/c2). Here, the collection of a few anomalies in semileptonic B-decays, especially in b â†' cÏ„$$\overline{v}$$, invites speculation about the emergence of some striking new phenomena, perhaps interpretable in terms of a weakly broken U(2) n flavor symmetry and of leptoquark mediators. We aim at a partial UV completion of this interpretation by generalizing the minimal composite Higgs model to include a composite vector leptoquark as well.