New Particle Physics Predicted by TGD: Part I

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Abstract

TGD predicts a lot of new physics and it is quite possible that this new physics becomes visible at LHC. Although the calculational formalism is still lacking, p-adic length scale hypothesis allows to make precise quantitative predictions for particle masses by using simple scaling arguments.

The basic elements of quantum TGD responsible for new physics are following.

1. The new view about particles relies on their identification as partonic 2-surfaces (plus 4-D tangent space data to be precise). This effective metric 2-dimensionality implies generalizaton of the notion of Feynman diagram and holography in strong sense. One implication is the notion of field identity or field body making sense also for elementary particles and the Lamb shift anomaly of muonic hydrogen could be explained in terms of field bodies of quarks.

2. The topological explanation for family replication phenomenon implies genus generation correspondence and predicts in principle infinite number of fermion families. One can however develop a rather general argument based on the notion of conformal symmetry known as hyper-ellipticity stating that only the genera $g = 0, 1, 2$ are light. What "light" means is however an open question. If light means something below CP_2 mass there is no hope of observing new fermion families at LHC. If it means weak mass scale situation changes.

   For bosons the implications of family replication phenomenon can be understood from the fact that they can be regarded as pairs of fermion and antifermion assignable to the opposite wormhole throats of wormhole throat. This means that bosons formally belong to octet and singlet representations of dynamical SU(3) for which 3 fermion families define 3-D representation. Singlet would correspond to ordinary gauge bosons. Also interacting fermions suffer topological condensation and correspond to wormhole contact. One can either assume that the resulting wormhole throat has the topology of sphere or that the genus is same for both throats.

3. The view about space-time supersymmetry differs from the standard view in many respects. First of all, the super symmetries are not associated with Majorana spinors. Super generators correspond to the fermionic oscillator operators assignable to leptonic and quark-like induced spinors and there is in principle infinite number of them so that formally one would have $\mathcal{N} = \infty$ SUSY. I have discussed the required modification of the formalism of SUSY theories and it turns out that effectively one obtains just $\mathcal{N} = 1$ SUSY required by experimental constraints. The reason is that the fermion states with higher fermion number define only short range interactions analogous to van der Waals forces. Right handed neutrino generates this super-symmetry broken by the mixing of the M^4 chiralities implied by the mixing of M^4 and CP_2 gamma matrices for induced gamma matrices. The simplest assumption is that particles and their superpartners obey the same mass formula but that the p-adic length scale can be different for them.

4. The new view about particle massivation based on p-adic thermodynamics raises the question about the role of Higgs field. The vacuum expectation value (VEV) of Higgs is not feasible in TGD since CP_2 does not allow covariantly constant holomorphic vector fields. The original too strong conclusion from this was that TGD does not allow Higgs. Higgs VEV is not needed for the selection of preferred electromagnetic direction in electro-weak gauge algebra (unitary gauge) since CP_2 geometry does that. p-Adic thermodynamics explains fermion masses bout the masses of weak bosons cannot be understood on basis of p-adic thermodynamics alone giving extremely small second order contribution only and failing to explain W/Z mass ratio. Weak boson mass can be associated to the string tension of the strings connecting the throats of two wormhole contacts associated with elementary particle (two of them are needed since the monopole magnetic flux must have closed field lines).

5. One of the basic distinctions between TGD and standard model is the new view about color.

   (a) The first implication is separate conservation of quark and lepton quantum numbers implying the stability of proton against the decay via the channels predicted by GUTs. This does not mean that proton would be absolutely stable. p-Adic and dark length scale hierarchies indeed predict the existence of scale variants of quarks and leptons and proton could decay to hadons of some zoomed up copy of hadrons physics. These decays should be slow and presumably they would involve phase

transition changing the value of Planck constant characterizing proton. It might be that the simultaneous increase of Planck constant for all quarks occurs with very low rate.

(b) Also color excitations of leptons and quarks are in principle possible. Detailed calculations would be required to see whether their mass scale is given by CP_2 mass scale. The so called leptohadron physics proposed to explain certain anomalies associated with both electron, muon, and τ lepton could be understood in terms of color octet excitations of leptons.

6. Fractal hierarchies of weak and hadronic physics labelled by p-adic primes and by the levels of dark matter hierarchy are highly suggestive. Ordinary hadron physics corresponds to $M_{107} = 2^{107} - 1$ One especially interesting candidate would be scaled up hadronic physics which would correspond to $M_{89} = 2^{89} - 1$ defining the p-adic prime of weak bosons. The corresponding string tension is about 512 GeV and it might be possible to see the first signatures of this physics at LHC. Nuclear string model in turn predicts that nuclei correspond to nuclear strings of nucleons connected by colored flux tubes having light quarks at their ends. The interpretation might be in terms of M_{127} hadron physics. In biologically most interesting length scale range 10 nm-2.5 μm there are four Gaussian Mersennes and the conjecture is that these and other Gaussian Mersennes are associated with zoomed up variants of hadron physics relevant for living matter. Cosmic rays might also reveal copies of hadron physics corresponding to M_{61} and M_{31}

   The well-definedness of em charge for the modes of induced spinor fields localizes them at 2-D surfaces with vanishing W fields and also Z^0 field above weak scale. This allows to avoid undesirable parity breaking effects. It is quite possible that this localization is consistent with Kähler-Dirac equation only in the Minkowskian regions where the effective metric defined by Kähler-Dirac gamma matrices can be effectively 2-dimensional and parallel to string world sheet.

7. Weak form of electric magnetic duality implies that the fermions and antifermions associated with both leptons and bosons are Kähler magnetic monopoles accompanied by monopoles of opposite magnetic charge and with opposite weak isospin. For quarks Kähler magnetic charge need not cancel and cancellation might occur only in hadronic length scale. The magnetic flux tubes behave like string like objects and if the string tension is determined by weak length scale, these string aspects should become visible at LHC. If the string tension is 512 GeV the situation becomes less promising.

In this chapter some aspects of the predicted new physics and possible indications for it are discussed. The evolution of the TGD based view about possible existing Higgs like particle and about space-time SUSY are discussed in separate chapters.

1 Introduction

TGD predicts a lot of new physics and it is quite possible that this new physics becomes visible at LHC. Although calculational formalism is still lacking, p-adic length scale hypothesis allows to make precise quantitative predictions for particle masses by using simple scaling arguments. Actually there is already now evidence for effects providing further support for TGD based view about QCD and first rumors about super-symmetric particles have appeared.

Before detailed discussion it is good to summarize what elements of quantum TGD are responsible for new physics.

1. The new view about particles relies on their identification as partonic 2-surfaces (plus 4-D tangent space data to be precise). This effective metric 2-dimensionality implies generalization of the notion of Feynman diagram and holography in strong sense. One implication is the notion of field identity or field body making sense also for elementary particles and the Lamb shift anomaly of muonic hydrogen could be explained in terms of field bodies of quarks.

2. The topological explanation for family replication phenomenon implies genus generation correspondence and predicts in principle infinite number of fermion families. One can however develop a rather general argument based on the notion of conformal symmetry known as hyper-ellipticity stating that only the genera $g = 0, 1, 2$ are light [?] What "light" means is however an open question. If light means something below CP_2 mass there is no hope of observing new fermion families at LHC. If it means weak mass scale situation changes.

For bosons the implications of family replication phenomenon can be understood from the fact that they can be regarded as pairs of fermion and anti-fermion assignable to the opposite wormhole throats of wormhole throat. This means that bosons formally belong to octet and singlet representations of dynamical SU(3) for which 3 fermion families define 3-D representation. Singlet would correspond to ordinary gauge bosons. Also interacting fermions suffer topological condensation and correspond to wormhole contact. One can either assume that the resulting wormhole throat has the topology of sphere or that the genus is same for both throats.

3. The view about space-time supersymmetry differs from the standard view in many respects. First of all, the super symmetries are not associated with Majorana spinors. Super generators correspond to the fermionic oscillator operators assignable to leptonic and quark-like induced spinors and there is in principle infinite number of them so that formally one would have $\mathcal{N} = \infty$ SUSY. I have discussed the required modification of the formalism of SUSY theories in [**?**]nd it turns out that effectively one obtains just $\mathcal{N} = 1$ SUSY required by experimental constraints. The reason is that the fermion states with higher fermion number define only short range interactions analogous to van der Waals forces. Right handed neutrino generates this super-symmetry broken by the mixing of the M^4 chiralities implied by the mixing of M^4 and CP_2 gamma matrices for induced gamma matrices. The simplest assumption is that particles and their superpartners obey the same mass formula but that the p-adic length scale can be different for them.

4. The new view about particle massivation based on p-adic thermodynamics raises the question about the role of Higgs field. The vacuum expectation value (VEV) of Higgs is not feasible in TGD since CP_2 does not allow covariantly constant holomorphic vector fields. The original too strong conclusion from this was that TGD does not allow Higgs. Higgs VEV is not needed for the selection of preferred electromagnetic direction in electro-weak gauge algebra (unitary gauge) since CP_2 geometry does that. p-Adic thermodynamics explains fermion masses bout the masses of weak bosons cannot be understood on basis of p-adic thermodynamics alone giving extremely small second order contribution only and failing to explain W/Z mass ratio. Weak boson mass can be associated to the string tension of the strings connecting the throats of two wormhole contacts associated with elementary particle (two of them are needed since the monopole magnetic flux must have closed field lines).

   At M^4 QFT limit Higgs VEV is the only possible description of massivation. Dimensional gradient coupling to Higgs field developing VEV explains fermion masses at this limit. The dimensional coupling is same for all fermions so that one avoids the loss of "naturalness" due to the huge variation of Higgs-fermion couplings in the usual description.

   The stringy contribution to elementary particle mass cannot be calculated from the first principles. A generalization of p-adic thermodynamics based on the generalization of super-conformal algebra is highly suggestive. There would be two conformal weights corresponding the the conformal weight assignable to the radial light-like coordinate of light-cone boundary and to the stringy coordinate and third integer characterizing the poly-locality of the generator of Yangian associated with this algebra (n-local generator acts on n partonic 2-surfaces simultaneously).

5. One of the basic distinctions between TGD and standard model is the new view about color.

   (a) The first implication is separate conservation of quark and lepton quantum numbers implying the stability of proton against the decay via the channels predicted by GUTs. This does not mean that proton would be absolutely stable. p-Adic and dark length scale hierarchies indeed predict the existence of scale variants of quarks and leptons and proton could decay to hadons of some zoomed up copy of hadrons physics. These decays should be slow and presumably they would involve phase transition changing the value of Planck constant characterizing proton. It might be that the simultaneous increase of Planck constant for all quarks occurs with very low rate.

   (b) Also color excitations of leptons and quarks are in principle possible. Detailed calculations would be required to see whether their mass scale is given by CP_2 mass scale.

The so called lepto-hadron physics proposed to explain certain anomalies associated with both electron, muon, and τ lepton could be understood in terms of color octet excitations of leptons [?]

6. Fractal hierarchies of weak and hadronic physics labelled by p-adic primes and by the levels of dark matter hierarchy are highly suggestive. Ordinary hadron physics corresponds to $M_{107} = 2^{107} - 1$ One especially interesting candidate would be scaled up hadronic physics which would correspond to $M_{89} = 2^{89} - 1$ defining the p-adic prime of weak bosons. The corresponding string tension is about 512 GeV and it might be possible to see the first signatures of this physics at LHC. Nuclear string model in turn predicts that nuclei correspond to nuclear strings of nucleons connected by colored flux tubes having light quarks at their ends. The interpretation might be in terms of M_{127} hadron physics. In biologically most interesting length scale range 10 nm-2.5 μm contains four electron Compton lengths $L_e(k) = \sqrt{5}L)k)$ associated with Gaussian Mersennes and the conjecture is that these and other Gaussian Mersennes are associated with zoomed up variants of hadron physics relevant for living matter. Cosmic rays might also reveal copies of hadron physics corresponding to M_{61} and M_{31}

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In this chapter the predicted new elementary particle physics and possible indications for it are discussed. Second chapter is devoted to new hadron physics and scaled up variants of hardon physics in both quark and lepton sector.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. There are concept maps about topics related to the contents of the chapter prepared using CMAP realized as html files. Links to all CMAP files can be found at `http://tgdtheory.fi/cmaphtml.html` [L8]. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L9]. The topics relevant to this chapter are given by the following list.

- TGD view about elementary particles [L20]
- p-Adic length scale hypothesis [L18]
- p-Adic mass calculations [L17]
- Geometrization of fields [L13]
- Magnetic body [L16]
- Emergent ideas and notions [L12]
- Elementary particle vacuum functionals [L10]
- Emergence of bosons [L11]
- Leptohadron hypothesis [L14]
- M89 hadron physics [L15]
- SUSY and TGD [L19]

2 Family Replication Phenomenon

2.1 Higher Gauge Boson Families

TGD predicts that also gauge bosons, with gravitons included, should be characterized by family replication phenomenon but not quite in the expected manner. The first expectation was that these gauge bosons would have at least 3 light generations just like quarks and leptons.

Only within last two years it has become clear that there is a deep difference between fermions and gauge bosons. Elementary fermions and particles super-conformally related to elementary fermions correspond to single throat of a wormhole contact assignable to a topologically condensed CP_2 type vacuum extremal whereas gauge bosons would correspond to a wormhole throat pair assignable to wormhole contact connecting two space-time sheets. Wormhole throats correspond to light-like partonic 3-surfaces at which the signature of the induced metric changes.

In the case of 3 generations gauge bosons can be arranged to octet and singlet representations of a dynamical SU(3) and octet bosons for which wormhole throats have different genus could be massive and effectively absent from the spectrum.

Exotic gauge boson octet would induce particle reactions in which conserved handle number would be exchanged between incoming particles such that total handle number of boson would be difference of the handle numbers of positive and negative energy throat. These gauge bosons would induce flavor changing but genus conserving neutral current. There is no evidence for this kind of currents at low energies which suggests that octet mesons are heavy. Typical reaction would be $\mu + e \rightarrow e + \mu$ scattering by exchange of $\Delta g = 1$ exotic photon.

2.1.1 New view about interaction vertices and bosons

There are two options for the identification of particle vertices as topological vertices.

1. *Option a)*

The original assumption was that one can assign also to bosons a partonic 2-surface X^2 with more or less well defined genus g. The hypothesis is consistent with the view that particle reactions are described by smooth 4-surfaces with vertices being singular 3-surfaces intermediate between two three-topologies. The basic objection against this option is that it can induce too high rates for flavor changing currents. In particular $g > 0$ gluons could induce these currents. Second counter argument is that stable $n > 4$-particle vertices are not possible.

2. *Option b)*

According to the new vision (option 2)), particle decays correspond to branchings of the partonic 2-surfaces in the same sense as the vertices of the ordinary Feynman diagrams do correspond to branchings of lines. The basic mathematical justification for this vision is the enormous simplification caused by the fact that vertices correspond to non-singular 2-manifolds. This option allows also $n > 3$-vertices as stable vertices.

A consistency with the experimental facts is achieved if the observed gauge bosons have each value of $g(X^2)$ with the same probability. Hence the general boson state would correspond to a phase $exp(in2\pi g/3)$, $n = 0, 1, 2$, in the discrete space of 3 lowest topologies $g = 0, 1, 2$. The observed bosons would correspond to $n = 0$ state and exotic higher states to $n = 1, 2$.

The nice feature of this option is that no flavor changing neutral electro-weak or color currents are predicted. This conforms with the fact that CKM mixing can be understood as electro-weak phenomenon described most naturally by causal determinants X^3_l (appearing as lines of generalized Feynman diagram) connecting fermionic 2-surfaces of different genus.

Consider now objections against this scenario.

1. Since the modular contribution does not depend on the gradient of the elementary particle vacuum functional but only on its logarithm, all three boson states should have mass squared which is the average of the mass squared values $M^2(g)$ associated with three generations. The fact that modular contribution to the mass squared is due to the super-symplectic thermodynamics allows to circumvent this objection. If the super-symplectic p-adic temperature is small, say $T_p = 1/2$, then the modular contribution to the mass squared is completely negligible also for $g > 0$ and photon, graviton, and gluons could remain massless. The wiggling

of the elementary particle vacuum functionals at the boundaries of the moduli spaces $\mathcal{M}_g$ corresponding to 2-surfaces intermediate between different 2-topologies (say pinched torus and self-touching sphere) caused by the change of overall phase might relate to the higher p-adic temperature T_p for exotic bosons.

2. If photon states had a 3-fold degeneracy, the energy density of black body radiation would be three times higher than it is. This problem is avoided if the the super-symplectic temperature for $n = 1, 2$ states is higher than for $n = 0$ states, and same as for fermions, say $T_p = 1$. In this case two mass degenerate bosons would be predicted with mass squared being the average over the three genera. In this kind of situation the factor 1/3 could make the real mass squared very large, or order CP_2 mass squared, unless the sum of the modular contributions to the mass squared values $M^2_{mod}(g) \propto n(g)$ is divisible by 3. This would make also photon, graviton, and gluons massive. Fortunately, $n(g)$ is divisible by 3 as is clear form $n(0) = 0$, $n(1) = 9$, $n(2) = 60$.

2.1.2 Masses of genus-octet bosons

For option 1) ordinary bosons are accompanied by $g > 0$ massive partners. For option 2) both ordinary gauge bosons and their exotic partners have suffered maximal topological mixing in the case that they are singlets with respect to the dynamical SU(3). There are good reasons to expect that Higgs mechanism for ordinary gauge bosons generalizes as such and that $1/T_p > 1$ means that the contribution of p-adic thermodynamics to the mass is negligible. The scale of Higgs boson expectation would be given by p-adic length scale and mass degeneracy of octet is expected. A good guess is obtained by scaling the masses of electro-weak bosons by the factor $2^{(k-89)/2}$. Also the masses of genus-octet of gluons and photon should be non-vanishing and induced by a vacuum expectation of Higgs particle which is electro-weak singlet but genus-octet.

2.1.3 Indications for genus-generation correspondence for gauge bosons

Tommaso Dorigo is a highly inspiring blogger since he writes from the point of view of experimental physicist without the burden of theoretical dogmas. I share with him also the symptoms of splitting of personality to fluctuation-enthusiast and die-hard skeptic. This makes life interesting but not easy. This time Tommaso Dorigo told about the evidence for new neutral gauge boson states in $p\overline{p}$ collisions. The title of the posting was "A New Z' Boson at 240 GeV? No, Wait, at 720!?" [C9].

1. The findings

The title tells that the tentative interpretation of these states are as excited states of Z^0 boson and that the masses of the states are around 240 GeV and 720 GeV. The evidence for the new states comes from electron-positron pairs in relatively narrow energy interval produced by the decays of the might-be-there gauge boson. This kind of decay is an especially clean signature since strong interaction effects are not present and it appears at sharp energy.

240 GeV bump was reported by CDF last year [C26] CDF last year in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. The probability that it is a fluctuation is.6 per cent. What is encouraging that also D0 found the same bump. If the particle in question is analogous to Z^0, it should decay also to muons. CDF checked this and found a negative result. This made Tommaso Dorigo rather skeptic.

Also indications for 720 GeV resonance (720 GeV is just a nominal value, the mass could be somewhere between 700-800 GeV) was reported by D0 collaboration: the report is titled as "Search for high-mass narrow resonances in the di-electron channel at D0" [C41]. There are just 2 events above 700 GeV but background is small: just three events above 600 GeV. It is easy to guess what skeptic would say.

Before continuing I want to make clear that I refuse to be blind believer or die-hard skeptic and that I am unable to say anything serious about the experimental side. I am just interested to see whether these events might be interpreted in TGD framework. TGD indeed predicts -or should I say strongly suggests- a lot of new physics above intermediate boson length scale.

2. Are exotic Z^0 bosons p-adically scaled up variants of ordinary Z^0 boson?

p-Adic length scale hypothesis allows the p-adic length scale characterized by prime $p \simeq 2^k$ vary since k can have several integer values. The TGD counterpart of Gell-Mann-Okubo mass formula involves varying value of k for quark masses. Several anomalies reported by Tommaso Dorigo during years could be resolved if k can have several values. Last anomaly was the discovery that Ω_b baryon containing two strange quarks and bottom quark seems to appear with two masses differing by about 100 MeV. TGD explains the mass difference correctly by assuming that strange quark can have besides ordinary mass scale mass differing by factor of 2. The prediction is 105 MeV.

One can look whether p-adic length scale hypothesis could explains the masses of exotic Z^0 candidates as multiples of half octaves of Z^0 mass which is 91 GeV. k=3 would give 257 GeV, not too far from 240 GeV. k=6 would give 728 GeV consistent with the nominal value of the mass. Also other masses are predicted and this could serve as a test for the theory. This option does not however explain why muon pairs are not produced in the case of 240 GeV resonance.

3. Support for topological explanation of family replication phenomenon?

The improved explanation is based on TGD based view about family replication phenomenon [K5].

1. In TGD the explanation of family replication is in terms of genus of 2-dimensional partonic surface representing fermion. Fermions correspond to SU(3) triplet of a dynamical symmetry assignable to the three lowest genera (sphere, torus, sphere with two handles). Bosons as wormhole contacts have two wormhole throats carrying fermion numbers and correspond to SU(3) singlet and octet. Sooner or later the members of the octet - presumably heavier than singlet- should be observed (maybe this has been done now).

2. The exchange of these particles predicts also charged flavor changing currents respecting conservation of corresponding "isospin" and "hypercharge". For instance, lepton quark scattering $e + s \rightarrow \mu + d$ would be possible. The most dramatic signature of these states is production of muon-positron pairs (for instance) via decays.

3. Since the Z^0 or photon like boson in question has vanishing "isospin" and "hypercharge", it must be orthogonal to the ordinary Z^0 which couples identically to all families. There are two states of this kind and they correspond to superpositions of fermion pairs of different generations in TGD framework. The two bosons - very optimistically identified as 240 GeV and 720 GeV Z^0, must be orthogonal to the ordinary Z^0. This requires that the phase factors in superposition of pairs adjust themselves properly. Also mixing effects breaking color symmetry are possible and expected to occur since the SU(3) in question is not an exact symmetry. Hence the exotic Z^0 bosons *could* couple preferentially to some fermion generation. This kind of mixing might be used to explain the absence of muon pair signal in the case of 240 GeV resonance.

4. The prediction for the masses is same as for the first option if the octet and singlet bosons have identical masses for same p-adic mass scale so that mass splitting between different representations would take place via the choice of the mass scale alone.

4. Could scaled up copy of hadron physics involved?

One can also ask whether these particles could come from the decays of hadrons of a scaled up copy of hadron physics strongly suggested by p-Adic length scale hypothesis.

1. Various hadron physics would correspond to Mersenne primes: standard hadron physics to M_{107} and new hadron physics to Mersenne prime $M_{89} = 2^{89} - 1$. The first guess for the mass scale of "light" M^{89} hadrons would be $2^{(107-89)/2} = 512$ times that for ordinary hadrons. The electron pairs might result in a decay of scaled up variant of pseudo-scalar mesons π, η, or of η' or spin one ρ and ω mesons with nearly the same mass. Only scaled up ρ and ω mesons remains under consideration if one assumes spin 1.

2. The scaling of pion mass about 140 MeV gives 72 GeV. This is three times smaller than 240 GeV but this is extremely rough estimate. Actually it is the p-adic mass scale of quarks involved which matters rather than that of hadronic space-time sheet characterized by M_{89}. The naive scaling of the mass of η meson with mass 548 MeV would give about 281 GeV. η'

would give 490 GeV. ρ meson with mass would give 396 GeV. The estimates are just order of magnitude estimates since the mass splitting between pseudo-scalar and corresponding vector meson is sensitive to quark mass scale.

3. This option does not provide any explanation for the lack of muon pairs in decays of 240 GeV resonance.

To conclude, family replication phenomenon for gauge bosons is consistent with the claimed masses and also absence of muon pairs might be understood and it remains to be seen whether only statistical fluctuations are in question.

2.1.4 First indications for the breaking of lepton universality due to the higher weak boson generations

Lepton and quark universality of weak interactions is a basic tenet of the standard model. Now the first indications for the breaking of this symmetry have been found.

1. Lubos (`http://motls.blogspot.fi/2015/08/lhcb-2-sigma-violation-of-lepton.html`) tells that LHCb has released a preprint with title "Measurement of the ratio of branching ratios $(B_0 \to D^* + \tau\nu)/(B_0 \to D^* + \mu\nu)$" [C49]. The news is that the measured branching ratio is is about 33 per cent instead of 25 percent determined by mass ratios if standard model is correct. The outcome differs by 2.1 standard deviations from the prediction so that it might be a statistical fluke.

2. There are also indications for second B^0 anomaly discovered at LHCb (`http://www.nature.com/news/lhc-signal-hints-at-cracks-in-physics-standard-model-1.18307`). B mesons have to long and short-lived variants oscillating to their antiparticles and back - this relates to CP breaking. The surprise is that the second B meson - I could not figure out was it short- or long-lived - prefers to decay to $e\nu$ instead of $\mu\nu$.

3. There are also indications for the breaking of universality [C48] (`http://arxiv.org/abs/1406.6482`) from $B^+ \to K^+e^+e^-$ and $B^+ \to K^+\mu^+\mu;^-$ decays.

In TGD framework my first - and wrong - guess for an explanation was CKM mixing for leptons [K5]. TGD predicts that also leptons should suffer CKM mixing induced by the different mixings of topologies of the partonic 2-surfaces assignable to charged and neutral leptons. The experimental result would give valuable information about the values of leptonic CKM matrix. What new this brings is that the decays of W bosons to lepton pairs involve the mixing matrix and CKM matrix whose deviation from unit matrix brings effects anomalous in standard model framework.

The origin of the mixing would be topological - usually it is postulated in completely ad hoc manner for fermion fields. Particles correspond to partonic 2-surfaces- actually several of them but in the case of fermions the standard model quantum numbers can be assigned to one of the partonic surfaces so that its topology becomes especially relevant. The topology of this partonic 2- surface at the end of causal diamond (CD) is characterized by its genus - the number of handles attached to sphere - and by its conformal equivalene class characterized by conformal moduli.

Electron and its muon correspond to spherical topology before mixing, muon and its neutrino to torus before mixing etc. Leptons are modelled assuming conformal invariance meaning that the leptons have wave functions - elementary particle vacuum functionals - in the moduli space of conformal equivalence classes known as Teichmueller space.

Contrary to the naive expection mixing alone does *not* explain the experimental finding. Taking into account mass corrections, the rates should be same to different charged leptons since neutrinos are *not* identified. That mixing does not have any implications follows from the unitary of the CKM matrix.

The next trial is inspired by a recent very special di-electron event and involves higher generations of weak bosons predicted by TGD leading to a breaking of lepton universality. Both Tommaso Dorigo (`http://www.science20.com/a_quantum_diaries_survivor/a_3_tev_dielectron_event_by_cms-157052`) and Lubos Motl (`http://motls.blogspot.fi/2015/09/cms-29-tev-electron-positron-pair.html#more`) tell about a spectacular 2.9 TeV di-electron event not observed in previous LHC runs.

Single event of this kind is of course most probably just a fluctuation but human mind is such that it tries to see something deeper in it - even if practically all trials of this kind are chasing of mirages.

Since the decay is leptonic, the typical question is whether the dreamed for state could be an exotic Z boson. This is also the reaction in TGD framework. The first question to ask is whether weak bosons assignable to Mersenne prime M_{89} have scaled up copies assignable to Gaussian Mersenne M_{79}. The scaling factor for mass would be $2^{(89-89)/2} = 32$. When applied to Z mass equal to about .09 TeV one obtains 2.88 TeV, not far from 2.9 TeV. Eureka!? Looks like a direct scaled up version of Z!? W should have similar variant around 2.6 TeV.

TGD indeed predicts exotic weak bosons and also gluons.

1. TGD based explanation of family replication phenomenon in terms of genus-generation correspondence forces to ask whether gauge bosons identifiable as pairs of fermion and antifermion at opposite throats of wormhole contact could have bosonic counterpart for family replication. Dynamical SU(3) assignable to three lowest fermion generations/genera labelled by the genus of partonic 2-surface (wormhole throat) means that fermions are combinatorially SU(3) triplets. Could 2.9 TeV state - if it would exist - correspond to this kind of state in the tensor product of triplet and antitriplet? The mass of the state should depend besides p-adic mass scale also on the structure of SU(3) state so that the mass would be different. This difference should be very small.

2. Dynamical SU(3) could be broken so that wormhole contacts with different genera for the throats would be more massive than those with the same genera. This would give SU(3) singlet and two neutral states, which are analogs of $\eta\prime$ and η and π^0 in Gell-Mann's quark model. The masses of the analogs of η and π^0 and the the analog of $\eta\prime$, which I have identified as standard weak boson would have different masses. But how large is the mass difference?

3. These 3 states are expected top have identical mass for the same p-adic mass scale, if the mass comes mostly from the analog of hadronic string tension assignable to magnetic flux tube. connecting the two wormhole contacts associates with any elementary particle in TGD framework (this is forced by the condition that the flux tube carrying monopole flux is closed and makes a very flattened square shaped structure with the long sides of the square at different space-time sheets). p-Adic thermodynamics would give a very small contribution genus dependent contribution to mass if p-adic temperature is $T = 1/2$ as one must assume for gauge bosons ($T = 1$ for fermions). Hence 2.95 TeV state could indeed correspond to this kind of state.

4. Can one imagine any pattern for the Mersennes and Gaussian Mersennes involved? Charged leptons correspond to electron (M_{127}), muon ($M_{G,113}$) and tau (M_{107}): Mersenne- Gaussian Mersenne-Mersenne. Does one have similar pattern for gauge bosons too: M_{89} - $M_{G,79}$ - M_{61}?

The orthogonality of the 3 weak bosons implies that their charge matrices are orthogonal. As a consequence, the higher generations of weak bosons do not have universal couplings to leptons and quarks. The breaking of universality implies a small breaking of universality in weak decays of hadrons due to the presence of virtual $M_{G,79}$ boson decaying to lepton pair. These anomalies should be seen both in the weak decays of hadrons producing $L\nu$ pairs via the decay of virtual W or its partner $W_{G,79}$ and via the decay of virtual Z of its partner $Z_{G,79}$ to L^+L^- . Also $\gamma_{G,79}$ could be involved.

This could explain the three anomalies associated with the neutral B mesons, which are analogs of neutral K mesons having long- and short-lived variants.

1. The two anomalies involving W bosons could be understood if some fraction of decays takes place via the decay $b \rightarrow c + W_{G,79}$ followed by $W_{G,79} \rightarrow L\nu$. The charge matrix of $W_{G,79}$ is not universal and CP breaking is involved. Hence one could have interference effects, which increase the branching fraction to $\tau\nu$ or $e\nu$ relative to $\mu\nu$ depending on whether the state is long- or short-lived B meson.

2. The anomaly in decays producing charged lepton pairs in decays of B^+ does not involve CP breaking and would be due to the non-universality of $Z_{G,79}$ charge matrix.

One expects that higher generation weak bosons are accompanied by a higher generation Higgses, which differ from SUSY Higgses in the sense that they all have only neutral component. The naive scaling of the Higgs mass by $2^{(-89-79)/2}$ gives mass of 4 TeV. There are indications for a scalar with this mass!

TGD allows also to consider leptoquarks as pairs of leptons and quarks and there is some evidence for them too! I wrote about this an article [L22] (`http://tgdtheory.fi/public_html/articles/leptoquark.pdf`). Also indications for M_{89} and $M_{G,79}$ hadron physics with scaled up mass scales is accumulating [L23] (`http://tgdtheory.fi/public_html/articles/MG79.pdf`). It seems that TGD is really there and nothing can prevent it showing up, and QCD is shifting to the verge of revolution [L1] (`http://tgdtheory.fi/public_html/articles/nodeconfinement.pdf`). I predict that next decades in physics will be a New Golden Age as colleagues finally wake up.

2.2 A Slight Indication For The Exotic Octet Of Gauge Bosons From Forward-Backward Asymmetry In Top Pair Production

CDF has reported two anomalies related to the production of top quark pairs. The production rate for the pairs is too high and the forward backward asymmetry is also anomalously high. Both these anomalies could be understood as support for the octet of gauge bosons associated predicted by TGD based explanation of family replication phenomenon [K5]. The exchange of both gauge bosons would induce both charged and neutral flavour changing electroweak and color currents.

2.2.1 Two high production rate for top quark pairs

Both Jester and Lubos Motl tell about top quark related anomaly in proton-antiproton collisions at Tevatron reported by CDF collaboration. The anomaly has been actually reported already last summer but has gone un-noticed. For more detailed data see this [C5].

What has been found is that the production rate for jet pairs with jet mass around 170 GeV, which happens to correspond to top quark mass, the production cross section is about 3 times higher higher than QCD simulations predict. 3.44 sigma deviation is in question meaning that its probability is same as for the normalized random variable x/σ to be larger than 3.44 for Gaussian distribution $exp(-(x/\sigma)^2/2)/(2\pi\sigma^2)^{1/2}$. Recall that 5 sigma is regarded as so improbable fluctuation that one speaks about discovery. If top pairs are produced by some new particle, this deviation should be seen also when second top decays leptonically meaning a large missing energy of neutrino. There is however a slight deficit rather than excess of these events.

One can consider three interpretations.

1. The effect is a statistical fluke. But why just at the top quark mass?

2. The hadronic signal is real but there is a downwards fluctuation reducing the number of leptonic events slightly from the expected one. In the leptonic sector the measurement resolution is poorer so that this interpretation looks reasonable. In this case the decay of some exotic boson to top quark pair could explain the signal. Below this option will be considered in more detail in TGD framework and the nice thing is that it can be connected to the anomalously high forward backward asymmetry in top quark pair production reported by CDF for few weeks ago [C28].

3. Both effects are real and the signal is due to R-parity violating 3-particle decays of gluinos with mass near to top quark mass. This is the explanation proposed in the paper of Perez and collabators.

2.2.2 Too high forward backward asymmetry in the production rate for top quark pairs

There is also a second anomaly involved with top pair production. Jester reports new data [C75] about the strange top-pair forward-backward asymmetry in top pair production in p-pbar collisions already mentioned [C28]. In Europhysics 2011 conference D0 collaboration reported the same result. CMS collaboration found however no evidence for the asymmetry in p-p collisions at LHC [C33]. For top pairs with invariant mass above 450 GeV the asymmetry is claimed by

CDF to be stunningly large 48+/-11 per cent. 3 times more often top quarks produced in qqbar annihilation prefer to move in the direction of quark. Note that this experiment would have reduced the situation from the level of ppbar collisions to the level of quark-antiquark collisions and the negative result suggests that valence quarks might play an essential role in the anomaly.

The TGD based explanation for the finding would relation on the flavor octet of gluons and the new view about Feynman diagrams.

1. The identification of family replication phenomenon in terms of genus of the wormhole throats (see this) predicts that family replication corresponds to a dynamical SU(3) symmetry (having nothing to do with color SU(3)or Gell-Mann's SU(3)) with gauge bosons belonging to the octet and singlet representations. Ordinary gauge bosons would correspond besides the familar singlet representation also to exotic octet representation for which the exchanges induce neutral flavor changing currents in the case of gluons and neutral weak bosons and charge changing ones in the case of charged gauge bosons. The exchanges of the octet representation for gluons could explain both the anomalously high production rate of top quark pairs and the anomalously large forward backward asymmetry! Also electroweak octet could of course contribute.

2. This argument requires a more detailed explanation for what happens in the exchange of gauge boson changing the genus. Particles correspond to wormhole contacts. For topologically condensed fermions the genus of the second throat is that of sphere created when the fermionic CP_2 vacuum extremal touches background space sheet. For bosons both wormhole throats are dynamical and the topologies of both throats matter. The exchange diagram corresponds to a situation in which $g = g_i$ fermionic wormhole throat from past turns back in time spending some time as second throat of virtual boson wormhole contact and $g = g_f$ from future turns back in time and defines the second throat of virtual boson wormhole contact. The turning corresponds to gauge boson exchange represented by a wormhole contact with $g = g_i$ and $g = g_f$ wormhole throats. Ordinary gauge bosons are quantum superpositions of (g, g) pairs transforming as SU(3) singlets and SU(3) charged octet bosons are of pairs (g_1, g_2) with $g_1 \neq g_2$. In the absence of topological mixing of fermions inducing CKM mixing the exchange is possible only between fermions of same generation. The mixing is however large and changes the situation.

3. One could say that top quark from the geometric future transforms at exchange line to space-like t-quark (genus $g = 2$) and returns to future. The quark from the geometric past does the same and returns back to the past as antiquark of antiproton. In the exchange line this quark combines with t-quark to form a virtual color octet gluon.

This mechanism could also give additional contributions to the mechanism generating CP breaking since new box diagrams involving two exchanges of flavor octet weak boson contribute to the mixings of quark pairs in mesons. The exchanges giving rise to an intermediate state of two top quarks are expected to give the largest contribution to the mixing of the neutral quark pairs making up the meson. This involves exchange of a member W boson flavor octet boson analogous to the usual exchange of the flavor singlet boson. This might relate to the reported anomalous like sign muon asymmetry in BBbar decay [C42] suggesting that the CP breaking in this system is roughly 50 times larger than predicted by CKM matrix. The new diagrams would only amplify the CP breaking associated with CKM matrix rather than bringing in any new source of CP breaking. This mechanism increases also the CP breaking in KKbar system known to be also anomalously high.

2.3 The Physics Of $M - \overline{M}$ Systems Forces The Identification Of Vertices As Branchings Of Partonic 2-Surfaces

For option 2) gluons are superpositions of $g = 0, 1, 2$ states with identical probabilities and vertices correspond to branchings of partonic 2-surfaces. Exotic gluons do not induce mixing of quark families and genus changing transitions correspond to light like 3-surfaces connecting partonic 2-surfaces with different genera. CKM mixing is induced by this topological mixing. The basic testable predictions relate to the physics of $M\overline{M}$ systems and are due to the contribution of exotic gluons and large direct CP breaking effects in $K-\overline{K}$ favor this option.

For option 1) vertices correspond to fusions rather than branchings of the partonic 2-surfaces. The prediction that quarks can exchange handle number by exchanging $g>0$ gluons (to be denoted by G_g in the sequel) could be in conflict with the experimental facts.

1. CP breaking in $K-\bar{K}$ as a basic test

CP breaking physics in kaon-antikaon and other neutral pseudo-scalar meson systems is very sensitive to the new physics. What makes the situation especially interesting, is the recently reported high precision value for the parameter ϵ'/ϵ describing direct CP breaking in kaon-antikaon system [C64]. The value is almost by an order of magnitude larger than the standard model expectation. $K-\bar{K}$ mass difference predicted by perturbative standard model is 30 per cent smaller than the the experimental value and one cannot exclude the possibility that new physics instead of/besides non-perturbative QCD might be involved.

In standard model the low energy effective action is determined by box and penguin diagrams. $\Delta S=2$ piece of the effective weak Lagrangian, which describes processes like $s\bar{d}\rightarrow d\bar{s}$, determines the value of the $K-\bar{K}$ mass difference Δm_K and since this piece determines $K\rightarrow\bar{K}$ amplitude it also contributes to the parameter ϵ characterizing indirect CP breaking. $\Delta S=2$ part of the weak effective action corresponds to box diagrams involving two W boson exchanges.

2. Δm_K kills option a

For option 1) box diagrams involving Z and $g>0$ exchanges are allowed provided exchanges correspond to exchange of both Z and $g>0$ gluon. The most obvious objection is that the exchanges of $g>0$ gluons make strong $\Delta S>0$ decays of mesons possible: $K_S\rightarrow\pi\pi$ is a good example of this kind of decay. The enhancement of the decay rate would be of order $(\alpha_s(g=1)/\alpha_{em})^2(m_W/m_G(g=1)^2\sim 10^3$. Also other $\Delta S=1$ decay rates would be enhanced by this factor. The real killer prediction is a gigantic value of Δm_K for kaon-antikaon system resulting from the possibility of $\overline{s}d\rightarrow\overline{d}s$ decay by single $g=1$ gluon exchange. This prediction alone excludes option 1).

3. Option 2) could explain direct CP breaking

For option 2) box diagrams are not affected in the lowest order by exotic gluons. The standard model contributions to Δm_K and indirect CP breaking are correct for the observed value of the top quark mass which results if top corresponds to a secondary padic length scale $L(2,k)$ associated with $k=47$ (Appendix). Higher order gluonic contribution could increase the value of Δm_K predicted to be about 30 per cent too small by the standard model.

In standard model penguin diagrams contribute to $\Delta S=1$ piece of the weak Lagrangian, which determines the direct CP breaking characterized by the parameter ϵ'/ϵ. Penguin diagrams, which describe processes like $s\bar{d}\rightarrow d\bar{d}$, are characterized by effective vertices dsB, where B denotes photon, gluon or Z boson. dsB vertices give the dominant contribution to direct CP breaking in standard model. The new penguin diagrams are obtained from ordinary penguin diagrams by replacing ordinary gluons with exotic gluons.

For option 2) the contributions predicted by the standard model are multiplied by a factor 3 in the approximation that exotic gluon mass is negligible in the mass scale of intermediate gauge boson. These diagrams affect the value of the parameter ϵ'/ϵ characterizing direct CP breaking in $K-\bar{K}$ system found experimentally to be almost order of magnitude larger than standard model expectation [C64].

3 Dark Matter In TGD Universe

TGD based explanation of dark matter means one of the strongest departures of TGD from the more standard approaches. In standard approaches dark matter corresponds to some very weakly interaction exotic particles contributing to the mass density of the Universe a fraction considerably larger than the contributions of "visible" matter. In TGD Universe dark matter corresponds to phases with non-standard value of Planck constant and also ordinary particles could be in dark phase.

3.1 Dark Matter And Energy In TGD Universe

In TGD framework the identification of dark matter comes from arguments which could start from the strange finding that ELF em fields in frequency range of EEG have quantal effects on vertebrate brain [K8]. This is impossible in standard physics since the energies of photons many orders of magnitude below the thermal energy.

The proposal is that Planck constant is dynamical having a discrete integer valued spectrum so that for a given frequency the energy of photon can be above thermal energy for sufficiently large value of Planck constant. Large values of Planck constant make possible macroscopic quantum coherence so that the hypothesis would explain how living matter manages to be quantum system in macroscopic scales. Particles characterized by different values of Planck constant cannot appear in same interaction vertices so that in this sense particles with different values of Planck constant are dark relative to each other. This however allows interactions by particle exchange involving phase transition changing the value of Planck constant and also the interaction via classical fields.

The observation of Nottale [E2] that planetary orbits could be understood as Bohr orbits with a gigantic value of gravitational Planck constant leads also to the same idea [K23, K22]. The expression $\hbar_{gr} = GMm/v_0$, where v_0 has dimensions of velocity, forces to identify the Planck constant as a characterizer of the space-time sheets mediating the gravitational interaction between Sun and planet. Quite generally, there is a strong temptation to assign dark matter with the field bodies (or magnetic bodies) of physical systems and this assumption is made in the model of living matter based on the notion of the magnetic body.

One must be cautious with the identification of galactic dark matter in terms of phases with large value of Planck constant. One explanation for the galactic dark matter would be in terms of string like objects containing galaxies like pearls in the necklace [K6]. The Newtonian gravitational potential of the long galactic string would give rise to constant velocity spectrum. It could of course be that dark matter in TGD sense resides as particles at the long strings which could also carry antimatter. At least part of dark matter could be in this form. One must also bear in mind that $\hbar_{grav}$ has gigantic values and could have different origin as large $\hbar$ assignable to living matter: this is discussed in [K23].

What can one the concldue about dark energy in this framework?

1. Dark energy might allow interpretation as dark matter at the space-time sheets mediating gravitational interaction and macroscopically quantum coherent in cosmological scales. The enormous Compton wave lengths would imply that the density of dark energy would be constant as required by the interpretation in terms of cosmological constant.

2. This is however not the only possible interpretation. The magnetic tension of the magnetic flux tubes gives rise to the negative "pressure" inducing the accelerated expansion of the Universe serving as the basic motivation for the dark energy [K24].

3. The Robertson-Walker cosmologies with critical or over-critical mass density imbeddable to the imbedding space are characterized by their necessarily finite duration and possess a negative pressure. The interpretation as a constraint force due to the imbeddability to $M^2 \times CP_2$ might explain dark energy [K24].

4. The GRT limit of TGD based on Einstein-Maxwell system with cosmological constant assigned with Eudlidian regions of space-time allowing to get CP_2 as a special solution of field equation suggests that cosmological constant equals to the cosmological constant of CP_2 multiplied by the fraction of 3-volume with Euclidian signature of metric [K28] and representing generalized Feynman graphs [K13].

Whether these explanations represent different manners to say one and the same thing is not clear.

One could add the hierarchy of Planck constants as a separate postulate to TGD but it has turned out that the vacuum degeneracy characterizing TGD could imply this hierarchy as an effective hierarchy so that at the fundamental level one would have just the standard value of Planck constant [K11]. For both options the geometric realization for the hierarchy of Planck constants comes in terms of local covering spaces of imbedding space inducing covering space structure for the space-time surfaces.

1. If the hierarchy is postulated rather than derived, the coverings in questions would be those of the causal diamond $CD \times CP_2$ such that the number of sheets of the covering equals to the value of Planck constant. The coverings of both CD and CP_2 are possible so that Planck constant is product of integers.

2. The hierarchy of local coverings would follow from the fact that time derivatives of imbedding space coordinates are in general many-valued functions of canonical momentum densities by the vacuum degeneracy of Kähler action. In this case the covering would be covering of H assignable to a regions of space-time sheet. Note that, for the vacuum extremals for which induced Kähler gauge field is pure gauge and CP_2 projection any 2-D Lagrangian of CP_2, an infinite number of branches of the covering co-incide. The situation can be characterized in terms of a generalization of catastrophe theory [A1] to infinite-D context.

3. Constant torque as a dynamical mechanism necessitating the covering is discussed in [K14].,

An open question is whether dark matter phases can/must correspond to same p-adic length scale and therefore same mass. Dark matter would correspond to particles with non-standard values of Planck constant and also ordinary particles with standard values of masses could appear in dark phase and is assumed in TGD inspired quantum biology. Even quarks with Compton lengths scaled up to cell length scale appear in the model of DNA as topological quantum computer [K10]. The model of lepto-pions [K27] in terms of colored excitations of leptons would suggests that colored excitations of leptons have same mass as leptons or possibibly p-adically scaled octave of it in the case of colored ta lepton. The colored excitation of lepton with ordinary value of Planck constant must have mass larger than one half of intermediate gauge boson mass scale. Same applies to possible colored excitations of quarks.

This picture modifies profoundly the ideas about how to detect dark matter.

1. For instance, it might be possible to photograph dark matter and it might be that Peter Gariaev and his group have actually achieved this. What they observe are strange flux tube like structures associated with DNA sample [I1]: a TGD based model for the findings is developed in [K1]. If dark matter is what TGD claims it to be, the experimental methods used to detect dark matter might be on wrong track.

2. One should try to find a situation in which the particles must be created in dark phase and in this respect colored excitations of leptons are a good candidate since the decay widths of intermediate gauge boson do not allow new light fermions so that if these excitations exist they must have non-standard value of Planck constant.

3. The recent results of DAMA and Cogent suggesting the existence of dark matter particles with mass around 7 GeV are in conflict with the findings of CDMS and Xenon100 experiments. It is encouraging that this conflict could be explained by using the fact that the detection criteria in these experiments are different and by assuming that the dark matter particles involved are tau-pions formed as bound states of colored excitations of tau-leptons.

3.2 Shy Positrons

The latest weird looking effect in atomic physics is the observation that positrium atoms consisting of positron and electron scatter particles almost as if they were lonely electrons [C79, C67]. The effect has been christened cloaking effect for positron.

The following arguments represent the first attempts to understand the cloaking of positron in terms of these notions.

1. Let us start with the erratic argument since it comes first in mind. If positron and electron correspond to different space-time sheets and if the scattered particles are at the space-time sheet of electron then they do not see positron's Coulombic field at all. The objection is obvious. If positron interacts with the electron with its full electromagnetic charge to form a bound state, the corresponding electric flux at electron's space-time sheet is expected to combine with the electric flux of electron so that positronium would look like neutral particle after all. Does the electric flux of positron return back to the space-time sheet of positronium at some distance larger than the radius of atom? Why should it do this? No obvious answer.

2. Assume that positron dark but still interacts classically with electron via Coulomb potential. In TGD Universe darkness means that positron has large $\hbar$ and Compton size much larger than positronic wormhole throat (actually wormhole contact but this is a minor complication) would have more or less constant wave function in the volume of this larger space-time sheet characterized by zoomed up Compton length of electron. The scattering particle would see point-like electron plus background charge diffused in a much larger volume. If the value of $\hbar$ is large enough, the effect of this constant charge density to the scattering is small and only electron would be seen.

3. As a matter fact, I have proposed this kind of mechanism to explain how the Coulomb wall, which is the basic argument against cold fusion could be overcome by the incoming deuteron nucleus [L2], [L2]. Some fraction of deuteron nuclei in the palladium target would be dark and have large size just as positron in the above example. It is also possible that only the protons of these nuclei are dark. I have also proposed that dark protons explain the effective chemical formula $H_{1.5}O$ of water in scattering by neutrons and electrons in atto-second time scale [L2], [L2]. The connection with cloaked positrons is highly suggestive.

4. Also one of TGD inspired proposals for the absence of antimatter is that antiparticles reside at different space-time sheets as dark matter and are apparently absent [K24]. Cloaking positrons (shy as also their discoverer Dirac!) might provide an experimental supports for these ideas.

The recent view about the detailed structure of elementary particles forces to consider the above proposal in more detail.

1. According to this view all particles are weak string like objects having wormhole contacts at its ends and magnetically charged wormhole throats (four altogether) at the ends of the string like objects with length given by the weak length cale connected by a magnetic flux tube at both space-time sheets. Topological condensation means that these structures in turn are glued to larger space-time sheets and this generates one or more wormhole contacts for which also particle interpretation is highly suggestive and could serve as space-time correlate for interactions described in terms of particle exchanges. As far electrodynamics is considered, the second ends of weak strings containing neutrino pairs are effectively non-existing. In the case of fermions also only the second wormhole throat carrying the fermion number is effectively present so that for practical purposes weak string is only responsible for the massivation of the fermions. In the case of photons both wormhole throats carry fermion number.

2. An interesting question is whether the formation of bound states of two charged particles at the same space-time sheet could involve magnetic flux tubes connecting magnetically charged wormhole throats associated with the two particles. If so, Kähler magnetic monopoles would be part of even atomic and molecular physics. I have proposed already earlier that gravitational interaction in astrophysical scales involves magnetic flux tubes. These flux tubes would have o interpretation as analogs of say photons responsible for bound state energy. In principle it is indeed possible that the energies of the two wormhole throats are of opposite sign for topological sum contact so that the net energy of the wormhole contact pair responsible for the interaction could be negative.

3. Also the interaction of positron and electron would be based on topological condensation at the same space-time sheet and the formation of wormhole contacts mediating the interaction. Also now bound states could be glued together by magnetically charged wormhole contacts. In the case of dark positron, the details of the interaction are rather intricate since dark positron would correspond to a multi-sheeted structure analogous to Riemann surface with different sheets identified in terms of the roots of the equation relating generalized velocities defined by the time derivatives of the imbedding space coordinates to corresponding canonical momentum densities.

3.3 Dark Matter Puzzle

Sean Carroll has explained in Cosmic Variance (http://blogs.discovermagazine.com/cosmicvariance/) the latest rather puzzling situation in dark matter searches. Some experiments support the existence of dark matter particles with mass of about 7 GeV, some experiments exclude them. The following arguments show that TGD based explanation might allow to understand the discrepancy.

3.3.1 How to detect dark matter and what's the problem?

Consider first the general idea behind the attempts to detect dark matter particles and how one ends up with the puzzling situation.

1. Galactic nucleus serves as a source of dark matter particles and these one should be able to detect. There is an intense cosmic ray flux of ordinary particles from galactic center which must be eliminated so that only dark matter particles interacting very weakly with matter remain in the flux. The elimination is achieved by going sufficiently deep underground so that ordinary cosmic rays are shielded but extremely weakly interacting dark matter particles remain in the flux. After this one can in the ideal situation record only the events in which dark matter particles scatter from nuclei provided one eliminates events such as neutrino scattering.

2. DAMA experiment does not detect dark matter events as such but annual variations in the rate of events which can include besides dark matter events and other kind of events. DAMA finds an annual variation interpreted as dark matter signal since other sources of events are not expected to have this kind of variation [C45]. Also CoGENT has reported the annual variation with 2.8 sigma confidence level [C89]. The mass of the dark matter particle should be around 7 GeV rather than hundreds of GeVs as required by many models. An unidentified noise with annual variation having nothing to do with dark matter could of course be present and this is the weakness of this approach.

3. For a few weeks ago we learned that XENON100 experiment detects no dark matter [C54] (http://blogs.discovermagazine.com/cosmicvariance/2011/04/14/no-dark-matter-seen-by-xenon/). Also CDMS has reported a negative result [C32]. According to Sean Carroll, the detection strategy used by XENON100 is different from that of DAMA: individual dark matter scatterings on nuclei are detected. This is a very significant difference which might explain the discrepancy since the theory laden prejudices about what dark matter particle scattering can look like, could eliminate the particles causing the annual variations. For instance, these prejudices are quite different for the habitants of the main stream Universe and TGD Universe.

3.3.2 TGD based explanation of the DAMA events and related anomalies

I have commented earlier the possible interpretation of DAMA events in terms of tau-pions (http://matpitka.blogspot.com/2010/10/tau-pions-again-but-now-in-galactic.html). The spirit is highly speculative.

1. Tau-pions would be identifiable as the particles claimed by Fermi Gamma Ray telescope with mass around 7 GeV and decaying into tau pairs so that one could cope with several independent observations instead of only single one.

2. Recall that the CDF anomaly gave for two and half years ago support for tau-pions whereas earlier anomalies dating back to seventies give support for electro-pions and mu-pions. The existence of these particles is purely TGD based phenomenon and due to the different view about the origin of color quantum numbers. In TGD colored states would be partial waves in CP_2 and spin like quantum numbers in standard theories so that leptons would not have colored excitations.

3. Tau-pions are of course highly unstable and would not come from the galactic center. Instead, they would be created in cosmic ray events at the surface of Earth and if they can penetrate the shielding eliminating ordinary cosmic rays they could produce events responsible for the annual variation caused by that for the cosmic ray flux from galactic center.

Can one regard tau-pion as dark matter in some sense? Or must one do so? The answer is affirmative to both questions on both theoretical and experimental grounds.

1. The existence of colored variants of leptons is excluded in standard physics by intermediate gauge boson decay widths. They could however appear as states with non-standard value of Planck constant and therefore not appearing in same vertices with ordinary gauge bosons so that they would not contribute to the decay widths of weak bosons. In this minimal sense they would be dark and this is what is required in order to understand what we know about dark matter.

   Of course, all particles can in principle appear in states with non-standard value of Planck constant so that tau-pion would be one special instance of dark matter. For instance, in living matter the role of dark variants of electrons and possibly also other stable particles would be decisive. To put it bluntly: in mainstream approach dark matter is identified as some exotic particle with ad hoc properties whereas in TGD framework dark matter is outcome of a generalization of quantum theory itself.

2. DAMA experiment requires that the tau-pions behave like dark matter: otherwise they would never reach the strongly shielded detector. The interaction with the nuclei of detector would be preceded by a transformation to a particle-tau-pion or something else- with ordinary value of Planck constant.

3.3.3 TGD based explanation for the dark matter puzzle

The criteria used in experiments to eliminate events which definitely are not dark matter events - according to the prevailing wisdom of course - dictates to high degree what interactions of tau pions with solid matter detector are used as a signature of dark matter event. It could well be that the criteria used in XENON100 do not allow the scatterings of tau-pions with nuclei. This is indeed the case. The clue comes from the comments of Jester in Resonaances. From a comment of Jester one learns that CoGENT - and also DAMA utilizing the same detections strategy - "does not cut on ionization fraction". Therefore, if dark matter mimics electron recoils (as Jester says) or if dark matter produced in the collisions of cosmic rays with the nuclei of the atmosphere decays to charged particles one can understand the discrepancy.

The TGD based model [K27] explaining the more than two years old CDF anomaly [C27, C71] indeed explains also the discrepancy between XENON100 and CDMS on one hand and DAMA and CoGENT on the other hand. The TGD based model for the CDF anomaly can be found in [K27].

1. To explain the observations of CDF [C27, C71] one had to assume that tau-pions and therefore also color excited tau-leptons inside them appear as several p-adically scaled up variants so that one would have several octaves of the ground state of tau-pion with masses in good approximation equal to 3.6 GeV (two times the tau-lepton mass), 7.2 GeV, 14.4 GeV. The 14.4 GeV tau-pion was assumed to decay in a cascade like manner via lepto-strong interactions to lighter tau-pions- both charged and neutral- which eventually decayed to ordinary charged leptons and neutrinos.

2. Also other decay modes -say the decay of neutral tau-pions to gamma pair and to a pair of ordinary leptons- are possible but the corresponding rates are much slower than the decay rates for cascade like decay via multi-tau-pion states proceeding via lepto-strong interactions.

3. Just this cascade would take place also now after the collision of the incoming cosmic ray with the nucleus of atmosphere. The mechanism producing the neutral tau-pions -perhaps a coherent state of them- would degenerate in the collision of charged cosmic ray with nucleus generating strong non-orthogonal electric and magnetic fields and the production amplitude would be essentially the Fourier transform of the "instanton density" $E \cdot B$. The decays of 14 GeV neutral tau-pions would produce 7 GeV charged tau-pions, which would scatter from the protons of nuclei and generate the events excluded by XENON100 but not by DAMA and Cogent.

4. In principle the model predicts to a high degree quantitatively the rate of the events. The scattering rates are proportional to an unknown parameter characterizing the transformation

probability of tau-pion to a particle with ordinary value of Planck constant and this allows to perform some parameter tuning. This parameter would correspond to a mass insertion in the tau-pion line changing the value of Planck constant and have dimensions of mass squared.

The overall conclusion is that the discrepany between DAMA and XENON100 might be interpreted as favoring TGD view about dark matter and it is fascinating to see how the situation develops. This confusion is not the only confusion in recent day particle physics. All believed-to-be almost-certainties are challenged.

3.3.4 Has Fermi observed dark matter?

Resonaances (http://resonaances.blogspot.com/2012/04/dark-matter-signal-in-fermi.html) reports about a possible dark matter signal at Fermi satellite [C17]. Also Lubos Motl (http://motls.blogspot.com/2012/04/fermi-fifty-dark-matter-photons-at-130.html) has a posting about the finding and mentions that the statistical significance is 3.3 sigma.

The proposed dark matter interpretation for the signal would be pair of monochromatic photons with second one detected at Earth. The interpretation would be that dark matter particles with mass m nearly at rest in galactic center annihilate to a pair of photons so that one obtains a pair of photons with energy equal to the cm energy which is in a good approximation the sum $E = 2 \times m$ for the masses of the particles. The mass value would be around m=130 GeV if the final state involves only 2 photons.

In TGD framework I would consider as a first guess a pion like state decaying to two photons with standard coupling given by the coupling to the "instanton density" $E \cdot B$ of electromagnetic field. The mass of this particle would be 260 GeV, in reasonable approximation 2 times the mass m=125 GeV of the Higgs candidate.

1. Similar coupling was assumed to [K27]. The anomaly would have been produced by tau-pions, which are pionlike states formed by pairs of colored excitations of tau and its antiparticle (or possibly their super-partners). What was remarkable that the mass had three values coming as powers of two: $M = 2^k \times 2m(\tau;)$, $k = 0, 1, 2$. The interpretation in terms of p-adic length scale hypothesis would be obvious: also the octaves of the basic state are there. The constraint from intermediate gauge boson decay widths requires that these states are dark in TGD sense and therefore correspond to a non-standard value of Planck constant coming as an integer multiple of the standard value.

2. Also the explanation of the findings of Pamela discussed in this chapter require octaves of tau-pion produced in Earth's atmosphere.

3. Even ordinary pion should have 2-adic octaves. But doesn't this kill the hypothesis? We "know" that pion does not have any octaves! Maybe not, there is recent evidence for satellites of ordinary pion with energy scale of 40 MeV interpreted in terms of IR Regge trajectories assignable to the color magnetic flux tubes assignable to pion. There has been several wrong alarms about Higgs: at 115 GeV and 155 GeV at least. Could it be that there there is something real behind these wrong alarms: the scale for IR Regge trajectories would be about 20 GeV now!

So: could the dark matter candidates with mass around 260 GeV correspond to the first octave of M_{89} pion with mass around 125 GeV, the particle that colleagues want to call Higgs boson although its decay signatures suggest something different?

1. In this case it does not seem necessary to assume that the Planck constant has non-standard value although this is possible.

2. This particle should be produced in M_{89} strong interactions in the galactic center. This would require the presence of matter consisting of M_{89} nucleons emitting these pions in strong interactions. Galactic center (http://en.wikipedia.org/wiki/Galactic_center) is very exotic place and believed to contain even super-massive black hole. Could this environment accommodate also a scaled up copy of hadron physics? Presumably this would require very high temperatures with thermal energy of order.5 TeV correspond to the mass of

> M_{89} proton to make possible the presence of M_{89} matter. Or could M_{89} pion be produced in ultrastrong non-orthogonal electric and magnetic fields in the galactic center by the coupling to the instanton density. The needed field strengths would be extremely high. I have indeed proposed long time ago an explanation of very high energy cosmic rays in terms of the decay products of scaled up hadron physics (see "Cosmic Rays and Mersenne primes" in this chapter).

One can of course imagine that the photon pair is produced in the annilation of M_{89} pions with opposite charges via standard electromagnetic coupling. Also the annihilation of M_{89} spions consisting of squark pair can be considered in TGD framework where squarks could have same mass scale as quarks. In this case mass would be near 125 GeV identified as mass of neutral M_{89} pion. By scaling up the mass difference 139.570-134.976 MeV of the ordinary charged and neutral pion by the ratio of the pion M_{89} and M_{107} pion masses equal to $(125/140) \times 10^3$ one obtains that the charged M_{89} pion should have mass equal to 129.6 MeV to be compared with the 130 GeV mass suggested by experimental evidence.

The story did not end here as so often when observations cannot be replicated. The Estonian researchers Elmo Tempel, Andi Hektora and Martti Raidala have found a confirmation for the 130 GeV Fermi excess in gamma radiation from galactic center discovered by Cristoph Weniger [E1]. An important conclusion of these researchers is that best fit is obtained if the dark matter candidates decay by two-body annihilation to photons and have mass 145 GeV. The reason for why the gamma peak is at 130 GeV rather than 145 GeV would be due to the emission light particle pairs by the photons. There are also indications for a peak at 111 GeV: this could be assigned to γZ finals state of two-body decay.

In TGD framework the annihilating particles with mass about 145 GeV mass could be charged pion-like states of M_{89} hadron physics. They could be dark in the sense of having large value of Planck constant but it is not clear whether this is necessarily so. The TGD based on view about galactic dark matter locates in cosmic string like objects containing galaxies as pearls in necklace and no halo is needed to explain galactic rotation spectrum [K6]. An ultrahigh temperature would be needed to excite M_{89} hadron physics and if there is giant blackhole in galactic nucleus, there are hopes about this. M_{89} hadron physics could also produce ultrahigh energy cosmic rays as described in this chapter.

It is amusing that also CDF found for a couple of years ago evidence for a bump at the same 145 GeV energy (this has been forgotten long time ago by bloggers in 125 GeV Higgs hysteria). Estonians propose that also a particle with 290 GeV (mass would twice that of 145 GeV state) is needed. This brings further support for the idea about mass octaves of ground state of pionlike states needed to explain various anomalies (see this chapter and [K27]).

If one takes seriously the evidence for 125 GeV state and its identification as Eucdlian pion together with the evidence for galactic pionlike state with mass of 145 GeV identified as M_{89}, one has a nice support for the overall TGD based view about situation described in this chapter. The small splitting between pionlike states has possible counterpart in the ordinary hadron physics: there is evidence for satellites of pion, mesons, and baryons in 20-40 MeV scale for mass splittings and in TGD framework they would correspond to IR Regge trajectories with the scale of 10-20 GeV mass splittings (see this chapter).

We are living exciting times!

3.4 AMS Results About Dark Matter

The results of AMS-02 experiment are published. There is an article [C19] at , live blog at `http://www.quantumdiaries.org/2013/04/03/april-2013-ams-liveblog/` from CERN, and article of Economist at `http://www.economist.com/news/science-and-technology/21575729-hunt-missing-85-matte` `utm_source=twitterfeed&utm_medium=twitte`. There is also press release from CERN at `http://press.web.cern.ch/press-releases/2013/04/ams-experiment-measures-antimatter-excess-space`. Also Lubos Motl has written a summary from the point of view of SUSY fan who wants to see the findings as support for the discovery of SUSY neutralino, see `http://motls.blogspot.fi/2013/04/ams-02-dark-matter-announcements.html`. More balanced and somewhat skeptic representations paying attention to the hype-like features of the announcement come from Jester at `http:`

//resonaances.blogspot.fi/2013/04/first-results-of-ams-02.html and Matt Strassler at http://profmattstrassler.com/2013/04/03/ams-presents-some-first-results/.

The abstract of the article is here.

A precision measurement by the alpha Magnetic Spectrometer on the International Space Station of the positron fraction in primary cosmic rays in the energy range from 0.5 to 350 GeV based on 6.8×10^6 *positron and electron events is presented. The very accurate data show that the positron fraction is steadily increasing from 10 to 250 GeV, but, from 20 to 250 GeV, the slope decreases by an order of magnitude. The positron fraction spectrum shows no fine structure, and the positron to electron ratio shows no observable anisotropy. Together, these features show the existence of new physical phenomena.*

New physics has been observed. The findings confirm the earlier findings of Fermi and Pamela also showing positron excess. The experimenters do not give data above 350 GeV but say that the flux of electrons does not change. The press release states that the data are consistent with dark matter particles annihilating to positron pairs. For instance, the flux of the particles is same everywhere, which does not favor supernovae in galactic plane as source of electron positron pairs. According to the press release, AMS should be able to tell within forthcoming months whether dark matter or something else is in question - this sounds rather hypeish statement.

3.4.1 About the neutralino interpretation

Lubos Motl trusts on his mirror neurons and deduces from the body language of Samuel Ting that the flux drops abruptly above 350 GeV as neutralino interpretation predicts.

1. The neutralino interpretation (see http://en.wikipedia.org/wiki/Neutralino) assumes that the positron pairs result in the decays $\chi\chi \rightarrow e^+e^-$ and predicts a sharp cutoff above mass scale of neutralino due to the reduction of the cosmic temperature below critical value determined by the mass of the neutralino.

2. According the press release and according to the figure 5 of the article [C19] the positron fraction settles to small but constant fraction before 350 GeV. The dream of Lubos Motl is that abrupt cutoff takes place above 350 GeV: about this region we did not learn anything yet because the measurement uncertainties are too high. From Lubos Motl's dream I would intuit that neutralino mass should be of the order 350 GeV. The electron/positron flux is fitted as a sum of diffuse background proportional to $C_e^{\pm}E^{-\gamma_e^{\pm}}$ and a contribution resulting from decays and parametrized as $C_sE^{-\gamma_s}exp(-E/E_s)$ - same for electron and positron. The cutoff E_s of order $E_s = 700$ GeV: error bars are rather large. The factor $exp(-E/E_s)$ does not vary too much in the range 1-350 GeV so that the exponential is probably motivated by the possible interpretation as neutralino for which sharp cutoff is expected. The mass of neutralino should be of order E_s. The positron fraction represented in figure 5 of the article [C19] seems to approach constant near 350 GeV. The weight of the common source is only 1 per cent of the diffuse electron flux.

3. Lubos Motl notices that in neutralino scenario also a new interaction mediated by a particle with mass of order 1 GeV is needed to explain the decrease of the positron fraction above 1 GeV. It would seem that Lubos Motl is trying to force right leg to the shoe of the left leg. Maybe one could understand the low end of the spectrum solely in terms of particle or particles with mass of order 10 GeV and the upper end of the spectrum in terms of particles of M_{89} hadron physics.

4. Jester lists several counter arguments against the interpretation of the observations in terms of dark matter. The needed annihilation cross section must be two orders of magnitude higher than required for the dark matter to be a cosmic thermal relic, this holds true also for the neutralino scenario. Second problem is that the annihilation of neutralinos to quark pairs predicts also antiproton excess, which has not been observed. One must tailor the couplings so that they favor leptons. It has been also argued that pulsars could explain the positron excess: the recent finding is that the flux is same from all directions.

3.4.2 What could TGD interpretation be?

What can one say about the results in TGD framework? The first idea that comes to mind is that electron-positron pairs result from single particle annihilations but it seems that this option is not realistic. Fermion-anti-fermion annihilations are more natural and brings in strong analogy with neutralinos, which would give rise to dark matter as a remnant remaining after annihilation in cold dark matter scenario. An analogous scenario is obtained in TGD Universe by replacing neutralinos with baryons of some dark and scaled up variant of ordinary hadron physics of lepto-hadron physics.

1. The positron fraction increases from 10 to 250 GeV with its slope decreasing between 20 GeV and 250 GeV by an order of magnitude. The observations suggest to my innocent mind a scale of order 10 GeV. The TGD inspired model for already forgotten CDF anomaly [K27] suggests the existence of τ pions with masses coming as three first octaves of the basic mass which is two times the mass of τ lepton. For years ago I proposed interpretation of the Fermi and Pamela anomalies now confirmed by AMS in terms τ pions. The predicted mass of the three octaves of τ pion would be 3.6 GeV, 7.2 GeV, and 14.4 GeV. Could the octaves of τ pion could explain the increase of the production rate up to 20 GeV and its gradual drop after that?

   There is a severe objection against this idea. The energy distribution of τ pions dictates the width of the energy interval in which their decays contribute to the electron spectrum and what suggests itself is that decays of τ pions yield almost monochromatic peaks rather than the observed continuum extending to high energies. Any resonance should yield similar distribution and this suggests that the electron positron pairs must be produced in the two particle annihilations of some particles.

   The annihilations of colored τ leptons and their antiparticles could however contribute to the spectrum of electron-positron pairs. Also the leptonic analogs of baryons could annihilate with their antiparticles to lepton pairs. For these two options the dark particles would be fermions as also neutralino is.

2. Could colored τ leptons and - hadrons and their muonic and electronic counterparts be really dark matter? These particles might be dark matter in TGD sense - that is particle with a non-standard value of effective Planck constant $\hbar_{eff}$ coming as integer multiple of $\hbar$. The existence of colored excitations of leptons and pion like states with mass in good approximation twice the mass of lepton leads to difficulties with the decay widths of W and Z unless the colored leptons have non-standard value of effective Planck constant and therefore lack direct couplings to W and Z. A more general hypothesis would be that the hadrons of all scaled up variant of QCD like world (lepto-hadron physics and scaled variants of hadron physics) predicted by TGD correspond to non-standard value of effective Planck constant and dark matter in TGD sense. This would mean that these new scaled up hadron physics would couple only very weakly to the standard physics.

3. At the high energy end of the spectrum M_{89} hadron physics would be naturally involved and also now the hadrons could be dark in TGD sense. E_s might be interpreted as temperature, which is in the energy range assigned to M_{89} hadron physics and correspond to a mass of some M_{89} hadron. The annihilations nucleons and anti-nucleons of M_{89} hadron physics could contribute to the spectrum of leptons at higher energies. The direct scaling of M_{89} proton mass gives mass of order 500 GeV and this value is consistent with the limits 480 GeV and 1760 GeV for E_s.

4. There would be also a relation to the observations of Fermi suggesting annihilation of some bosonic states to gamma pairs with gamma energy around 135 GeV could be interpreted in terms of annihilations of a M_{89} pion with mass of 270 GeV (maybe octave of lepto-pion with mass 135 Gev in turn octave of pion with mass 67.5 GeV).

3.4.3 How to resolve the objections against dark matter as thermal relic?

The basic objection against dark matter scenarios is that dark matter particles as thermal relics annihilate also to quark pairs so that proton excess should be also observed. TGD based vision could also circumvent this objection.

1. Cosmic evolution would be a sequence of phase transitions between hadron physics characterized by Mersenne primes. The lowest Mersenne primes are $M_2 = 3$, $M_3 = 7$, $M_5 = 31$, $M_7 = 127$, M_{13}, M_{17}, M_{19}, M_{31}, M_{61}, M_{89}, and M_{107} assignable to the ordinary hadron physics are involved but it might be possible to have also M_{127}. There are also Gaussian Mersenne primes $M_{G,n} = (1+i)^n - 1$. Those labelled by $n = 151, 157, 163, 167$ and spanning p-adic length scales in biologically relevant length scales 10 nm, ..., 2.5 μm.

2. The key point is that at given period characterised by M_n the hadrons characterized by larger Mersenne primes would be absent. In particular, before the period of the ordinary hadrons only M_{89} hadrons were present and decayed to ordinary hadrons. Therefore no antiproton excess is expected - at least by the mechanism producing it in the standard dark matter scenarios where all dark and ordinary particles are present simultaneously.

3. Since M_{89} hadrons are strongly interacting one can hope that the cross section is indeed high enough to produce positron excess.

4. Second objection relates to the cross section, which must be two orders of magnitude larger than required by the cold dark matter scenarios. I am unable to say anything definite about this. The fact that both M¡sub¿89¡/sub¿ hadrons and colored leptons are strongly interacting would increase corresponding annilation cross section and lepto-hadrons could later decay to ordinary leptons.

3.4.4 Connection with strange cosmic ray events and strange observations at RHIC and LHC

The model allows also to understand the strange cosmic ray events (Centauros) suggesting a formation of a blob ("hot spot" of exotic matter in atmosphere and decaying to ordinary hadrons. In the center of mass system of atmospheric particle and incoming cosmic ray cm energies are indeed of order M_{89} mass scale. As suggested [K17] already earlier, these hot spots would be hot in p-adic sense and correspond to p-adic temperature assignable to M_{89}. Also the strange events observed already at RHIC in heavy ion collisions and later at LHC in proton-heavy ion collisions), and in conflict with the perturbative QCD predicting the formation of quark gluon plasma could be understood as a formation of M_{89} hot spots. The basic finding was that there were strong correlations: two particles tended to move either parallel or antiparallel, as if they had resulted in a decay of string like objects. The AdS/CFT inspired explanation was in terms of higher dimensional blackholes. TGD explanation is more prosaic: string like objects (color magnetic flux tubes) dominating the low energy limit of M_{89} hadron physics were created.

The question whether M_{89} hadrons, or their cosmic relics are dark in TGD sense remains open. In the case of colored variants of the ordinary leptons the decay widths of weak bosons force this. In the case of colored variants of the ordinary leptons the decay widths of weak bosons force this. It however seems that a coherent story about the physics in TGD Universe is developing as more data emerges. This story is bound to remain to qualitative description: quantitative approach would require a lot of collective theoretical work.

3.4.5 Also CDMS claims dark matter

Also CDMS (Cryogenic Dark Matter Search) reports new indications for dark matter particles: see the Nature blog article Another dark matter sign from a Minnesota mine at `http://blogs.nature.com/news/2013/04/another-dark-matter-sign-from-a-minnesota-mine.htm`. Experimenters have observed 3 events with expected background of.7 events and claim that the mass of the dark matter particle is 8.6 GeV. This mass is much lighter than what has been expected: something like 350 GeV was suggested as explanation of the AMS observations. The low mass is however consistent with the identification as first octave of tau-pion with mass about 7.2 GeV for which already forgotten CDF anomaly provided support for years ago (as explained above p-adic length scale hypothesis allows octaves of the basic mass for lepto-pion which is in good approximation 2 times the mass of the charged lepton, that is 3.6 GeV). The particle must be dark in TGD sense, in other words it must have non-standard value of effective Planck constant. Otherwise it would contribute to the decay widths of W and Z.

4 Scaled Variants Of Quarks And Leptons

4.1 Fractally Scaled Up Versions Of Quarks

The strange anomalies of neutrino oscillations [C83] suggesting that neutrino mass scale depends on environment can be understood if neutrinos can suffer topological condensation in several p-adic length scales [K15] . The obvious question whether this could occur also in the case of quarks led to a very fruitful developments leading to the understanding of hadronic mass spectrum in terms of scaled up variants of quarks. Also the mass distribution of top quark candidate exhibits structure which could be interpreted in terms of heavy variants of light quarks. The ALEPH anomaly [C80], which I first erratically explained in terms of a light top quark has a nice explanation in terms of b quark condensed at $k = 97$ level and having mass ~ 55 GeV. These points are discussed in detail in [K21] .

The emergence of ALEPH results [C80] meant a an important twist in the development of ideas related to the identification of top quark. In the LEP 1.5 run with $E_{cm} = 130 - 140\ GeV$, ALEPH found 14 e^+e^- annihilation events, which pass their 4-jet criteria whereas 7.1 events are expected from standard model physics. Pairs of dijets with vanishing mass difference are in question and dijets could result from the decay of a new particle with mass about 55 GeV.

The data do not allow to conclude whether the new particle candidate is a fermion or boson. Top quark pairs produced in e^+e^- annihilation could produce 4-jets via gluon emission but this mechanism does not lead to an enhancement of 4-jet fraction. No $b\bar{b}b\bar{b}$ jets have been observed and only one event containing b has been identified so that the interpretation in terms of top quark is not possible unless there exists some new decay channel, which dominates in decays and leads to hadronic jets not initiated by b quarks. For option 2), which seems to be the only sensible option, this kind of decay channels are absent.

Super symmetrized standard model suggests the interpretation in terms of super partners of quarks or/and gauge bosons [C78] . It seems now safe to conclude that TGD does not predict sparticles. If the exotic particles are gluons their presence does not affect Z^0 and W decay widths. If the condensation level of gluons is $k = 97$ and mixing is absent the gluon masses are given by $m_g(0) = 0$, $m_g(1) = 19.2\ GeV$ and $m_g(2) = 49.5\ GeV$ for option 1) and assuming $k = 97$ and hadronic mass renormalization. It is however very difficult to understand how a pair of $g = 2$ gluons could be created in e^+e^- annihilation. Moreover, for option 2), which seems to be the only sensible option, the gluon masses are $m_g(0) = 0$, $m_g(1) = m_g(2) = 30.6\ GeV$ for $k = 97$. In this case also other values of k are possible since strong decays of quarks are not possible.

The strong variations in the order of magnitude of mass squared differences between neutrino families [C83] can be understood if they can suffer a topological condensation in several p-adic length scales. One can ask whether also t and b quark could do the same. In absence of mixing effects the masses of $k = 97$ t and b quarks would be given by $m_t \simeq 48.7$ GeV and $m_b \simeq 52.3$ GeV taking into account the hadronic mass renormalization. Topological mixing reduces the masses somewhat. The fact that b quarks are not observed in the final state leaves only $b(97)$ as a realistic option. Since Z^0 boson mass is ~ 94 GeV, $b(97)$ does not appreciably affect Z^0 boson decay width. The observed anomalies concentrate at cm energy about 105 GeV. This energy is 15 percent smaller than the total mass of top pair. The discrepancy could be understood as resulting from the binding energy of the $b(97)\bar{b}(97)$ bound states. Binding energy should be a fraction of order $\alpha_s \simeq .1$ of the total energy and about ten per cent so that consistency is achieved.

4.2 Toponium at 30.4 GeV?

Prof. Matt Strassler tells about a gem found from old data files of ALEPH experiment (see `http://tinyurl.com/ze6l5wr`) by Arno Heisner [C13](see `http://tinyurl.com/hy8ugf4`). The 3-sigma bump appears at 30.40 GeV and could be a statistical fluctuation and probably is so. It has been found to decay to muon pairs and b-quark pairs. The particle that Strassler christens V (V for vector) would have spin 1.

Years ago [K17] I have commented a candidate for scaled down top quark reported by Aleph: this had mass around 55 GeV and the proposal was that it corresponds to p-adically scaled up b quark with estimated mass of 52.3 GeV.

Could TGD allow to identify V as a scaled up variant of some spin 1 meson?

1. p-Adic length scale hypothesis states that particle mass scales correspond to certain primes $p \simeq 2^k$, $k > 0$ integer. Prime values of k are of special interest. Ordinary hadronic space-time sheets would correspond to hadronic space-time sheets labelled by Mersenne prime $p = M_{107} = 2^{107} - 1$ and quarks would be labelled by corresponding integers k.

2. For low mass mesons the contribution from color magnetic flux tubes to mass dominates whereas for higher mass mesons consisting of heavy quarks heavy quark contribution is dominant. This suggests that the large mass of V must result by an upwards scaling of some light quark mass or downwards scaling of top quark mass by a power of square root of 2.

3. The mass of b quark is around 4.2-4.6 GeV and Upsilon meson has mass about 9.5 GeV so that at most about 1.4 GeV from total mass would correspond to the non-perturbative color contribution partially from the magnetic body. Top quark mass is about 172.4 GeV and p-adic mass calculations suggest $k = 94$ (M_{89}) for top. If the masses for heavy quark mesons are additive as the example of Upsilon suggests, the non-existing top pair vector meson (toponium) (see `https://en.wikipedia.org/wiki/Quarkonium`) would have mass about $m(toponium) = 2 \times 172.4$ GeV $= 344.8$ GeV.

4. Could the observed bump correspond to p-adically scaled down version of toponium with $k = 94 + 7 = 101$, which is prime? The mass of toponium would be 30.47 GeV, which is consistent with the mass of the bump. If this picture is correct, V would be premature toponium able to exist for prime $k = 101$. Its decays to b quark pair are consistent with this.

5. Tommaso Dorigo (see `http://tinyurl.com/zhgyecd`) argues that the signal is spurious since the produced muons tend to be parallel to b quarks in cm system of Z^0. Matt Strassler identifies the production mechanism as a direct decay of Z^0 and in this case Tommaso would be right: the direct 3-particle decay of $Z^0 \rightarrow b + \bar{b} + V$ would produce different angular distribution for V. One cannot of course exclude the possibility that the interpretation of Tommaso is that muon pairs are from decays of V in its own rest frame in which case they certainly cannot be parallel to b quarks. So elementary mistake from a professional particle physicist looks rather implausible. The challenge of the experiments was indeed to distinguish the muon pairs from muons resulting from b quarks decaying semileptonically and being highly parallel to b quarks.

   A further objection of Tommaso is that the gluons should have roughly opposite momenta and fusion seems highly implausible classically since the gluons tend to be emitted in opposite directions. Quantally the argument does not look so lethal if one thinks in terms of plane waves rather than wave packets. Also fermion exchange is involved so that the fusion is not local process.

6. How the bump appearing in $Z^0 \rightarrow b + \bar{b} + V$ would be produced if toponium is in question? The mechanism would be essentially the same as in the production of Ψ/J meson by a $c + \bar{c}$ pair. The lowest order diagram would correspond to gluon fusion. Both b and $\bar{b}$ emit gluon and these could annihilate to a top pair and these would form the bound state. Do virtual t and $\bar{t}$ have ordinary masses 172 GeV or scaled down masses of about 15 GeV? The checking which option is correct would require numerical calculation and a model for the fusion of the pair to toponium.

   That the momenta of muons are parallel to those of b and $\bar{b}$ might be understood. One can approximate gluons with energy about 15 GeV as a brehmstrahlung almost parallel/antiparallel to the direction of b $/\bar{b}$ both having energy about 45 GeV in the cm system of Z^0. In cm they would combine to V with helicity in direction of axis nearly parallel to the direction defined by the opposite momenta of b and $\bar{b}$. The V with spin 1 would decay to a muon pair with helicities in the direction of this axis, and since relativistic muons are in question, the momenta would by helicity conservation tend to be in the direction of this axis as observed.

Are there other indications for scaled variants of quarks?

1. Tony Smith [C93] has talked about indications for several mass peaks for top quark. I have discussed this in [K21] in terms of p-adic length scale hypothesis. There is evidence for a

sharp peak in the mass distribution of the top quark in 140-150 GeV range). There is also a peak slightly below 120 GeV, which could correspond to a p-adically scaled down variant t quark with $k = 93$ having mass 121.6 GeV for $(Y_e = 0, Y_t = 1)$. There is also a small peak also around 265 GeV which could relate to $m(t(95)) = 243.2$ GeV. Therefore top could appear at least at p-adic scales $k = 93, 94, 95$. This argument does not explain the peak in 140-150 GeV range rather near to top quark mass.

2. What about Aleph anomaly? The value of $k(b)$ in $p_b \simeq 2^{k_b}$ uncertain. $k(b) = 103$ is one possible value. In [K17]. I have considered the explanation of Aleph anomaly in terms of $k = 96$ variant of b quark. The mass scaling would be by factor of $2^{7/2}$, which would assign to mass $m_b = 4.6$ GeV mass of about 52 GeV to be compared with 55 GeV.

To sum up, the objections of Tommasso Dorigo might well kill the toponium proposal and the bump is probably a statistical fluctuation. It is however amazing that its mass comes out correctly from p-adic length scale hypothesis which does not allow fitting.

4.3 Could Neutrinos Appear In Several P-Adic Mass Scales?

There are some indications that neutrinos can appear in several mass scales from neutrino oscillations [C7]. These oscillations can be classified to vacuum oscillations and to solar neutrino oscillations believed to be due to the so called MSW effect in the dense matter of Sun. There are also indications that the mixing is different for neutrinos and antineutrinos [C57, C6].

In TGD framework p-adic length scale hypothesis might explain these findings. The basic vision is that the p-adic length scale of neutrino can vary so that the mass squared scale comes as octaves. Mixing matrices would be universal. The large discrepancy between LSND and MiniBoone results [C57] contra solar neutrino results could be understood if electron and muon neutrinos have same p-adic mass scale for solar neutrinos but for LSND and MiniBoone the mass scale of either neutrino type is scaled up. The existence of a sterile neutrino [C77] suggested as an explanation of the findings would be replaced by p-adically scaled up variant of ordinary neutrino having standard weak interactions. This scaling up can be different for neutrinos and antineutrinos as suggested by the fact that the anomaly is present only for antineutrinos.

The different values of Δm^2 for neutrinos and antineutrinos in MINOS experiment [C6] can be understood if the p-adic mass scale for neutrinos increases by one unit. The breaking of CP and CPT would be spontaneous and realized as a choice of different p-adic mass scales and could be understood in ZEO. Similar mechanism would break supersymmetry and explain large differences between the mass scales of elementary fermions, which for same p-adic prime would have mass scales differing not too much.

4.3.1 *Experimental results*

There several different type of experimental approaches to study the oscillations. One can study the deficit of electron type solar electron neutrinos (Kamiokande, Super-Kamiokande); one can measure the deficit of muon to electron flux ratio measuring the rate for the transformation of ν_μ to ν_τ (super-Kamiokande); one can study directly the deficit of ν_e ($\overline{\nu}_e$) neutrinos due to transformation to ν_μ $\nu_{\overline{\mu}}$ coming from nuclear reactor with energies in the same range as for solar neutrinos (KamLAND); and one can also study neutrinos from particle accelerators in much higher energy range such as solar neutrino oscillations (K2K,LSND,Miniboone,Minos).

1. Solar neutrino experiments and atmospheric neutrino experiments

The rate of neutrino oscillations is sensitive to the mass squared differences Δm_{12}^2, Δm_{12}^2, Δm_{13}^2 and corresponding mixing angles θ_{12}, θ_{13}, θ_{23} between ν_e, ν_μ, and ν_τ (ordered in obvious manner). Solar neutrino experiments allow to determine $sin^2(2\theta_{12})$ and Δm_{12}^2. The experiments involving atmospheric neutrino oscillations allow to determine $sin^2(2\theta_{23})$ and Δm_{23}^2.

The estimates of the mixing parameters obtained from solar neutrino experiments and atmospheric neutrino experiments are $sin^2(2\theta_{13}) = 0.08$, $sin^2(2\theta_{23}) = 0.95$, and $sin^2(2\theta_{12}) = 0.86$. The mixing between ν_e and ν_τ is very small. The mixing between ν_e and ν_μ, and ν_μ and ν_τ tends is rather near to maximal. The estimates for the mass squared differences are $\Delta m_{12}^2 = 8 \times 10^{-5}$ eV^2,

$\Delta m_{23}^2 \simeq \Delta m_{13}^2 = 2.4 \times 10^{-3}$ eV^2. The mass squared differences have obviously very different scale but this need not means that the same is true for mass squared values.

2. The results of LSND and MiniBoone

LSND experiment measuring the transformation of $\overline{\nu}_\mu$ to $\overline{\nu}_e$ gave a totally different estimate for Δm_{12}^2 than solar neutrino experiments MiniBoone [C77]. If one assumes same value of $sin^2(\theta_{12})^2 \simeq$ .86 one obtains $\Delta m_{23}^2 \sim .1$ eV^2 to be compared with $\Delta m_{12}^2 = 8 \times 10^{-5}$ eV^2. This result is known as LSND anomaly and led to the hypothesis that there exists a sterile neutrino having no weak interactions and mixing with the ordinary electron neutrino and inducing a rapid mixing caused by the large value of Δm^2. The purpose of MiniBoone experiment [C57] was to test LSND anomaly.

1. It was found that the two-neutrino fit for the oscillations for $\nu_\mu \to \nu_e$ is not consistent with LSND results. There is an unexplained 3σ electron excess for $E < 475$ MeV. For $E > 475$ MeV the two-neutrino fit is not consistent with LSND fit. The estimate for Δm^2 is in the range $.1 - 1$ eV^2 and differs dramatically from the solar neutrino data.

2. For antineutrinos there is a small 1.3σ electron excess for $E < 475$ MeV. For $E > 475$ MeV the excess is 3 per cent consistent with null. Two-neutrino oscillation fits are consistent with LSND. The best fit gives $(\Delta m_{12}^2, sin^2(2\theta_{12}) = (0.064 \ \ eV^2, 0.96)$. The value of Δm_{12}^2 is by a factor 800 larger than that estimated from solar neutrino experiments.

All other experiments (see the table of the summary of [C77] about sterile neutrino hypothesis) are consistent with the absence of $\nu_\mu \to n_e$ and $\overline{\nu}_\mu \to \overline{\nu}_e$ mixing and only LSND and MiniBoone report an indication for a signal. If one however takes these findings seriously they suggest that neutrinos and antineutrinos behave differently in the experimental situations considered. Two-neutrino scenarios for the mixing (no sterile neutrinos) are consistent with data for either neutrinos or antineutrinos but not both [C77].

3. The results of MINOS group

The MINOS group at Fermi National Accelerator Laboratory has reported evidence that the mass squared differences between neutrinos are not same for neutrinos and antineutrinos [C6]. In this case one measures the disappearance of ν_μ and $\overline{\nu}_\mu$ neutrinos from high energy beam beam in the range .5-1 GeV and the dominating contribution comes from the transformation to τ neutrinos. Δm_{23}^2 is reported to be about 40 percent larger for antineutrinos than for neutrinos. There is 5 percent probability that the mass squared differences are same. The best fits for the basic parameters are $(\Delta m_{23}^2 = 2.35 \times 10^{-3}, sin^2(2\theta_{23} = 1)$ for neutrinos with error margin for Δm^2 being about 5 per cent and $(\Delta m_{23}^2 = 3.36 \times 10^{-3}, sin^2(2\theta_{23}) = .86)$ for antineutrinos with errors margin around 10 per cent. The ratio of mass squared differences is $r \equiv \Delta m^2(\overline{\nu})/\Delta m^2(\nu) = 1.42$. If one assumes $sin^2(2\theta_{23}) = 1$ in both cases the ratio comes as $r = 1.3$.

4.3.2 *Explanation of findings in terms of p-adic length scale hypothesis*

p-Adic length scale hypothesis predicts that fermions can correspond to several values of p-adic prime meaning that the mass squared comes as octaves (powers of two). The simplest model for the neutrino mixing assumes universal topological mixing matrices and therefore for CKM matrices so that the results should be understood in terms of different p-adic mass scales. Even CP breaking and CPT breaking at fundamental level is un-necessary although it would occur spontaneously in the experimental situation selecting different p-adic mass scales for neutrinos and antineutrinos. The expression for the mixing probability a function of neutrino energy in two-neutrino model for the mixing is of form

$$P(E) = sin^2(2\theta) sin^2(X) \ \ , \ \ X = k \times \Delta m^2 \times \frac{L}{E} \ \ .$$

Here k is a numerical constant, L is the length travelled, and E is neutrino energy.

1. LSND and MiniBoone results

LSND and MiniBoone results are inconsistent with solar neutrino data since the value of Δm_{12}^2 is by a factor 800 larger than that estimated from solar neutrino experiments. This could be understood if in solar neutrino experiments ν_μ and ν_w correspond to the same p-adic mass scale $k = k_0$ and have very nearly identical masses so that Δm^2 scale is much smaller than the mass squared scale. If either p-adic scale is changed from k_0 to $k_0 + k$, the mass squared difference increases dramatically. The counterpart of the sterile neutrino would be a p-adically scaled up version of the ordinary neutrino having standard electro-weak interactions. The p-adic mass scale would correspond to the mass scale defined by Δm^2 in LSND and MiniBoone experiments and therefore a mass scale in the range .3-1 eV. The electron Compton scale assignable to eV mass scale could correspond to $k = 167$, which corresponds to cell length scale of 2.5 μm. $k = 167$ defines one of the Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$. $L_e(k) = \sqrt{5}L(k)$, $k = 151, 157, 163, 167$, varies in the range 10 nm (cell membrane thickness) and 2.5 μm defining the size of cell nucleus. These scales could be fundamental for the understanding of living matter [K8] .

2. MINOS results

One must assume also now that the p-adic mass scales for ν_τ and $\overline{\nu}_\tau$ are near to each other in the "normal" experimental situation. Assuming that the mass squared scales of ν_μ or $\overline{\nu}_\mu$ come as 2^{-k} powers of $m^2_{\nu_\mu} = m^2_{\nu_\tau} + \Delta m^2$, one obtains

$$m^2_{\nu_\tau}(k_0) - m^2_{\overline{\nu}_\mu}(k_0 + k) = (1 - 2^{-k}) m^2_{nu_\tau} - 2^{-k}\Delta m_0^2 \ .$$

For $k = 1$ this gives

$$r = \frac{\Delta m^2(k=2)}{\Delta m^2(k=1)} = \frac{\frac{3}{2} - \frac{2r}{3}}{1-r} \ , \ r = \frac{\Delta m_0^2}{m^2_{\nu_\tau}} \ . \tag{4.1}$$

One has $r \geq 3/2$ for $r > 0$ if one has $m_{\nu_\tau} > m_{\nu_\mu}$ for the same p-adic length scale. The experimental ratio $r \simeq 1.3$ could be understood for $r \simeq -.31$. The experimental uncertainties certainly allow the value $r = 1.5$ for $k(\overline{\nu}_\mu) = 1$ and $k(\nu_\mu) = 2$.

This result implies that the mass scale of ν_μ and ν_τ differ by a factor 1/2 in the "normal" situation so that mass squared scale of ν_τ would be of order 5×10^{-3} eV^2. The mass scales for $\overline{\nu}_\tau$ and ν_τ would about .07 eV and .05 eV. In the LSND and MiniBoone experiments the p-adic mass scale of other neutrino would be around .1-1 eV so that different p-adic mass scale large by a factor $2^{k/2}$, $2 \leq 2 \leq 7$ would be in question. The different resuts from various experiments could be perhaps understood in terms of the sensitivity of the p-adic mass scale to the experimental situation. Neutrino energy could serve as a control parameter.

CPT breaking [B1] requires the breaking of Lorentz invariance. ZEO could therefore allow a spontaneous breaking of CP and CPT. This might relate to matter antimatter asymmetry at the level of given CD.

There is some evidence that the mixing matrices for neutrinos and antineutrinos are different in the experimental situations considered [C6, C57]. This would require CPT breaking in the standard QFT framework. In TGD p-adic length scale hypothesis allowing neutrinos to reside in several p-adic mass scales. Hence one could have apparent CPT breaking if the measurement arrangements for neutrinos and antineutrinos select different p-adic length scales for them [K17] .

4.3.3 *Is CP and T breaking possible in ZEO?*

The CKM matrices for quarks and possibly also leptons break CP and T. Could one understand the breaking of CP and T at fundamental level in TGD framework?

1. In standard QFT framework Chern-Simons term breaks CP and T. Kähler action indeed reduces to Chern-Simons terms for the proposed ansatz for preferred extremals assuming that weak form of electric-magnetic duality holds true.

   In TGD framework one must however distinguish between space-time coordinates and imbedding space coordinates. CP breaking occurs at the imbedding space level but instanton term and Chern-Simons term are odd under P and T only at the space-time level and thus distinguish between different orientations of space-time surface. Only if one identifies P and T at space-time level with these transformations at imbedding space level, one has hope of interpreting CP and T breaking as spontaneous breaking of these symmetries for Kähler action and basically due to the weak form of electric-magnetic duality and vanishing of $j \cdot A$ term for the preferred extremals. This identification is possible for space-time regions allowing representation as graphs of maps $M^4 \rightarrow CP_2$.

2. In order to obtain non-trivial fermion propagator one must add to Dirac action 1-D Dirac action in induced metric with the boundaries of string world sheets at the light-like parton orbits. Its bosonic counterpart is line-length in induced metric. Field equations imply that the boundaries are light-like geodesics and fermion has light-like 8-momentum. This suggests strongly a connection with quantum field theory and an 8-D generalization of twistor Grassmannian approach. By field equations the bosonic part of this action does not contribute to the Kähler action. Chern-Simons Dirac terms to which Kähler action reduces could be responsible for the breaking of CP and T symmetries as they appear in CKM matrix.

3. The GRT-QFT limit of TGD obtained by lumping together various space-time sheets to a region of Minkowski space with effective metric defined by the sum of Minkowski metric and deviations of the induced metrics of sheets from Minkowski metric. Gauge potentials for the effective space-time would idenfied as sums of gauge potentials for space-time sheets. At this limit the identification of P and T at space-time level and imbedding space level would be natural. Could the resulting effective theory in Minkowski space or GRT space-time break CP and T slightly? If so, CKM matrices for quarks and fermions would emerge as a result of representing different topologies for wormhole throats with different topologies as single point like particle with additional genus quantum number.

4. Could the breaking of CP and T relate to the generation of the arrow of time? The arrow of time relates to the fact that state function reduction can occur at either boundary of CD [K3]. Zero energy states do not change at the boundary at which reduction occurs repeatedly but the change at the other boundary and also the wave function for the position of the second boundary of CD changes in each quantum jump so that the average temporal distance between the tips of CD increases. This gives to the arrow of psychological time, and in TGD inspired theory of consciousness "self" as a counterpart of observed can be identified as sequence of quantum jumps for which the state function reduction occurs at a fixed boundary of CD. The sequence of reductions at fixed boundary breaks T-invariance and has interpretation as irreversibility. The standard view is that the irreversibility has nothing to do with breaking of T-invariance but it might be that in elementary particle scales irreversibility might manifest as small breaking of T-invariance.

4.3.4 *Is CPT breaking needed/possible?*

Different values of Δm_{ij}^2 for neutrinos and antineutrinos would require in standard QFT framework not only the violation of CP but also CPT [B1] which is the cherished symmetry of quantum field theories. CPT symmetry states that when one reverses time's arrow, reverses the signs of momenta and replaces particles with their antiparticles, the resulting Universe obeys the same laws as the original one. CPT invariance follows from Lorentz invariance, Lorentz invariance of vacuum state, and from the assumption that energy is bounded from below. On the other hand, CPT violation requires the breaking of Lorentz invariance.

In TGD framework this kind of violation does not seem to be necessary at fundamental level since p-adic scale hypothesis allowing neutrinos and also other fermions to have several mass scales coming as half-octaves of a basic mass scale for given quantum numbers. In fact, even in TGD inspired low energy hadron physics quarks appear in several mass scales. One could explain the different choice of the p-adic mass scales as being due to the experimental arrangement which selects different p-adic length scales for neutrinos and antineutrinos so that one could speak about spontaneous breaking of CP and possibly CPT. The CP breaking at the fundamental level which is however expected to be small in the case considered. The basic prediction of TGD and relates to the CP breaking of Chern-Simons action inducing CP breaking in the Kähler-Dirac action defining the fermionic propagator [L3]. For preferred extremals Kähler action would indeed reduce to Chern-Simons terms by weak form of electric-magnetic duality.

In TGD one has breaking of translational invariance and the symmetry group reduces to Lorentz group leaving the tip of CD invariant. Positive and negative energy parts of zero energy states correspond to different Lorentz groups and zero energy states are superpositions of state pairs with differen values of mass squared. Is the breaking of Lorentz invariance in this sense enough for breaking of CPT is not clear.

One can indeed consider the possibility of a spontaneous breaking of CPT symmetry in TGD framework since for a given CD (causal diamond defined as the intersection of future and past directed light-cones whose size scales are assumed to come as octaves) the Lorentz invariance is broken due to the preferred time direction (rest system) defined by the time-like line connecting the tips of CD. Since the world of classical worlds is union of CDs with all boosts included the Lorentz invariance is not violated at the level of WCW. Spontaneous symmetry breaking would be analogous to that for the solutions of field equations possessing the symmetry themselves. The mechanism of breaking would be same as that for supersymmetry. For same p-adic length scale particles and their super-partners would have same masses and only the selection of the p-adic mass scale would induces the mass splitting.

5 Scaled Variants Of Hadron Physics And Of Weak Bosons

5.1 Leptohadron Physics

TGD suggest strongly ("predicts" is perhaps too strong expression) the existence of color excited leptons. The mass calculations based on p-adic thermodynamics and p-adic conformal invariance lead to a rather detailed picture about color excited leptons.

1. The simplest color excited neutrinos and charged leptons belong to the color octets ν_8 and L_{10} and $L_{\overline{10}}$ decouplet representations respectively and lepto-hadrons are formed as the color singlet bound states of these and possible other representations. Electro-weak symmetry suggests strongly that the minimal representation content is octet and decouplets for both neutrinos and charged leptons.

2. The basic mass scale for lepto-hadron physics is completely fixed by p-adic length scale hypothesis. The first guess is that color excited leptons have the levels $k = 127, 113, 107, ...$ ($p \simeq 2^k$, k prime or power of prime) associated with charged leptons as primary condensation levels. p-Adic length scale hypothesis allows however also the level $k = 11^2 = 121$ in case of electronic lepto-hadrons. Thus both $k = 127$ and $k = 121$ must be considered as a candidate for the level associated with the observed lepto-hadrons. If also lepto-hadrons correspond non-perturbatively to exotic Super Virasoro representations, lepto-pion mass relates to pion mass by the scaling factor $L(107)/L(k) = k^{(107-k)/2}$. For $k = 121$ one has $m_{\pi_L} \simeq 1.057$ MeV which compares favorably with the mass $m_{\pi_L} \simeq 1.062$ MeV of the lowest observed state: thus $k = 121$ is the best candidate contrary to the earlier beliefs. The mass spectrum of lepto-hadrons is expected to have same general characteristics as hadronic mass spectrum and a satisfactory description should be based on string tension concept. Regge slope is predicted to be of order $\alpha' \simeq 1.02/MeV^2$ for $k = 121$. The masses of ground state lepto-hadrons are calculable once primary condensation levels for colored leptons and the CKM matrix describing the mixing of color excited lepton families is known.

The strongest counter arguments against color excited leptons are the following ones.

1. The decay widths of Z^0 and W boson allow only $N = 3$ light particles with neutrino quantum numbers. The introduction of new light elementary particles seems to make the decay widths of Z^0 and W intolerably large.

2. Lepto-hadrons should have been seen in e^+e^- scattering at energies above few MeV. In particular, lepto-hadronic counterparts of hadron jets should have been observed.

A possible resolution of these problems is provided by the loss of asymptotic freedom in lepto-hadron physics. Lepto-hadron physics would effectively exist in a rather limited energy range about one MeV.

The development of the ideas about dark matter hierarchy [K12, K25, K9, K7] led however to a much more elegant solution of the problem.

1. TGD predicts an infinite hierarchy of various kinds of dark matters which in particular means a hierarchy of color and electro-weak physics with weak mass scales labelled by appropriate p-adic primes different from M_{89}: the simplest option is that also ordinary photons and gluons are labelled by M_{89}.

2. There are number theoretical selection rules telling which particles can interact with each other. The assignment of a collection of primes to elementary particle as characterizer of p-adic primes characterizing the particles coupling directly to it, is inspired by the notion of infinite primes [K26] , and discussed in [K12] . Only particles characterized by integers having common prime factors can interact by the exchange of elementary bosons: the p-adic length scale of boson corresponds to a common primes.

3. Also the physics characterized by different values of h_{eff} are dark with respect to each other as far quantum coherent gauge interactions are considered. Laser beams might well correspond to photons characterized by p-adic prime different from M_{89} and de-coherence for the beam would mean decay to ordinary photons. De-coherence interaction involves scaling down of the Compton length characterizing the size of the space-time of particle implying that particles do not anymore overlap so that macroscopic quantum coherence is lost.

4. Those dark physics which are dark relative to each other can interact only via graviton exchange. If lepto-hadrons correspond to a physics for which weak bosons correspond to a p-adic prime different from M_{89}, intermediate gauge bosons cannot have direct decays to colored excitations of leptons irrespective of whether the QCD in question is asymptotically free or not. Neither are there direct interactions between the QED:s and QCD:s in question if M_{89} characterizes also ordinary photons and gluons. These ideas are discussed and applied in detail in [K12, K25, K9] .

Skeptic reader might stop the reading after these counter arguments unless there were definite experimental evidence supporting the lepto-hadron hypothesis.

1. The production of anomalous e^+e^- pairs in heavy ion collisions (energies just above the Coulomb barrier) suggests the existence of pseudo-scalar particles decaying to e^+e^- pairs. A natural identification is as lepto-pions that is bound states of color octet excitations of e^+ and e^-.

2. The second puzzle, Karmen anomaly, is quite recent [C66] . It has been found that in charge pion decay the distribution for the number of neutrinos accompanying muon in decay $\pi \to \mu + \nu_\mu$ as a function of time seems to have a small shoulder at $t_0 \sim ms$. A possible explanation is the decay of charged pion to muon plus some new weakly interacting particle with mass of order 30 MeV [C14] : the production and decay of this particle would proceed via mixing with muon neutrino. TGD suggests the identification of this state as color singlet leptobaryon of, say type $L_B = f_{abc} L_8^a L_8^b \bar{L}_8^c$, having electro-weak quantum numbers of neutrino.

3. The third puzzle is the anomalously high decay rate of orto-positronium. [C74] . e^+e^- annihilation to virtual photon followed by the decay to real photon plus virtual lepto-pion followed by the decay of the virtual lepto-pion to real photon pair, $\pi_L\gamma\gamma$ coupling being determined by axial anomaly, provides a possible explanation of the puzzle.

4. There exists also evidence for anomalously large production of low energy e^+e^- pairs [C63, C72, C69, C90] in hadronic collisions, which might be basically due to the production of lepto-hadrons via the decay of virtual photons to colored leptons.

In this chapter a revised form of lepto-hadron hypothesis is described.

1. Sigma model realization of PCAC hypothesis allows to determine the decay widths of lepto-pion and lepto-sigma to photon pairs and e^+e^- pairs. Ortopositronium anomaly determines the value of $f(\pi_L)$ and therefore the value of lepto-pion-lepto-nucleon coupling and the decay rate of lepto-pion to two photons. Various decay widths are in accordance with the experimental data and corrections to electro-weak decay rates of neutron and muon are small.

2. One can consider several alternative interpretations for the resonances.

   Option 1: For the minimal color representation content, three lepto-pions are predicted corresponding to $8, 10, \overline{10}$ representations of the color group. If the lightest lepto-nucleons e_{ex} have masses only slightly larger than electron mass, the anomalous e^+e^- could be actually $e^+_{ex} + e^-_{ex}$ pairs produced in the decays of lepto-pions. One could identify 1.062, 1.63 and 1.77 MeV states as the three lepto-pions corresponding to $8, 10, \overline{10}$ representations and also understand why the latter two resonances have nearly degenerate masses. Since d and s quarks have same primary condensation level and same weak quantum numbers as colored e and μ, one might argue that also colored e and μ correspond to $k = 121$. From the mass ratio of the colored e and μ, as predicted by TGD, the mass of the muonic lepto-pion should be about 1.8 MeV in the absence of topological mixing. This suggests that 1.83 MeV state corresponds to the lightest $g = 1$ lepto-pion.

   Option 2: If one believes sigma model (in ordinary hadron physics the existence of sigma meson is not established and its width is certainly very large if it exists), then lepto-pions are accompanied by sigma scalars. If lepto-sigmas decay dominantly to e^+e^- pairs (this might be forced by kinematics) then one could adopt the previous sceneario and could identify 1.062 state as lepto-pion and 1.63, 1.77 and 1.83 MeV states as lepto-sigmas rather than lepto-pions. The fact that muonic lepto-pion should have mass about 1.8 MeV in the absence of topological mixing, suggests that the masses of lepto-sigma and lepto-pion should be rather close to each other.

   Option 3: One could also interpret the resonances as string model "satellite states" having interpretation as radial excitations of the ground state lepto-pion and lepto-sigma. This identification is not however so plausible as the genuinely TGD based identification and will not be discussed in the sequel.

3. PCAC hypothesis and sigma model leads to a general model for lepto-hadron production in the electromagnetic fields of the colliding nuclei and production rates for lepto-pion and other lepto-hadrons are closely related to the Fourier transform of the instanton density $\bar{E} \cdot \bar{B}$ of the electromagnetic field created by nuclei. The first source of anomalous e^+e^- pairs is the production of $\sigma_L \pi_L$ pairs from vacuum followed by $\sigma_L \rightarrow e^+e^-$ decay. If $e^+_{ex}e^-_{ex}$ pairs rather than genuine e^+e^- pairs are in question, the production is production of lepto-pions from vacuum followed by lepto-pion decay to lepto-nucleon pair.

   Option 1: For the production of lepto-nucleon pairs the cross section is only slightly below the experimental upper bound for the production of the anomalous e^+e^- pairs and the decay rate of lepto-pion to lepto-nucleon pair is of correct order of magnitude.

   Option 2: The rough order of magnitude estimate for the production cross section of anomalous e^+e^- pairs via $\sigma_l \pi_l$ pair creation followed by $\sigma_L \rightarrow e^+e^-$ decay, is by a factor of order $1/\sum N_c^2$ (N_c is the total number of states for a given colour representation and sum over the representations contributing to the ortopositronium anomaly appears) smaller than the reported cross section in case of 1.8 MeV resonance. The discrepancy could be due to the neglect of the large radiative corrections (the coupling $g(\pi_L \pi_L \sigma_L) = g(\sigma_L \sigma_L \sigma_L)$ is very large) and also due to the uncertainties in the value of the measured cross section.

   Given the unclear status of sigma in hadron physics, one has a temptation to conclude that anomalous e^+e^- pairs actually correspond to lepto-nucleon pairs.

4. The vision about dark matter suggests that direct couplings between leptons and lepto-hadrons are absent in which case no new effects in the direct interactions of ordinary leptons are predicted. If colored leptons couple directly to ordinary leptons, several new physics effects such as resonances in photon-photon scattering at cm energy equal to lepto-pion masses and the production of $e_{ex}\bar{e}_{ex}$ (e_{ex} is leptobaryon with quantum numbers of electron) and $e_{ex}\bar{e}$ pairs in heavy ion collisions, are possible. Lepto-pion exchange would give dominating contribution to $\nu - e$ and $\bar{\nu} - e$ scattering at low energies. Lepto-hadron jets should be observed in e^+e^- annihilation at energies above few MeV:s unless the loss of asymptotic freedom restricts lepto-hadronic physics to a very narrow energy range and perhaps to entirely non-perturbative regime of lepto-hadronic QCD.

During 18 years after the first published version of the model also evidence for colored μ has emerged. Towards the end of 2008 CDF anomaly gave a strong support for the colored excitation of τ. The lifetime of the light long lived state identified as a charged τ-pion comes out correctly and the identification of the reported 3 new particles as p-adically scaled up variants of neutral τ-pion predicts their masses correctly. The observed muon jets can be understood in terms of the special reaction kinematics for the decays of neutral τ-pion to 3 τ-pions with mass scale smaller by a factor 1/2 and therefore almost at rest. A spectrum of new particles is predicted. The discussion of CDF anomaly led to a modification and generalization of the original model for lepto-pion production and the predicted production cross section is consistent with the experimental estimate.

5.2 First Evidence For M_{89} Hadron Physics?

The first evidence -or should we say indication- for the existence of M_{89} hadron physics has emerged from CDF which for two and half years ago provided evidence also for the colored excitations of tau lepton and for lepto-hadron physics.

5.2.1 Has CDF discovered a new boson with mass around 145 GeV?

The story began when The eprint of CDF collaboration [C2] reported evidence for a new resonance like state, presumably a boson decaying to a dijet (jj) with mass around 145 GeV. The dijet is produced in association with W boson. The interpretation as Higgs is definitely excluded.

Bloggers reacted intensively to the possibility of a new particle. Tommaso Dorigo gave a nice detailed analysis about the intricacies of the analysis of the data leading to the identification of the bump. Also Lubos Motl and Resonaances commented the new particle. Probably the existence of the bump had been known for months in physics circles. The flow of eprints to arXiv explaining the new particle begun immediately.

One should not forget that 3 sigma observation was in question and that 5 sigma is required for discovery. It is quite possible that the particle is just a statistical fluke due to an erratic estimation of the background as Tommaso Dorigo emphasizes. Despite this anyone who has a theory able to predict something is extremely keen to see whether the possibly existing new particle has a natural explanation. This also provides the opportunity for dilettantes like me to develop the theoretical framework in more detail. We also know from general consistency conditions that New Physics must emerge in TeV scale: what we do not know what this New Physics is. Therefore all indications for it must be taken seriously.

CDF bump did not disappear and the most recent analysis assigns 4.1 sigma significance to it. The mass of the bump was reported to be at 147 ± 5 GeV. Also some evidence that the entire Wjj system results in a decay of a resonance with mass slightly below 300 GeV has emerged. D0 was however not able to confirm the existence of the bump and the latest reincarnation of the bump is as 2.8 sigma evidence for Higgs candidate in the range 140-150 GeV range and one can of ask whether this is actually evidence for the familiar 145 GeV boson which cannot be Higgs. The story involves many twists and turns and teaches how cautiously theoretician should take also the claims of experimentalists. In the following I pretend that the 145 GeV bump is real but this should not confuse the reader to believe that this is really the case.

5.2.2 Why an exotic weak boson a la TGD cannot be in question?

For the inhabitant of the TGD Universe the most obvious identification of the new particle would be as an exotic weak boson. The TGD based explanation of family replication phenomenon predicts that gauge bosons come in singlets and octets of a dynamical SU(3) symmetry associated with three fermion generations (fermion families correspond to topologies of partonic wormhole throats characterized by the number of handles attached to sphere). Exotic Z or W boson could be in question.

If the symmetry breaking between octet and singlet is due to different value of p-adic prime alone then the mass would come as an power of half-octave of the mass of Z or W. For W boson one would obtain 160 GeV only marginally consistent with 145 GeV. Z would give 180 GeV mass which is certainly too high. The Weinberg angle could be however different for the singlet and octet so that the naive p-adic scaling need not hold true exactly.

Note that the strange forward backward asymmetry in the production of top quark pairs [C28, C75] might be understood in terms of exotic gluon octet whose existence means neutral flavor changing currents as discussed in this chapter.

The *extremely* important data bit is that the decays to two jets favor quark pairs over lepton pairs. A model assuming exotic Z -called Z'- produced together with W and decaying preferentially to quark pairs has been proposed as an explanation [C4]. Neither ordinary nor the exotic weak gauge bosons of TGD Universe have this kind of preference to decay to quark pairs so that my first guess was wrong.

5.2.3 Is a scaled up copy of hadron physics in question?

The natural explanation for the preference of quark pairs over lepton pairs would be that strong interactions are somehow involved. This suggests a state analogous to a charged pion decaying to W boson two gluons annihilating to the quark pair (box diagram). This kind of proposal is indeed made in Technicolor at the Tevatron [C8]: the problem is also now why the decays to quarks are favored. Techicolor has as its rough analog second fundamental prediction of TGD that p-adically scaled up variants of hadron physics should exist and one of them is waiting to be discovered in TeV region. This prediction emerged already for about 15 years ago as I carried out p-adic mass calculations and discovered that Mersenne primes define fundamental mass scales.

Also colored excitations of leptons and therefore lepto-hadron physics are predicted [K27]. What is amusing that CDF discovered towards the end of 2008 what became known as CDF anomaly giving support for tau-pions. The evidence for electro-pions and mu-pions had emerged already earlier (for references see [K27]). All these facts have been buried underground because they simply do not fit to the standard model wisdom. TGD based view about dark matter is indeed needed to circumvent the fact that the lifetimes of weak bosons do not allow new light particles. There is also a long series of blog postings in my blog summarizing development of the TGD based model for CDF anomaly.

As should have become already clear, TGD indeed predicts p-adically scaled up copy of hadron physics in TeV region and the lightest hadron of this physics is a pion like state produced abundantly in the hadronic reactions. Ordinary hadron physics corresponds to Mersenne prime $M_{107} = 2^{107} - 1$ whereas the scaled up copy would correspond to M_{89}. The mass scale would be 512 times the mass scale 1 GeV of ordinary hadron physics so that the mass of M_{89} proton should be about 512 GeV. The mass of the M_{89} pion would be by a naive scaling 71.7 GeV and about two times smaller than the observed mass in the range 120-160 GeV and with the most probable value around 145 GeV as Lubos Motl reports in his blog. $2 \times 71.7 GeV = 143.4$ GeV would be the guess of the believer in the p-adic scaling hypothesis and the assumption that pion mass is solely due to quarks. It is important to notice that this scaling works precisely only if CKM mixing matrix is same for the scaled up quarks and if charged pion consisting of u-d quark pair is in question. The well-known current algebra hypothesis that pion is massless in the first approximation would mean that pion mass is solely due to the quark masses whereas proton mass is dominated by other contributions if one assumes that also valence quarks are current quarks with rather small masses. The alternative which also works is that valence quarks are constituent quarks with much higher mass scale.

According to p-adic mass calculations the mass of pion is just the sum of mass squared for the quarks composing. If one assumes that u and d quarks of M_{89} hadron physics correspond to $k = 93$ (top corresponds to $k = 94$, the mass of these quarks is predicted to be 102 GeV whereas the pion mass is predicted to be 144.3 GeV (the argument will be discussed in detail later). My guess based on deep ignorance about the experimental side is that this signature should be easily testable: one should try to detect mono-chromatic gamma pairs with gamma ray energy around 72.2 GeV.

5.2.4 The simplest identification of the 145 GeV resonance

The picture about CDF resonance has become (see the postings Theorists vs. the CDF bump and More details about the CDF bump by Jester [C12]. One of the results is that leptophobic Z' can explain only 60 per cent of the production rate. There is also evidence that Wjj corresponds to a resonance with mass slightly below 300 GeV as naturally predicted by technicolor models [C61].

The simplest TGD based model indeed relies on the assumption that the entire Wjj corresponds to a resonance with mass slightly below 300 GeV for which there is some evidence as noticed. If one assume that only *neutral pions* are produced in strong non-orthogonal electric and magnetic fields of colliding proton and antiproton, the mother particle must be actually second octave of 147 GeV pion and have mass somewhat below 600 GeV producing in its possibly allowed strong decays pions which are almost at rest for kinematic reasons. Therefore the production mechanism could be exactly the same as proposed for two and one half year old CDF anomaly and for the explanation of DAMA events and DAMA-Xenon100 discrepancy,

1. This suggests that the mass of the mother resonance is in a good accuracy two times the mass of 145 GeV bump for which best estimate is 147 ± 5 GeV. This brings in mind the explanation for the two and half year old CDF anomaly in which tau-pions with masses coming as octaves of basic tau-pion played a key role (masses were in good approximation $2^k \times m(\pi_\tau)$, $m(\pi_\tau) \simeq 2m_\tau$, $k = 1, 2$. The same mechanism would explain the discrepancy between the DAMA and Xenon100 experiments.

2. If this mechanism is at work now, the mass of the lowest M_{89} pion should be around 73 GeV as the naivest scaling estimate gives. One can however consider first the option for which lightest M_{89} has mass around 147 GeV so that the 300 GeV resonance could correspond to its first p-adic octave. This pion would decay to W and neutral M_{89} pion with mass around 147 GeV in turn decaying to two jets. At quark level the simplest diagram would involve the emission of W and exchange of gluon of M_{89} hadron physics. Also the decay to Z and charged pion is possible but in this case the decay of the final state could not take place via annihilation to gluon so that jet pair need not be produced.

3. One could also imagine the mother particle to be ρ meson of M_{89} hadron physics with mass in a good approximation equal to pion mass. At the level of mathematics this option is very similar to the technicolor model of CDF bump based also on the decay of ρ meson discussed in [C61]. In this model the decays of π to heavy quarks have been assumed to dominate. In TGD framework the situation is different. If π consists of scaled up u and d quarks, the decays mediated by boson exchanges would produce light quarks. In the annihilation to quark pair by a box diagram involving two gluons and two quarks at edges the information about the quark content of pion is lost. The decays involving emission of Z boson the resulting pion would be charged and its decays by annihilation to gluon would be forbidden so that Wjj final states would dominate over Zjj final states as observed.

4. The strong decay of scaled up pion to charged and neutral pion are forbidden by parity conservation. The decay can however proceed by via the exchange of intermediate gauge boson as a virtual particle. The first quark would emit virtual W/Z boson and second quark the gluon of the hadron physics. Gluon would decay to a quark pair and second quark would absorb the virtual W boson so that a two-pion final state would be produced. The process would involve same vertices as the decay of ρ meson to W boson and pion. The proposed model of the two and one half year old CDF anomaly and the explanation of DAMA and Xenon100 experiments assumes cascade like decay of pion at given level of hierarchy to two pions at lower level of hierarchy and the mechanism of decay should be this.

Consider next the masses of the M_{89} mesons. Naive scaling of the mass of ordinary pion gives mass about 71 GeV for M_{89} pion. One can however argue that color magnetic spin-spin splitting need not obey scaling formula and that it becomes small because if is proportional to eB/m where B denotes typical value of color magnetic field and m quark mass scale which is now large. The mass of pion at the limit of vanishing color magnetic splitting given by m_0 could however obey the naive scaling.

1. For (ρ, π) system the QCD estimate for the color magnetic spin-spin splitting would be

$$(m(\rho), m(\pi)) = (m_0 + 3\Delta/4, m_0 - \Delta/4) \ .$$

p-Adic mass calculations are for mass squared rather than mass and the calculations for the mass splittings of mesons [K21] force to replace this formula with

$$(m^2(\rho), m^2(\pi)) = (m_0^2 + 3\Delta^2/4, m_0^2 - \Delta^2/4) \ . \tag{5.1}$$

The masses of ρ and ω are very near to each other: $(m(\rho), m(\omega) = (.770, .782)$ GeV and obey the same mass formula in good approximation. The same is expected to hold true also for M_{89}.

2. One obtains for the parameters Δ and m_0 the formulas

$$\Delta = [m^n(\rho) - m^n(\pi)]^{1/n} \ , \ m_0 = [(m^2(\rho) + 3m(\pi)^2)/4]^{1/n} \ . \tag{5.2}$$

Here $n = 1$ corresponds to ordinary QCD and $n = 2$ to p-adic mass calculations.

3. Assuming that m_0 experiences an exact scaling by a factor 512, one can deduce the value of the parameter Δ from the mass 147 GeV of M_{89} pion and therefore predict the mass of ρ_{89}. The results are following

$$m_0 = 152.3 \ GeV \ , \ \Delta = 21.3 \ GeV \ , \ m(\rho_{89}) = 168.28 \ GeV \tag{5.3}$$

for QCD model for spin-spin splitting and

$$m_0 = 206.7 \ GeV \ , \ \Delta = 290.5 \ GeV \ , \ m(\rho_{89}) = 325.6 \ GeV \ . \tag{5.4}$$

for TGD model for spin-spin splitting.

4. Rather remarkably, there are indications from D0 [C10] for charged and from CDF [C10, C11] for neutral resonances with masses around 325 GeV such that the neutral one is split by.2 GeV: the splitting could correspond to $\rho - \omega$ mass splitting. Hence one obtains support for both M_{89} hadron physics and p-adic formulas for color magnetic spin-spin splitting. Note that the result excludes also the interpretation of the nearly 300 GeV resonance as ρ_{89} in TGD framework.

5. This scenario allows to make estimates also for the masses other resonances and naive scaling argument is expected to improve as the mass increases. For (K_{89}, K^*_{89}) system this would predict mass $m(K_{89}) > 256$ GeV and $m(K^*_{89}) < 456.7$ GeV.

The nasty question is why the octaves of pion are not realized as a resonances in ordinary hadron physics. If they were there, their decays to ordinary pion pairs by this mechanism would very slow.

1. Could it be that also ordinary pion has these octaves but are not produced by ordinary strong interactions in nucleon collisions since the nucleons do not contain the p-adically scaled up quarks fusing to form the higher octave of the pion. Also the fusion rate for two pions to higher octave of pion would be rather small by parity breaking requiring weak interactions.

2. The production mechanism for the octaves of ordinary pions, for M_{89} pions in the collisions of ordinary nucleons, and for lepto-hadrons would be universal, namely the collision of charged particles with cm kinetic energy above the octave of pion. The presence of strong non-orthogonal electric and magnetic fields varying considerably in the time scale defined by the Compton time of the pion is necessary since the interaction Lagrangian density is essentially the product of the abelian instanton density and pion field. In fact, in [C61] it is mentioned that 300 GeV particle candidate is indeed created at rest in Tevatron lab -in other words in the cm system of colliding proton and antiproton beams.

3. The question is whether the production of the octaves of scaled up pions could have been missed in proton-proton and proton antiproton collisions due to the very peculiar kinematics: pions would be created almost at rest in cm system [K27]. Whether or not this is the case should be easy to test. For a theorists this kind of scenario does not look impossible but at the era of LHC it would require a diplomatic genius and authority of Witten to persuade experimentalists to check whether low energy collisions of protons produce octaves of pions!

There is also the question about the general production mechanisms for M_{89} hadrons.

1. Besides the production of scalar mesons in strong non-orthogonal magnetic and electric fields also the production via annihilation of quark pairs to photon and weak bosons in turn decaying to the quarks of M_{89} hadron physics serves as a possible production mechanism. These production mechanisms do not give much hopes about the production of nucleons of M_{89} physics.

2. If ordinary gluons couple to M_{89} quarks, also the production via fusion to gluons is possible. If the transition from M_{107} hadron physics corresponds to a phase transition transforming M_{107} hadronic space-time sheets/gluons to M_{89} space-time sheets/gluons, M_{107} gluons do not couple directly to M_{89} gluons. In this case however color spin glass phase for M_{107} gluons could decay to M_{89} gluons in turn producing also M_{89} nucleons. Recall that naive scalings for M_{89} nucleon the mass 481 GeV. The actual mass is expected to be higher but below the scaled up Δ resonance mass predicted to be below 631 GeV.

5.2.5 How could one understand CDF-D0 discrepancy concerning 145 GeV resonance?

The situation concerning 145 GeV bump has become rather paradoxical. CDF claims that 145 GeV resonance is there at 4.3 sigma level. The new results from D0 however fail to support CDF bump [C44] (see Lubos Motl, Jester, and Tommaso Dorigo).

This shows only that either CDF or D0 is wrong, not that CDF is wrong as some of us suddenly want to believe. My own tentative interpretation -not a belief- relies on bigger picture provided by TGD and is that both 145 GeV, 300 GeV, and 325 GeV resonances are there and have interpretations in terms of π and its p-adic octave, ρ, and ω of M_{89} hadron physics. I could of course be wrong. LHC will be the ultimate jury.

In any case, neither CDF and D0 are cheating and one should explain the discrepancy rationally. Resonaances mentions different estimates for QCD background as a possible explanation. What one could say about this in TGD framework allowing some brain storming?

1. There is long history of this kind of forgotten discoveries having same interpretation in TGD framework. Always pionlike states-possibly coherent state of them- would have been produced in strong non-orthogonal magnetic and electric fields of the colliding charges and most pion-like states predicted to be almost at rest in cm frame.

   Electro-pions were observed already at seventies in the collisions of heavy nuclei at energies near Coulomb wall, resonances having interpretation as mu-pions about three years ago, tau-pions detected by CDF for two and half years ago with refutation coming from D0, now DAMA and Cogent observed dark matter candidate having explanation in terms of tau-pion in TGD framework but Xenon100 found nothing (in this case on can understand the discrepancy in TGD framework). The octaves of M_{89} pions would represent the last episode of this strange history. In the previous posting universality of the production mechanism forced to made the proposal that also the collisions of ordinary nuclei could generate octaves of ordinary pions. They have not been observed and as I proposed this might due to the peculiarity of the production mechanism.

   What could be a common denominator for this strange sequence of almost discoveries? Light colored excitations of leptons can be of course be argued to be non-existent because intermediate boson decay widths do not allow them but it is difficult to believe that his would have been the sole reason for not taking lepto-pions seriously.

2. Could the generation of a pionic coherent state as a critical phenomenon very sensitive to the detailed values of the dynamical parameters, say the precise cm energies of the colliding beams? For lepto-pions a phase transition generating dark colored variants of leptons (dark in the sense having non-standard value of Planck constant) would indeed take place so that criticality might make sense. Could also M_{89} quarks be dark or colored excitations of ordinary quarks which are dark? Could the $M_{107} \rightarrow M_{89}$ phase transition take place only near criticality? This alone does not seem to be enough however.

3. The peculiarity of the production mechanism is that the pion like states are produced mostly at rest in cm frame of the colliding charges. Suppose that the cm frame for the colliding charged particles is not quite the lab frame in D0. Since most dark pions are produced nearly at rest in the cm frame, they could in this kind of situation leave the detector before decaying to ordinary particles: they would behave just like dark matter is expected to behave and would not be detected. The only signature would be missing energy. This would also predict that dark octaves of ordinary pions would not be detected in experiments using target which is at rest in lab frame.

4. This mechanism is actually quite general. Dark matter particles decaying to ordinary matter and having long lifetime remain undetected if they move with high enough velocity with respect to laboratory. Long lifetime would be partially due to the large value of $\hbar$ and relativistic with respect to laboratory velocities also time dilation would increases the lifetime. Dark matter particles could be detected only as a missing energy not identifiable in terms of neutrinos. A special attention should be directed to state candidates which are nearly at rest in laboratory.

An example from ordinary hadron physics is the production of pions and their octaves in the strong electric and magnetic field of nuclei colliding with a target at rest in lab. The lifetime of neutral pion is about 10^{-8} seconds and scaled up for large $\hbar$ and by time dilation when the colliding nucleons have relativistic energies. Therefore the dark pion might leave the measurement volume before decay to two gammas when the the target is at rest in laboratory. It is not even clear whether the gammas need to have standard value of Planck constant.

For the second octave of M_{89} pion the lifetime would be scaled down by the ratio of masses giving a factor 2^{11} and lifetime of order $.5 \times 10^{-11}$ seconds. Large $\hbar$ would scale up the lifetime. For non-relativistic relativistic velocities the distance travelled before the decay to gamma pair would $L = (\hbar/\hbar_0) \times (v/c) \times 1.1$ mm.

If also the gamma pair is dark, the detection would require even larger volume. TGD suggests strongly that also photons have a small mass which they obtain by eating the remaining component of Higgs a la TGD (transforming like 1+3 under vectorial weak SU(2)). If photon mass defines the upper bound for the rate for the transformation to ordinary photons, dark photons would remain undetected.

5.2.6 Higgs or a pion of M_{89} hadron physics?

D0 refuted the 145 GeV bump and after this it was more or less forgotten in blogs, which demonstrates how regrettably short the memory span of blog physicists is. CDF reported it in Europhysics 2011 and it seems that the groups are considering seriously possible explanations for the discrepancy. To my opinion the clarification of his issue is of extreme importance.

The situation changed at the third day of conference (Saturday) when ATLAS reported about average 2.5 sigma evidence for what might be Higgs in the mass range 140-150 GeV. The candidate revealed itself via decays to WW in turn decaying to lepton pairs. Also D0 and CDF told suddenly that they have observed similar evidence although the press release had informed that Higgs had been located to the mass range 120-137 GeV. There is of course no reason to exclude the possibility that the decays of 145 GeV resonance are in question and in this case the interpretation as standard model Higgs would be definitely excluded. If the pion of M_{89} physics is in question it would decay to WW pair instead of quark pair producing two jets. Since weak decay is in question one an expect that the decay rate is small.

If this line of reasoning is correct, standard model Higgs is absent. TGD indeed predicts that the components of TGD Higgs become longitudinal components of gauge bosons since also photon and graviton gain a small mass. This however leaves the two Higgses predicted by MSSM under consideration. The stringent lower bounds for the masses of squarks and gluinos of standard SUSY were tightened in the conference and are now about 1 TeV and this means that the the basic argument justifying MSSM (stability of Higgs mass against radiative corrections) is lost.

The absence of Higgs forces a thorough re-consideration of the fundamental ideas about particle massivation. p-Adic thermodynamics combined with zero energy ontology and the identification of massive particles as bound states of massless fermions is the vision provided by TGD.

5.2.7 Short digression to TGD SUSY

Although the question about TGD variant of SUSY is slightly off-topic, its importance justifies a short discussion. Although SUSY is not needed to stabilize Higgs mass, the anomaly of muonic g-2 suggests TGD SUSY and the question is whether TGD SUSY could explain it.

1. Leptons are characterized by Mersennes or Gaussian Mersennes: $(M_{127}, M_{G,113}, M_{107})$ for (e, μ, τ). If also sleptons correspond to Mersennes of Gaussian Mersennes, then (selectron, smuon, stau) should correspond to $(M_{89}, M_{G,79}, M_{61})$ is one assumes that selectron corresponds to M_{89}. Selectron mass would be 250 GeV and smuon mass 13.9 TeV. g-2 anomaly for muon [K17] suggests that the mass of selectron should not be much above.1 TeV and M_{89} fits the bill. Valence quarks correspond to the Gaussian Mersenne $k \leq 113$, which suggests that squarks have $k \geq 79$ so that squark masses should be above 13 TeV. If sneutrinos correspond to Gaussian Mersenne $k = 167$ then sneutrinos could have mass below electron mass scale. Selectron would remain the only experiment signature of TGD SUSY at this moment.

2. One decay channel for selectron would be to electron+ sZ or neutrino+ sW. sZ/sW would eventually decay to possibly virtual Z+ neutrino/W+neutrino: that is weak gauge boson plus missing energy. Neutralino and chargino need not decay in the detection volume. The lower bound for neutralino mass is 46 GeV from intermediate gauge boson decay widths. Hence this option is not excluded by experimental facts.

3. If the sfermions decay rapidly enough to fermion plus neutrino, the signature of TGD SUSY would be excess of events of type lepton+ missing energy or jet+ missing energy. For instance, lepton+missing jet could be mis-identified as decay products of possibly exotic counterpart of weak gauge boson. The decays of 250 GeV selectron would give rise to decays which might be erratically interpreted as decays of W' to electron plus missing energy. The study of CDF at $\sqrt{s}$= 1.96 TeV in p-pbar collisions excludes heavy W$'$ with mass below 1.12 TeV [C30]. The decay rate to electron plus neutrino must therefore be slow.

   There are indications for a tiny excess of muon + missing energy events in the decays of what has been tentatively identified as a heavy W boson W^{prime} (see Figure 1 of [C23]). The excess is regarded as insignificant by experimenters. W^{prime} candidate is assumed to have mass 1.0 TeV or 1.4 TeV. If smuon is in question, one must give up the Mersenne hypothesis.

5.2.8 The mass of u and d quarks of M_{89} physics

While updating the chapter about the p-adic model for hadronic masses [K21] I found besides some silly numerical errors also a gem that I had forgotten. For pion the contributions to mass squared from color-magnetic spin-spin interaction and color Coulombic interaction and super-symplectic gluons cancel and the mass is in excellent approximation given by the $m^2(\pi) = 2m^2(u)$ with $m(u) = m(d) = 0.1$ GeV in good approximation. That only quarks contribute is the TGD counterpart for the almost Goldstone boson character of pion meaning that its mass is only due to the massivation of quarks. The value of the p-adic prime is $p \simeq 2^k$, with $k(u) = k(d) = 113$ and the mass of charged pion is predicted with error of .2 per cent.

If the reduction of pion mass to mere quark mass holds true for all scaled variants of ordinary hadron physics, one can deduce the value of u and d quark masses from the mass of the pion of M_{89} hadron physics and vice versa. The mass estimate is 145 GeV if one identifies the bump claimed by CDF [C31] as M_{89} pion. Recall that D0 did not detect the CDF bump [C44] (I have discussed possible reasons for the discrepancy in terms of the hypothesis that dark quarks are in question). From this one can deduce that the p-adic prime $p \simeq 2^k$ for the u and d quarks of M_{89} physics is

$k = 93$ using $m(u, 93) = 2^{(113-93)/2}m(u, 113)$, $m(u, 113) \simeq .1$ GeV. For top quark one has $k = 94$ so that a very natural transition takes place to a new hadron physics. The predicted mass of $\pi(89)$ is 144.8 GeV and consistent with the value claimed by CDF. What makes the prediction non-trivial is that possible quark masses comes as as half-octaves meaning exponential sensitivity with respect to the p-adic length scale.

The common mass of $u(89)$ and $d(89)$ quarks is 102 GeV in a good approximation and quark jets with mass peaked around 100 GeV should serve as a signature for them. The direct decays of the $\pi(89)$ to M_{89} quarks are of course non-allowed kinematically.

5.2.9 A connection with the top pair backward-forward asymmetry in the production of top quark pars?

One cannot exclude the possibility that the predicted exotic octet of gluons proposed as an explanation of the anomalous backward-forward asymmetry in top pair production correspond sto the gluons of the scaled up variant of hadron physics. M_{107} hadron physics would correspond to ordinary gluons only and M_{89} only to the exotic octet of gluons only so that a strict scaled up copy would not be in question. Could it be that given Mersenne prime tolerates only single hadron physics or lepto-hadron physics?

In any case, this would give a connection with the TGD based explanation of the backward-forward asymmetry in the production of top pairs also discussed in this chapter. In the collision incoming quark of proton and antiquark of antiproton would topologically condense at M_{89} hadronic space-time sheet and scatter by the exchange of exotic octet of gluons: the exchange between quark and antiquark would not destroy the information about directions of incoming and outgoing beams as s-channel annihilation would do and one would obtain the large asymmetry. The TGD based generalized Feynman diagram would involve an exchange of a gluon represented by a wormhole contact. The first wormhole throat would have genus two as also top quark and second throat genus zero. One can imagine that the top quark comes from future and then travels along space-like direction together with antiquark wormhole throat of genus zero a and then turns back to the future. Incoming quark and antiquark perform similar turn around [K17].

This asymmetry observed found a further confirmation in Europhysics 2011 conference [C40]. The obvious question is whether this asymmetry could be reduced to that in collisions of quarks and antiquarks. Tommaso Dorigo tells that CMS has found that this is not the case, which suggests that the phenomenon might be assignable to valence quarks only.

5.3 Other Indications For M_{89} Hadron Physics

Also other indications for M_{89} hadron physics have emerged during this year and although the fate of these signals is probably the usual one, they deserve to be discussed briefly.

5.3.1 Bumps also at CDF and D0?

It seems that experimentalists have gone totally crazy. Maybe new physics is indeed emerging from LHC and they want to publish every data bit in the hope of getting paid visit to Stockholm. *CDF* and ATLAS have told about bumps and now Lubos Motl [C10] tells about a new 3 sigma bump reported by D0 collaboration at mass 325 GeV producing muon in its decay producing W boson plus jets [C43]. The proposed identification of bump is in terms of decay of t′ quark producing W boson.

Lubos Motl mentions also second mysterious bump at 324.8 GeV or 325.0 GeV reported by *CDF* collaboration [C29] and discussed by Tommaso Dorigo [C11] towards the end of the last year. The decays of these particles produce 4 muons through the decays of two Z bosons to two muons. What is peculiar is that two mass values differing by.2 GeV are reported. The proposed explanation is in terms of Higgs decaying to two Z bosons. TGD based view about new physics suggests strongly that the three of four particles forming a multiplet is in question.

One can consider several explanations in TGD framework without forgetting that these bumps very probably disappear. Consider first the D0 anomaly alone.

1. TGD predicts also higher generations but there is a nice argument based on conformal invariance and saying that higher particle families are heavy. What “heavy” means is not clear. It

could of mean heavier that intermediate gauge boson mass scale. This explanation does not look convincing to me.

2. Another interpretation would be in terms of scaled up variant of top quark. The mass of top is around 170 GeV and p-adic length scale hypothesis would predict that the mass should equal to a multiple of half octave of top quark mass. Single octave would give mass of 340 GeV. The deviation from predicted mass would be 5 per cent.

3. The third interpretation is in terms of ρ and ω mesons of M_{89}. By assuming that the masses of M_{89} π and ρ in absence of color magnetic spin-spin splitting scale naively in the transition from M_{107} to M_{89} physics and by determining the parameter characterizing color magnetic spin-spin splitting from the condition that M_{89} pion has 157 GeV mass, one predicts that M_{89} ρ and ω have same mass 325.6 GeV in good approximation The.2 GeV mass difference would have interpretation as $\rho - \omega$ mass difference. In TGD framework this explanation is unique.

5.3.2 Indications for M_{89} charmonium from ATLAS

Lubos Motl commented last ATLAS release about dijet production. There is something which one might interpret as the presence of resonances above 3.3 TeV [see Fig. 2) of the article] [C20]. Of course, just a slight indication is in question, so that it is perhaps too early to pay attention to the ATLAS release. I am however advocating a new hadron physics and it is perhaps forgivable that I am alert for even tiniest signals of new physics.

In a very optimistic mood I could believe that a new hadron physics is being discovered (145 GeV boson could be identified as charged pion and 325 GeV bumps could allow interpretation as kaons). With this almost killer dose of optimism the natural question is whether this extremely slight indication about new physics might have interpretation as a scaled up J/Ψ and various other charmonium states above it giving rise to what is not single very wide bump to a family of several resonances in the range 3-4 TeV by scaling the 3-4 GeV range for charmonium resonances. For instance, J/Ψ decay width is very small, about.1 MeV, which is about $.3 \times 10^{-4}$ of the mass of J/Ψ. In the recent case direct scaling would give decay of about 300 MeV for the counterpart of J/Ψ if the decay is also now slow for kinematic reasons. For other charmonium resonances the widths are measurement in per cents meaning in the recent case width of order of magnitude 30 GeV: this estimate looks more reasonable as the first estimate.

One can also now perform naive scalings. J/Ψ has mass of about 3 GeV. If the scaling of ordinary pion mass from.14 GeV indeed gives something like 145 GeV then one can be very naive and apply the same scaling factor of about 1030 to get the scaled up J/Ψ; with mass of order 3.1 TeV. The better way to understand the situation is to assume that color-magnetic spin spin splitting is small also for M_{89} charmonium states and apply naive scaling to the mass of J/Ψ; to get a lower bound for the mass of its M_{89} counterpart. This would give mass of 1.55 TeV which is by a factor 1/2 too small. p-Adic mass calculations lead to the conclusion that c quark is characterized by $p \simeq 2^k$, $k = 104$. Naive scaling would give $k = 104 - 18 = 86$ and 1.55 TeV mass for J/Ψ. Nothing however excludes $k = 84$ and the lower bound 3.1 TGD for the mass of J/Ψ. Since color magnetic spin-spin splitting is smaller for M_{89} pion, same is expected to be true also for charmonium states so that the mass might well be around 3.3 TeV.

5.3.3 Blackholes at LHC: or just bottonium of M_{89} hadron physics?

The latest Tommaso Dorigo's posting has a rather provocative title: The Plot Of The Week - A Black Hole Candidate. Some theories inspired by string theories predict micro black holes at LHC. Micro blackholes have been proposed as explanation for certain exotic cosmic ray events such as Centauros, which however seem to have standard physics explanation.

Without being a specialist one could expect that evaporating black hole would be in many respects analogous to quark gluon plasma phase decaying to elementary particles producing jets. Or any particle like system, which has forgot all information about colliding particles which created it- say the information about the scattering plane of partons leading to the jets as a final state and reflecting itself as the coplanarity of the jets. If the information about the initial state is lost, one would expect more or less spherical jet distribution. The variable used as in the study is sum of transverse energies for jets emerging from same point and having at least 50 GeV transverse energy. QCD predicts that this kind of events should be rather scarce and if they are present, one can seriously consider the possibility of new physics.

The LHC document containing the sensational proposal is titled Search for Black Holes in pp collisions at $\sqrt{s} = 7$ TeV [C18] and has the following abstract:

An update on a search for microscopic black hole production in pp collisions at a center-of-mass energy of 7 TeV by the CMS experiment at the LHC is presented using a 2011 data sample corresponding to an integrated luminosity of 190 pb1. This corresponds to a six-fold increase in statistics compared to the original search based on 2010 data. Events with large total transverse energy have been analyzed for the presence of multiple energetic jets, leptons, and photons, typical of a signal from an evaporating black hole. A good agreement with the expected standard model backgrounds, dominated by QCD multijet production, has been observed for various multiplicities of the final state. Stringent model-independent limits on new physics production in high-multiplicity energetic final states have been set, along with model-specific lim- its on semi-classical black hole masses in the 4-5 TeV range for a variety of model parameters. This update extends substantially the sensitivity of the 2010 analysis.

The abstract would suggest that nothing special has been found but in sharp contrast with this the article mentions black hole candidate decaying to 10 jets with total transverse energy S_T. The event is illustrated in the figure 3 of the article. The large number of jets emanating from single point would suggest a single object decaying producing the jets.

Personally I cannot take black holes as an explanation of the event seriously. What can I offer instead? p-Adic mass calculations rely on p-adic thermodynamics and this inspires obvious questions. What p-adic cooling and heating processes could mean? Can one speak about p-adic hot spots? What p-adic overheating and over-cooling could mean? Could the octaves of pions and possibly other mesons explaining several anomalous findings including CDF bump correspond to unstable over-heated hadrons for which the p-adic prime near power of two is smaller than normally and p-adic mass scale is correspondingly scaled up by a power of two?

The best manner to learn is by excluding various alternative explanations for the 10 jet event.

1. M_{89} variants of QCD jets are excluded both because their production requires higher energies and because their number would be small. The first QCD three-jets were observed around 1979 [C88]. $q - \overline{q} - g$ three-jet was in question and it was detected in e^+e^- collision with cm energy about 7 GeV. The naive scaling by factor 512 would suggest that something like 5.6 TeV cm energy is needed to observed M_{89} parton jets. The recent energy is 7 TeV so that there are hopes of observing M_{89} three- jets in decays of heavy M_{89}. For instance, the decays of charmonium and bottonium of M_{89} physics to three gluons or two-gluons and photon would create three-jets.

2. Ordinary quark gluon plasma is excluded since in a sufficiently large volume of quark gluon plasma so called jet quenching [C3] occurs so that jets have small transverse energies. This would be due to the dissipation of energy in the dense quark gluon plasma. Also ordinary QCD jets are predicted to be rare at these transverse energies: this is of course the very idea of how black hole evaporation might be observed. Creation of quark gluon plasma of M_{89} hadron physics cannot be in question since ordinary quark gluon plasma was created in p-anti-p collision with cm energy of few TeV so that something like 512 TeV of cm energy might be needed!

3. Could the decay correspond to a decay of a blob of M_{89} hadronic phase to M_{107} hadrons? How this process could take place? I proposed for about 15 years ago [K17] that the transition from M_{89} hadron physics to M_{107} hadron physics might take place as a p-adic cooling via a cascade like process via highly unstable intermediate hadron physics. The p-adic temperature is quantized and given by $T_p = n/log(p) \simeq n/klog(2)$ for $p \simeq 2^k$ and p-adic cooling process would proceed in a step-wise manner as $k \to k+2 \to k+4+...$ Also $k \to k+1 \to k+2+..$ with mass scale reduced in powers of $\sqrt{2}$ can be considered. If only octaves are allowed, the p-adic prime characterizing the hadronic space-time sheets and quark mass scale could decrease in nine steps from M_{89} mass scale proportional to $2^{-89/2}$ octave by octave down to the hadronic mass scale proportional $2^{-107/2}$ as $k = 89 \to 91 \to 93... \to 107$. At each step

the mass in the propagator of the particle would be changed. In particular on mass shell particles would become off mass shell particles which could decay.

At quark level the cooling process would naturally stop when the value of k corresponds to that characterizing the quark. For instance b quark one has $k(b) = 103$ so that 7 steps would be involved. This would mean the decay of M_{89} hadrons to highly unstable intermediate states corresponding to $k = 91, 93, ..., 107$. At every step states almost at rest could be produced and the final decay would produce large number of jets and the outcome would resemble the spectrum blackhole evaporation. Note that for u, d, s quarks one has $k = 113$ characterizing also nuclei and muon which would mean that valence quark space-time sheets of lightest hadrons would be cooler than hadronic space-time sheet, which could be heated by sea partons. Note also that quantum superposition of phases with several p-adic temperatures can be considered in zero energy ontology.

This is of course just a proposal and might not be the real mechanism. If M_{89} hadrons are dark in TGD sense as the TGD based explanation of CDF-D0 discrepancy suggests, also the transformation changing the value of Planck constant is involved.

4. This picture does not make sense in the TGD inspired model explaining DAMA observations and DAMA-Xenon100 anomaly, CDF bump discussed in this chapter and two and half year old CDF anomaly [K27]. The model involves creation of second octave of M_{89} pions decaying in stepwise manner. A natural interpretation of p-adic octaves of pions is in terms of a creation of over-heated unstable hadronic space-time sheet having $k = 85$ instead of $k = 89$ and p-adically cooling down to relatively thermally stable M_{89} sheet and containing light mesons and electroweak bosons. If so then the production of CDF bump would correspond to a creation of hadronic space-time sheet with p-adic temperature corresponding to $k = 85$ cooling by the decay to $k = 87$ pions in turn decaying to $k = 89$. After this the decay to M_{107} hadrons and other particles would take place.

Consider now whether the 10 jet event could be understood as a creation of a p-adic hot spot perhaps assignable to some heavy meson of M_{89} physics. The table below is from [K15, K20] and gives the p-adic primes assigned with constituent quarks identified as valence quarks. For current quarks the p-adic primes can be much large so that in the case of u and d quark the masses can be in 10 MeV range (which together with detailed model for light hadrons supports the view that quarks can appear at several p-adic temperatures).

1. According to p-adic mass calculations [K20] ordinary charmed quark corresponds to $k = 104 = 107 - 3$ and that of bottom quark to $k = 103 = 107 - 4$, which is prime and correspond to the second octave of M_{107} mass scale assignable to the highest state of pion cascade. By naive scaling M_{89} charmonium states (Ψ would correspond to $k = 89 - 3 = 86$ with mass of about 1.55 TeV by direct scaling. $k = 89 - 4 = 85$ would give mass about 3.1 GeV and there is slight evidence for a resonance around 3.3 TeV perhaps identifiable as charmonium. Υ (bottonium) consisting of $b\bar{b}$ pair correspond to $k = 89 - 4 = 85$ just like the second octave of M_{89} pion. The mass of M_{89} Υ meson would be about 4.8 TeV for $k = 85$. $k = 83$ one obtains 9.6 TeV, which exceeds the total cm energy 7 TeV.

2. Intriguingly, $k = 85$ for the bottom quark and for first octave of charmonium would correspond to the second octave of M_{89} pion. Could it be that the hadronic space-time sheet of Υ is heated to the p-adic temperature of the bottom quark and then cools down in a stepwise manner? If so, the decay of Υ could proceed by the decay to higher octaves of light M_{89} mesons in a process involving two steps and could produce a large number jets.

3. For the decay of ordinary Υ meson 81.7 per cent of the decays take place via ggg state. In the recent case they would create three M_{89} parton jets producing relativistic M_{89} hadrons. 2.2 per cent of decays take place via γgg state producing virtual photon plus M_{89} hadrons. The total energies of the three jets would be about 1.6 TeV each and much higher than the energies of QCD jets so that this kind of jets would serve as a clearcut signature of M_{89} hadron physics and its bottom quark. Note that there already exists slight evidence for charmonium state. Recall that the total transverse energy of the 10 jet event was about 1 TeV.

Also direct decays to M_{89} hadrons take place. η' +anything - presumably favored by the large contribution of $b\bar{b}$ state in η'- corresponds to 2.9 per cent branching ratio for ordinary hadrons. If second octaves of η' and other hadrons appear in the hadron state, the decay product could be nearly at rest and large number of M_{89} would result in the p-adic cooling process (the naive scaling of η' mass gives.5 TeV and second octave would correspond to 2 TeV.

4. If two octave p-adic over-heating is dynamically favored, one must also consider the first octave of of scaled variant of J/Ψ state with mass around 3.1 GeV scaled up to 3.1 TeV for the first octave. The dominating hadronic final state in the decay of J/Ψ is $\rho^{\pm}\pi^{\mp}$ with branching ratio of 1.7 per cent. The branching fractions of $\omega\pi^+\pi^+\pi^-\pi^-$, $\omega\pi^+\pi^-\pi^0$, and $\omega\pi^+\pi^+pi^-$ are 8.5×10^{-3} 4.0×10^{-3}, and 8.6×10^{-3} respectively. The second octaves for the masses of ρ and π would be 1.3 TeV and.6 TeV giving net mass of 1.9 TeV so that these mesons would be relativistic if charmonium state with mass around 3.3 TeV is in question. If the two mesons decay by cooling, one would obtain two jets decaying two jets. Since the original mesons are relativistic one would probably obtain two wide jets decomposing to sub-jets. This would not give the desired fireball like outcome.

   The decays $\omega\pi^+\pi^+\pi^-\pi^-$ (see Particle Data Tables would produce five mesons, which are second octaves of M_{89} mesons. The rest masses of M_{89} mesons would in this case give total rest mass of 3.5 TeV. In this kind of decay -if kinematically possible- the hadrons would be nearly at rest. They would decay further to lower octaves almost at rest. These states in turn would decay to ordinary quark pairs and electroweak bosons producing a large number of jets and black hole like signatures might be obtained. If the process proceeds more slowly from M_{89} level, the visible jets would correspond to M_{89} hadrons decaying to ordinary hadrons. Their transverse energies would be very high.

q	d	u	s	c	b	t
n_q	4	5	6	6	59	58
s_q	12	10	14	11	67	63
$k(q)$	113	113	113	104	103	94
$m(q)/GeV$	.105	.092	.105	2.191	7.647	167.8

Constituent quark masses predicted for diagonal mesons assuming $(n_d, n_s, n_b) = (5, 5, 59)$ and $(n_u, n_c, n_t) = (5, 6, 58)$, maximal CP_2 mass scale($Y_e = 0$), and vanishing of second order contributions.

To sum up, the most natural interpretation for the 10-jet event in TGD framework would be as p-adic hot spots produced in collision.

5.3.4 Has CMS detected λ baryon of M_{89} hadron physics?

In his recent posting Lubos Motl tells about a near 3-sigma excess of 390 GeV 3-jet RPV-gluino-like signal reported by CMS collaboration in article Search for Three-Jet Resonances in p-p collisions at $\sqrt{s} = 7$ TeV [C22]. This represents one of the long waited results from LHC and there are good reason to consider it at least half-seriously.

Gluinos are produced in pairs and in the model based on standard super-symmetry decay to three quarks. The observed 3-jets in question would correspond to a decay to uds quark triplet. The decay would be R-parity breaking. The production rate would however too high for standard SUSY so that something else is involved if the 3 sigma excess is real.

1. *Signatures for standard gluinos correspond to signatures for M_{89} baryons in TGD framework*

In TGD Universe gluinos would decay to ordinary gluons and right-handed neutrino mixing with the left handed one so that gluino in TGD sense is excluded as an explanation of the 3-jets. In TGD framework the gluino candidate would be naturally replaced with $k = 89$ variant of strange baryon λ decaying to *uds* quark triplet. Also the 3-jets resulting from the decays of proton and neutron and Δ resonances are predicted. The mass of ordinary λ is $m(\lambda, 107) = 1.115$ GeV. The naive scaling by a factor 512 would give mass $m(\lambda, 107) = 571$ GeV, which is considerably higher than 390 GeV. Naive scaling would predict the scaled up copies of the ordinary light hadrons so that the model is testable.

It is quite possible that the bump is a statistical fluctuation. One can however reconsider the situation to see whether a less naive scaling could allow the interpretation of 3-jets as decay products of M_{89} λ-baryon.

2. Massivation of hadrons in TGD framework

Let us first look the model for the masses of nucleons in p-adic thermodynamics [K21].

1. The basic model for baryon masses assumes that mass squared -rather than energy as in QCD and mass in naive quark model- is additive at space-time sheet corresponding to given p-adic prime whereas masses are additive if they correspond to different p-adic primes. Mass contains besides quark contributions also "gluonic contribution" which dominates in the case of baryons. The additivity of mass squared follows naturally from string mass formula and distinguishes dramatically between TGD and QCD. The value of the p-adic prime $p \simeq 2^k$ characterizing quark depends on hadron: this explains the mass differences between baryons and mesons. In QCD approach the contribution of quark masses to nucleon masses is found to be less than 2 per cent from experimental constraints. In TGD framework this applies only to sea quarks for which masses are much lighter whereas the light valence quarks have masses of order 100 MeV.

   For a mass formula for quark contributions additive with respect to quark mass squared quark masses in proton would be around 100 MeV. The masses of u, d, and s quarks are in good approximation 100 MeV if p-adic prime is $k = 113$, which characterizes the nuclear space-time sheet and also the space-time sheet of muon. The contribution to proton mass is therefore about $\sqrt{3} \times 100$ MeV.

   Remark: The masses of u and d sea quarks must be of order 10 MeV to achieve consistency with QCD. In this case p-adic primes characterizing the quarks are considerably larger. Quarks with mass scale of order MeV are important in nuclear string model which is TGD based view about nuclear physics [L2].

2. If color magnetic spin-spin splitting is neglected, p-adic mass calculations lead to the following additive formula for mass squared.

$$M(baryon) = M(quarks) + M(gluonic) \ \ , \ \ M^2(gluonic) = nm^2(107) \ . \tag{5.5}$$

   The value of integer n can almost predicted from a model for the TGD counterpart of the gluonic contribution [K21] to be $n = 18$. $m^2(107)$ corresponds to p-adic mass squared associated with the Mersenne prime $M_{107} = 2^{107} - 1$ characterizing hadronic space-time sheet responsible for the gluonic contribution to the mass squared. One has $m(107) = 233.55$ MeV from electron mass $m_e \simeq \sqrt{5} \times m(127) \simeq 0.5$ MeV and from $m(107) = 2^{(127-107)/2} \times m(127)$.

3. For proton one has

$$M(quarks) = (\sum_{quarks} m^2(quark))^{1/2} \simeq 3^{1/2} \times \ \ 100 \ \ MeV$$

   for $k(u) = k(d) = 113$ [K21].

3. Super-symplectic gluons as TGD counterpart for non-perturbative aspects of QCD

A key difference as compared to QCD is that the TGD counterpart for the gluonic contribution would contain also that due to "super-symplectic gluons" besides the possible contribution assignable to ordinary gluons.

1. Super-symplectic gluons do not correspond to pairs of quark and and antiquark at the opposite throats of wormhole contact as ordinary gluons do but to single wormhole throat

carrying purely bosonic excitation corresponding to color Hamiltonian for CP_2. They therefore correspond directly to wave functions in WCW ("world of classical worlds") and could therefore be seen as a genuinely non-perturbative objects allowing no description in terms of a quantum field theory in fixed background space-time.

2. The description of the massivation of super-symplectic gluons using p-adic thermodynamics allows to estimate the integer n characterizing the gluonic contribution. Also super-symplectic gluons are characterized by genus g of the partonic 2-surface and in the absence of topological mixing $g = 0$ super-symplectic gluons are massless and do not contribute to the ground state mass squared in p-adic thermodynamics. It turns out that a more elegant model is obtained if the super-symplectic gluons suffer a topological mixing assumed to be same as for U type quarks. Their contributions to the mass squared would be $(5, 6, 58) \times m^2(107)$ with these assumptions.

3. The quark contribution $(M(nucleon) - M(gluonic))/M(nucleon)$ is roughly 82 per cent of proton mass. In QCD approach experimental constraints imply that the sum of quark masses is less that 2 per cent about proton mass. Therefore one has consistency with QCD approach if one assumes that the light quarks correspond to sea quarks.

4. What happens in $M_{107} \to M_{89}$ transition?

What happens in the transition $M_{107} \to M_{89}$ depends on how the quark and gluon contributions depend on the Mersenne prime.

1. One can also scale the "gluonic" contribution to baryon mass which should be same for proton and λ. Assuming that the color magnetic spin-spin splitting and color Coulombic conformal weight expressed in terms of conformal weight are same as for the ordinary baryons, the gluonic contribution to the mass of $p(89)$ corresponds to conformal weight $n = 11$ reduced from its maximal value $n = 3 \times 5 = 15$ corresponding to three topologically mixed super-symplectic gluons with conformal weight 5 [K21]. The reduction is due to the negative colour Coulombic conformal weight. This is equal to $M_g = \sqrt{11} \times 512 \times m(107)$, $m(107) = 233.6$ MeV, giving $M_g = 396.7$ GeV which happens to be very near to the mass about 390 GeV of CMS bump. The facts that quarks appear already in light hadrons in several p-adic length scales and quark and gluonic contributions to mass are additive, raises the question whether the state in question corresponds to p-adically hot ($1/T_p \propto log(p) \simeq klog(2)$ gluonic/hadronic space-time sheet with $k = 89$ containing ordinary quarks giving a small contribution to the mass squared. Kind of overheating of hadronic space-time sheet would be in question.

2. The option for which quarks have masses of thermally stable M_{89} hadrons with quark masses deduced from the questionable 145 GeV CDF bump identified as the pion of M_{89} physics does not work.

   (a) If both contributions scale up by factor 512, one obtains $m(p, 89) = 482$ GeV and $m(\lambda) = 571$ GeV. The values are too large.

   (b) A more detailed estimate gives the same result. One can deduce the scaling of the quark contribution to the baryon mass by generalizing the condition that the mass of pion is in a good approximation just $m(\pi) = \sqrt{2}m(u, 107)$ (Goldstone property). One obtains that u and d quarks of M_{89} hadron physics correspond to $k = 93$ whereas top quark corresponds to $k = 94$: the transition between hadron physics would be therefore natural. One obtains $m(u, 89) = m(d, 89) = 102$ GeV in good approximation: note that this predicts quark jets with mass around 100 GeV as a signature of M_{89} hadron physics.
   The contribution of quarks to proton mass would be $M_q = \sqrt{3} \times 2^{(113-93)/2} m(u, 107) \simeq$ 173 GeV. By adding the quark contribution to gluonic contribution $M_g = 396.7$ GeV, one obtains $m(p, 89) = 469.7$ GeV which is rather near to the naively scaled mass 482 GeV and too large. For $\lambda(89)$ the mass is even larger: if $\lambda(89) - p(89)$ mass difference obeys the naive scaling one has $m(\lambda, 89) - m(p, 89) = 512 \times m(\lambda, 107) - m(p, 107)$. One obtains $m(\lambda, 89) = m(p, 89) + m(s, 89) - m(u, 89) = 469.7 + 89.6$ GeV $= 559.3$ GeV rather near to the naive scaling estimate 571 GeV. This option fails.

Maybe I would be happier if the 390 GeV bump would turn out to be a fluctuation (as it probably does) and were replaced with a bump around 570 GeV plus other bumps corresponding to nucleons and Δ resonances and heavier strange baryons. The essential point is however that the mass scale of the gluino candidate is consistent with the interpretation as λ baryon of M_{89} hadron physics. Quite generally, the signatures of R-parity breaking standard SUSY have interpretation as signatures for M_{89} hadron physics in TGD framework.

5.3.5 3-jet and 9-jet events as a further evidence for M_{89} hadron physics?

The following arguments represent a fresh approach to 390 GeV bump which I developed without noticing that I had discussed already earlier the above un-successful explanation.

Lubos Motl told about slight 3-jet and 9-jet excesses seen by CMS collaboration in LHC data. There is an article about 3-jet excess titled Search for Three-Jet Resonances in pp Collisions at $s^{1/2} = 7$ TeV by CMS collaboration [C35]. The figure in Lubos Motl's blog (see `http://tinyurl.com/z3wcke8` shows what has been found. In 3-jet case the effects exceeds 3-sigma level between 350 GeV and 410 GeV and the center is around 380-390 GeV.

Experimenters see 3-jets as 1.9 sigma evidence for SUSY. It is probably needless to tell that 1.9 sigma evidences come and go and should not be taken seriously. Gluino pair would be produced and each gluino with mass around 385 GeV would decay to three quarks producing three jets. In tri-jet case altogether 3+3=6 jets would be produced in the decays of gluinos. The problem is that there is no missing energy predicted by MSSM scenario without R-parity breaking. Therefore the straightforward proposal of CMS collaboration is that R-parity is broken by a coupling of gluino to 3 quark state so that gluino would effectively have quark number three and gluino can decay to 3 light quarks- say uds.

The basic objection against this idea is that the distribution of 3-jet masses is very wide extending from 75 GeV (slightly below 100 GeV for selected events) to about 700 GeV as one learns from figure 1 of the CMS preprint [C35]. Resonance interpretation does not look convincing to me and to my humble opinion this is a noble but desperate attempt to save the standard view about SUSY. After proposing the explanation which follows I realized to my surprise that I had already earlier tried to explain the 390 GeV bump in terms of M_{89} baryon but found that this explanation fails [L6] since the mass is too low to allow this interpretation.

There is also an article about nona-jets titled Has SUSY Gone Undetected in 9-jet Events? A Ten-Fold Enhancement in the LHC Signal Efficiency [C73] but I will not discuss this except by noticing that nona-jet events would serve as a unique signature of M_{89} baryon decays in TGD framework if the proposed model for tri-jets is correct.

Before continuing I want to make clear my motivations for spending time with thinking about this kind events which are probably statistical fluctuations. If I were an opportunist I would concentrate all my efforts to make a maximum noise about the successes of TGD. I am however an explorer rather than career builder and physics is to me a passion- something much more inspiring than personal fame. My urge is to learn what TGD SUSY is and what it predicts and this kind of activity is the best manner to do it.

1. Could one interpret the 3-jet events in terms of TGD SUSY without R-parity breaking?

I already mentioned the very wide range of 3-jet distribution as a basic objection against gluino pair interpretation. But just for curiousity one can also consider a possible interpretation in the framework provided by TGD SUSY.

As I have explained in the article [L5], one could understand the apparent absence of squarks and gluinos in TGD framework in terms of shadronization which would be faster process than the selectro-weak decays of squarks so that the standard signatures of SUSY (jest plus missing energy) would not be produced. The mass scales and even masses of quark and squark could be identical part from a splitting caused by mixing. The decay widths of weak bosons do not however allow light exotic fermions coupling to them and this in the case of ordinary hadron physics this requires that squarks are dark having therefore non-standard value of Planck constant coming as an integer multiple of the ordinary Planck constant [K11]. For M_{89} hadron physics this constraint is not necessary.

One can indeed imagine an explanation for 3-jets in terms of decays of gluino pair in TGD framework without R-parity breaking.

1. Both gluinos would decay as $\tilde{g} \rightarrow \tilde{q} + \overline{q}$ (or charge conjugate of this) and squark in turn decays as $\tilde{q} \rightarrow q + \tilde{g}$. This would give quark pair and two virtual gluinos. Virtual gluinos would transform to a quark pair by an exchange of virtual squark: $\tilde{g} \rightarrow q + \overline{q}$. This would give 3 quark jets and 3 anti-quark jets.

2. Why this option possible also in MSSM is not considered by CMS collaboration? Do the bounds on squark masses make the rate quite too low? The very strong lower bounds on squark masses in MSSM type SUSY were indeed known towards the end of August when the article was published. In TGD framework these bounds are not present since squarks could appear with masses of ordinary quarks if they are dark in TGD sense. Gluinos would be however dark and the amplitude for the phase transition transforming gluon to its dark variant decaying to a gluino pair could make the rate too low.

3. If one takes the estimate for the M_{89} gluino mass seriously and scales to a very naive mass estimate for M_{107} gluino by a factor 1/512, one obtains $m(\tilde{g}_{107}) = 752$ MeV.

As already noticed, I do not take this explanation too seriously: the tri-jet distribution is quite too wide.

2. Could tri-jets be interpreted in terms of decays of M_{89} quarks to three ordinary quarks?

3+3 jets are observed and they correspond to 3 quarks and antiquarks. If one takes 3-jet excess seriously it seems that one has to assume a fermion decaying to 3 quarks or two quarks and antiquark. All these quarks could be light (u, d, s type quarks).

Could M_{89} quarks decaying to three M_{107} (ordinary) quarks ($q_{89} \rightarrow q_{107}q_{107}\overline{q}_{107}$) be in question? If this were the case the 9-jets might allow interpretation as decays of M_{89} proton or neutron with mass which from naive scaling would be $512 \times .94$ GeV $\simeq 481$ GeV resulting when each quark the nucleon decays to three ordinary quarks. Nona-jets would serve as a unique signature for the production of M_{89} baryons!

M_{89} quarks must decay somehow to ordinary quarks.

1. The simplest guess is that the transformation $q_{89} \rightarrow q_{107}q_{107}\overline{q}_{107}$ begins with the decay $q_{89} \rightarrow q_{107} + g_{89}$. Here g_{89} can be virtual.

2. This would be followed by $g_{89} \rightarrow q_{107}\overline{q}_{107}$. The final state would consist of two quarks and one antiquark giving rise to tri-jet. The decay of M_{89} gluon could produce all quark families democratically apart from phase space factors larger for light quarks. This would produce 3+3 jets with a slight dominance of light quark 3-jets.

There are two options to consider. The first option corresponds to a production of a pair of on mass shell M_{89} quarks with mass around 385 GeV (resonance option) and second option to a production of a pair of virtual M_{89} quarks suggested by the wide distribution of tri-jets.

1. Could the resonance interpretation make sense? Can the average 3-jet mass about 385 GeV correspond to the mass of M_{89} quark? The formulas $m(\pi_{89}) = 2^{1/2}m(u_{89})$ (mass squared is additive) together with $m(\pi_{89}) = 144$ GeV would give $m(u_{89}) \simeq 101.8$ GeV. Unfortunately the mass proposed for the gluino is almost 4 times higher. The naive scaling by factor 512 for charmed quark mass $m(c_{107}) = 1.29$ GeV would give 660.5 GeV, which is quite too high. It seems very difficult to find any reasonable interpretation in terms of decays of on mass shell M_{89} quarks with mass around 385 GeV.

2. One can however consider completely different interpretation. From figure 1 [C35] of the CMS preprint one learns that the distribution of 3-jet masses is very wide beginning around 75 GeV (certainly consistent with 72 GeV, which is one half of the predicted mass 144 GeV of M_{89} pion) for all triplets and slightly below 100 GeV for selected triplets.

   Could one interpret the situation without selection by assuming that a pair of M_{89} quarks forming a virtual M_{89} pion is produced just as the naive expectation that the old-fashioned proton-pion picture could make sense at "low" energies (using of course M_{89} QCD Λ as a natural mass scale) also for M_{89} physics. The total mass of M_{89} quark pair would be above 144 GeV and its decay to virtual M_{89} quark pair would give quark pair with quark masses above 72 GeV. Could the selected events with total 3-jet mass above 100 GeV correspond to the production of a virtual M_{89} quark pair?

To sum up, if one takes the indications for 3-jets seriously, the interpretation in terms of M_{89} hadron physics is the most plausible TGD option. I am unable to say anything about the 9-jet article but 9-jets would serve as a unique and very dramatic signature of M_{89} baryons: the naive prediction for the mass of M_{89} nucleon is 481 GeV.

5.3.6 3 sigma evidence for kaons of M_{89} hadron physics?

The news about Moriond conference (for details see for the posting of Phil Gibbs) did not bring anything really new concerning the situation with Higgs. The two-photon discrepancy is still there although the production rate is now about 1.6 times higher than predicted. The error bars are however getting narrower so that there are excellent reasons to hope/fear that unexpected kind of new physics is trying to tell about itself. Also the masses deduced from gamma pair and Z pair decay widths are slightly different.

The TGD-based explanation would be in terms of M_{89} hadron physics, a fractal copy of ordinary hadron physics with 512 times higher overall mass scale. If the pion of this new physics has mass not too far from 125 GeV its decays to gamma and Z pairs would affect the observed decay rates of Higgs to gamma and Z pairs if one assumes just standard model. Fermi anomaly suggests mass of about 135 GeV for the pion of M_{89} hadron physics. The observations of RHIC and those from proton-heavy nucleus collisions - correlated pairs of charged particles moving in same or opposite directions- could be understood in terms of decays of M_{89} mesons behaving like hadronic strings in low energies in the relevant energy scale.

Lubos Motl tells in his recent posting about 3 sigma excess for new charged and neutral particles with mass around 420 GeV [C25]. They would be produced as pairs of charged and neutral particle. M_{89} physics based explanation would be in terms of kaons of M_{89} hadron physics. The naive scaling by the ratio $r = m(\pi^+_{107})/m(K^+_{107})$ of masses of ordinary pion and kaon predicts that the M_{89} pion should have mass $m(\pi^+_{89}) = r \times 420$ GeV. This would give $m(\pi^+_{89}) = 119$ GeV not too far from 125 GeV to affect the apparent decay rates of Higgs to gamma and Z pairs since its width as strongly interacting particle decaying to ordinary quarks and gluons is expected to be large. This mass however deviates from the 135 GeV mass suggested by Fermi data by 18 per cent.

5.4 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 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 $M_{107} = 2^{107} - 1$.

5.4.1 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 [C36]. 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.*

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

Second highly attractive explanation discussed by Lubos Motl 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 Resonaance at `http://tinyurl.com/hpeq4q3`). 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.

One can consider a more concrete model for the situation.

1. The first picture is that M_{89} color magnetic flubes tubes are created between the colliding protons and have length and thickness which is 512 shorter than that of ordinary hadronic color flux tubes and therefore also 512 times higher energy. The energy of colliding protons would be partially transformed to that of M_{89} mesons. This process should occur above critical collision energy $E_{cr}(p) = 512m_p \sim .5$ TeV and perhaps already above $E_{cr}(p) = m(pi_{89}) = 67.5$ GeV. One can worry about the small geometric size of M_{89} mesons: is it

really possible to transfer of energy of protons consisting of quarks to a scale shorter by factor 1/512 or does this process occur at quark level and doesn't one encounter the same problem here? This problem leads to second picture.

2. M_{89} mesons could be dark so that their size is same as the size of protons: this could make possible a collective transfer of collision energy in the scale of entire proton to that of dark M_{89} mesons transforming later to much smaller ordinary M_{89} mesons. If this is the size the value $h_{eff}/h = 512$ is favourable.

3. The proposal [K35] is that dark phases of matter are generated at quantum criticality: does quantum criticality mean now that dark M_{89} mesons are created only near the threshold for the process but not at higher collision energies? If so, the production of M_{89} mesons would be observed only near energies E_{cr} assignable to proton-proton cm and quark-quark cm. For constituent quarks identifiable as current quark plus its magnetic body, the masses would be roughly $m_p/3$ and one would have $E_{cr}(q) = 3E_{cr}(q)$ (note that the masses of u and d current quarks are the scale of 5-20 MeV so thatcolor magnetic energy dominates baryon mass).

4. This brings in mind leptohadron model [K27] explaining the reported production of mesonlike states in heavy ion collisions. These states had mass slightly larger than twice the mass of electron and they decayed to electron-positron pair. The production was observed only in the vicinity of Coulomb wall of order MeV, the mass of electro-pion. The explanation is in terms of color excited electrons forming pion like bound state. If color excited leptons are light, the decay widths of weak bosons are predicted to be too large. If the produced states are dark, one circumvents this problem. Quantum criticality corresponds to Coulomb wall and explains why the production occurs around it.

   In the recent case quantum criticality could mean the threshold for production of M_{89} mesons. The bad news is that quantum criticality could mean that M_{89} mesons are not produced at higher LHC energies so that the observed bumps assignable to M_{89} would suffer the usual fate of the bump. Since quantum criticality does not belong to the conceptual repertoire of particle physicist, one cannot expect that the notion of M_{89} hadron would be accepted easily by the community.

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.

5.4.3 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 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 [K22] 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 [L4]. 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!

5.5 New Results From Phenix Concerning Quark Gluon Plasma

New results have been published on properties of what is conventionally called quark gluon plasma (QGP). As a matter fact, this phase does not resemble plasma at all. The decay patterns bring in mind decays of string like objects parallel to the collision axes rather than isotropic blackbody radiation. The initial state looks like a perfect fluid rather than plasma and thus more like a particle like object.

The results of QGP - or color glass condensate (CGC) as it is also called - come from three sources and are very similar. The basic characteristic of the collisions is the cm energy $\sqrt{s}$ of nucleon pair. The data sources are Au-Au collisions at RHIC, Brookhaven with $\sqrt{s} = 130$ GeV, p-p collisions and p-nucleus collisions at LHC with $\sqrt{s} = 200$ GeV [C59] and d-Au collisions at RHIC with $\sqrt{s} = 200$ GeV studied by PHENIX collaboration [C52].

According to the popular article telling about the findings of PHENIX collaboration (`http://www.sciencedaily.com/releases/2013/12/131206163022.htm#.UqYYWdqz7Fg.email`) the collisions are believed to involve a creation of what is called hot spot. In Au-Au collisions this hot spot has size of order Au nucleus. In d-Au collisions it is reported to be much, much smaller. What does this mean? The size of deuteron nucleus or of nucleon? Or something even much smaller? Hardly so if one believes in QCD picture. If this is however the case, the only reasonable candidate for its size would be the longitudinal size scale of colliding nucleon-nucleon system of order $L = \hbar/\sqrt{s}$ if an object with this size is created in the collision. I did my best to find some estimate for the very small size of the hot spot from articles some related to the study but failed [C51, C52, C59]: paranoid would see this as a conspiracy to keep this as a state secret.

5.5.1 How to understand the findings?

I have already earlier considered the basic characteristics of the collisions. What is called QGP does not behave at all like plasma phase for which one would expect particle distributions mimicking blackbody radiation of quarks and gluons. Strong correlations are found between charged particles created in the collision and the best manner to describe them is in terms of a creation of longitudinal string-like objects parallel to the collision axes.

In TGD framework this observation leads to the proposal that the string like objects could be assigned with M_{89} hadron physics introduced much earlier to explain strange cosmic ray events like Centauro. The p-adic mass scale assignable to M_{89} hadron physics is obtained from that of electron (given by p-adic thermodynamics in good approximation by $m_{127} = m_e/\sqrt{5}$) as $m_{89} = 2^{(127-89)/2} \times m_e/\sqrt{5}$. This gives $m_{89} = 111.8$ GeV. This is conveniently below the cm mass of nucleon pair in all the experiments.

In standard approach based on QCD the description is completely different. The basic parameters are now thermodynamical. One assumes that thermalized plasma phase is created and is parametrized by the energy density assignable to gluon fields for which QCD gives the estimate $\epsilon \geq 1$ GeV/fm^3 and by temperature which is about $T = 170$ GeV and more or less corresponds to QCD Λ. One can think of the collision regions as highly flattened pancake (Lorentz contraction) containing very density gluon phase called color glass condensate, which would be something different from QGP and definitely would not conform with the expectations from perturbative QCD since QGP would be precisely a manifestation of perturbative QGP [C59].

Also a proposal has been made that this phase could be described by AdS/CFT correspondence non-perturbatively - again in conflict with the basic idea that perturbative QCD should work. It has however turned out that this approach does not work even qualitatively as Sabine Hossenfelder lucidly explains this in her blog article *Whatever happened to AdS/CFT and the Quark Gluon Plasma?* (`http://backreaction.blogspot.fi/2013/09/whatever-happened-to-adscft-and-quark.html`).

Strangely enough, this failure of QGP and AdS/CFT picture has not created any fuss although one might think that the findings challenging the basic pillars of standard model should be seen as sensational and make happy all those who have publicly told that nothing would be more wellcome than the failure of standard model. Maybe particle theorists have enough to do with worrying about the failure of standard SUSY and super string inspired particle phenomenology that they do not want to waste their time to the dirty problems of low energy phenomenology.

A further finding mentioned in the popular article is stronger charm-anticharm suppression in head-on collisions than in peripheral collisions [C65]. What is clear that if M_{89} hadrons are created, they consist of lightest quarks present in the lightest hadrons of M_{89} hadron physics - that is u and d (and possibly also s) of M_{89} hadrons, which are scaled variants of ordinary u and d quarks and decay to u and d (and possibly s) quarks of M_{107} hadron physics. If the probability of creating a hot M_{89} spot is higher in central than peripheral collisions the charm suppression is stronger. Could a hot M_{89} spot associated with a nucleon-nucleon pair heat some region around it to M_{89} hadronic phase so that charm suppression would take place inside larger volume than in periphery?

There is also the question whether the underlying mechanism relies on specks of hot QGP or some inherent property of nuclei themselves. At the first sight, the latter option could not be farther from the TGD inspired vision. However, in nuclear string model [L2] inspired by TGD nuclei consists of nucleons connected by color bonds having quark and antiquark at their ends. These bonds are characterized by rather large p-adic prime characterizing current quark mass scale of order 5-20 GeV for u and d quarks (the first rough estimate for the p-adic scales involved is $p \simeq 2^k$, $k = 121$ for 5 MeV and $k = 119$ for 20 MeV). These color bonds Lorentz contract in the longitudinal direction so that nearly longitudinal color bonds would shorten to M_{89} scale whereas transversal color bonds would get only thinner. Could they be able to transform to color bonds characterized by M_{89} and in this manner give rise to M_{89} mesons decaying to ordinary hadrons?

5.5.2 Flowers to the grave of particle phenomenology

The recent situation in theoretical particle physics and science in general does not raise optimism. Super string gurus are receiving gigantic prizes from a theory that was a failure. SUSY has failed in several fronts and cannot be anymore regarded as a manner to stabilize the mass of Higgs. Although the existence of Higgs is established, the status of Higgs mechanism is challenged by its un-naturalness: the assumption that massivation is due to some other mechanism and Higgs has gradient coupling provides a natural explanation for Higgs couplings. This coupling is dimensional and could be critized for this reason. Also Higgs couplings contain dimensional parameter (tachyonic Higgs mass squared).

The high priests (`http://www.math.columbia.edu/~woit/wordpress/?p=6457`) are however talking about "challenges" instead of failures. Even evidence for the failure of even basic QCD is accumulating as explained above. Peter Higgs, a Nobel winner of this year, commented the situation ironically (`http://www.theguardian.com/science/2013/dec/06/peter-higgs-boson-academic-system`) by saying that he would have not got a job in the recent day particle physics community since he is too slow.

The situation is not much better in the other fields of science. Randy Scheckman, also this year's Nobel prize winner in physiology and medicine (`http://www.theguardian.com/science/2013/dec/09/nobel-winner-boycott-science-journals`) has declared boycott of top science journals Nature, Cell and Science. Scheckman said that the pressure to publish in "luxury" journals encourages researchers to cut corners and pursue trendy fields of science instead of doing more important work. The problem is exacerbated, he said, by editors who were not active scientists but professionals who favoured studies that were likely to make a splash.

Theoretical and experimental particle physics is a marvellous creation of humankind. Perhaps we should bring flowers to the grave of the particle physics phenomenology and have a five minutes respectful silence. It had to leave us far too early.

5.6 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 (`http://www.math.columbia.edu/~woit/wordpress/?p=5428`) and soon propagated to the blogs of Lubos Motl (`http://motls.blogspot.fi/2012/12/christmas-rumor-105gev-dimuon-excess-at.html#more`) and Phil Gibbs (`http://blog.vixra.org/2012/12/25/christmas-rumour/`).

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 Motl however represents a graph from a publication of ATLAS (`http://arxiv.org/abs/1210.5070`) [C24] 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. Also CMS has reported same Christmas rumor but 4 years later (see http://arxiv.org/abs/1411.4131).

5.6.1 TGD view about color allows charge 2 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 [K27], 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.

5.6.2 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 [K17] 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.

The decay of bound states of two colored leptons with same (or opposite) charge would require a trilinear coupling gLL_8 analogous to magnetic moment coupling. Color octet leptons L_8 would transform to ordinary leptons by gluon emission.

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.

5.7 Has Icecube Detected Neutrinos Coming From Decays Of P-Adically Scaled Up Copies Of Weak Bosons?

There is a very interesting posting Storm in IceCube by Jester (`http://resonaances.blogspot.fi/2013/09/storm-in-ice-cube.html`). IceCube is a neutrino detector located at South Pole. Most of the neutrinos detected are atmospheric neutrinos originating from Sun but what one is interested in are neutrinos from astrophysical sources.

1. Last year the collaboration reported [C46] the detection for neutrino cascade events, with with energy around 1 PeV=10^6 GeV. The atmospheric background decreases rapidly with energy and at these energies the detection of a pair of events at these energies corresponds to about 3 sigma. The recent report [C55] tells about a broad excess of events (28 events) above 30 TeV: only about 10 are expected from atmospheric neutrinos alone. The flavor composition is consistent with 1: 1: 1 ratio of the 3 neutrino species as expected for distant sources for which the oscillations during the travel should cause complete mixing. The distribution of the observed events is consistent with isotropy.

2. There is a dip ranging from.4 PeV to about 1 PeV and the spectrum has probably a sharp cutoff somewhat above 1 TeV. This suggests a monochromatic neutrino line resulting from the decays of some particle decaying to neutrino and some other particle - possibly also neutrino [C70] (see this). Astrophysical phenomena with standard model physics are expected to produce smooth power-law spectrum - typically $1/E^2$ - rather than peak. The proposal is that the events around 1 PeV could come from the decay of dark matter particles with energy scale of 2 TeV. The observation of two events gives a bound for the life-time of dark matter particle in question: about 10^{21} years much longer than the age of the Universe. The bound of course depends on what density is assumed for the dark matter.

3. There is also a continuum excess in the range [.1, .4] PeV. This could result from many-particle decay channels containing more than 2 particles.

What says TGD?

1. TGD almost-predicts a fractal hierarchy of hadron physics and weak physics labelled by Mersenne primes $M_n = 2^n - 1$. Also Gaussian primes $M_{G,n} = (1+i)^n - 1$ are possible. M_{107} would correspond to the ordinary hadron physics. M_{89} would correspond to weak bosons and a scaled up copy of hadron physics, for which there are several indications: in particular, the breaking of perturbative QCD at rather high energies assignable at LHC to proton heavy nucleus collisions. The explanation in terms of AdS/CFT correspondence has not been successful and is not even well-motivated since it assumes strong coupling regime.

2. The next Mersenne prime is M_{61} and the first guess is that the observed TeV neutrinos result from the decay of W and Z bosons of scaled up copy of weak physics having mass near 1 TeV. The naivest estimate for the masses of these weak bosons is obtained by the naive scaling the masses of ordinary weak bosons by factor $2^{(89-61)/2} = 2^{14}$. For $m_W = 80$ GeV and $m_Z = 90$ GeV one obtains $m_{W(61)} = 1.31$ PeV and $m_{Z(61)} = 1.47$ PeV. The energy of the mono-chromatic neutrino would be about about.65 PeV and.74 PeV in the two cases. This is in the almost empty range between.4 PeV and 1 PeV and too small roughly by a factor of $\sqrt{2}$.

   An improved estimate for upper bound of Z^0 mass is based on the p-adic mass scale $m(M_{89})$ related to the p-adic mass scale M_{127} of electron by scaling factor $2^{(127-89)/2} = 2^{19}$ giving $m(M_{89}) \simeq 120$ GeV for $m_e = \sqrt{5+X}m(M_{127}) = .51$ MeV and $X = 0$ ($X \leq 1$ holds true for the second order contribution to electron mass [K15]). The scaling by the factor $2^{(89-61)/2} = 2^{14}$ gives $m(61) = 1.96$ TeV consistent with the needed 2 TeV. The exact value of weak boson mass depends on the value of Weinberg angle $sin^2(\theta_W)$ and the value of the second order contribution to the mass: $m(61)$ gives upper bound for the mass of $Z(61)$. The model predicts two peaks with distance depending on the value of Weinberg angle of M_{61} weak physics.

3. What about the interpretation of the continuum part of anomaly? The proposed interpretation for many-particle decays looks rather reasonable. The simplest possibility is the decay to a pair of light quarks of M_{61} hadron physics, followed by a decay of quark or antiquark via emission of W boson decaying to lepton-neutrino pair.

TGD predicts 3 generations of gauge bosons in analogy with In TGD the 3 generations of fermions correspond to the 3 lowest genera for 2-surfaces (handle number 0,1,2). One can formally interpret fermion generations as a triplet of broken dynamical symmetry $U(3)$. Gauge bosons correspond to pairs of fermions and antifermions. One obtains octet and singlet with respect $U(3)$. The 3 $U(3)$ "neutral" bosons are expected to be the lightest ones. There are 3 states of this kind analogous to neutral pion, η and η' of Gell-Mann model.

A possible interpretation for M_{61} weak bosons is as weak bosons of third generation. The second generation would correspond to M_{79} and the first generation to M_{89} and ordinary weak bosons. There is evidence for a bump at the mass of Higgs boson of M_{79} physics whose mass is obtained by scaling with the factor $2^{10/2} = 32$ from the ordinary Higgs mass 125 GeV. One obtains 4 TeV, which is the mass of the bump. M_{61} Higgs would have mass $2^9 = 512$ times higher mass - that is 2048 TeV= 2.048 PeV.

5.8 Some Comments About $\tau - \mu$ Anomaly Of Higgs Decays And Anomalies Of B Meson Decays

Lubos Motl (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) [C38] observed in the decay of Higgs to $\tau - \mu$ pair or its charge conjugate not allowed by standard model. Lubos Motl 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 Motl 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.

5.8.1 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 [K5, K21].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 [K37] [L24] 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 [K16, K3, K38] 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 leptonic CP breaking (see `http://tinyurl.com/zr8xm26`) 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!

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

To my humble opinion both models mentioned by Lubos Motl 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 $WL_i\nu_j$ vertices can produce the anomaly. The $h \rightarrow \mu - \tau_c$ 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.

5.8.3 What about the anomalies related to B meson decays?

The model (`http://arxiv.org/abs/1501.00993`) that Lubos Motl 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 Motl (`http://tinyurl.com/hx9dv2b`) has a nice posting about surprisingly many anomalies related to the leptonic and pion and kaon decays of neutral B meson. Tommaso Dorigo (`http://goo.gl/k0Imz4`) 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://tinyurl.com/grzld8c`).

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.

5.8.4 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 [K34] and particle massivation in particular [K15, K31, K17, K18] 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 [K15] 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 [K37] 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.

6 QCD And TGD

During last week I have been listening some very inspiring Harward lectures relating to QCD, jets, gauge-gravity correspondence, and quark gluon plasma. Matthew Schwartz gave a talk titled *The Emergence of Jets at the Large Hadron Collider* [C85]. Dam Thanh Son gave a talk titled *Viscosity, Quark Gluon Plasma, and String Theory* [C58]. Factorization theorems of jet QCD discussed in very clear manner by Ian Stewart [C81] in this talk titled *Mastering Jets: New Windows into Strong Interaction and Beyond*.

These lecture inspired several blog postings and also the idea about systematical comparison of QCD and TGD. This kind of comparisons are always very useful - at least to myself - since they make it easier to see why the cherished beliefs- now the belief that QCD is *the* theory of strong interactions - might be wrong.

There are several crucial differences between QCD and TGD.

1. The notion of color is different in these two theories. One prediction is the possibility of lepto-hadron physics [K27] involving colored excitations of leptons.

2. In QCD AdS/CFT duality is hoped to allow the description of strong interactions in long scales where perturbative QCD fails. The TGD version of gauge-gravity duality is realized at space-time level and is much stronger: string-parton duality is manifest at the level of generalized Feynman diagrams.

3. TGD form of gauge-gravity duality suggests a stronger duality: p-adic-real duality. This duality allows to sum the perturbation theories in strong coupling regime by summing the p-adic perturbation series and mapping it to real one by canonical correspondence between p-adics and reals. This duality suggests that factorization "theorems" have a rigorous basis basis due to the fact that quantum superposition of amplitudes would be possible inside regions characterized by given p-adic prime. p-Adic length scale hypothesis suggests that p-adically scaled up variants of quarks are important for the understanding of the masses of low lying hadrons. Also scaled up versions of hadron physics are important and both Tevatron and LHC have found several indications for M_{89} hadron physics.

4. Magnetic flux tubes are the key entities in TGD Universe. In hadron physics color magnetic flux tubes carrying Kähler magnetic monopole fluxes would be responsible for the non-perturbative aspects of QCD [K13]. Reconnection process for the flux tubes (or for the corresponding strings) would be responsible for the formation of jets and their hadronization. Jets could be seen as structures connected by magnetic flux tubes to form a connected structure and therefore as hadron like objects. Ideal QCD plasma would be single hadron like objects. In QCD framework quark-gluon plasma would be more naturally gas of partons.

5. Super-symmetry in TGD framework differs from the standard SUSY and the difficult-to-understand X and Y bosons believed to consist of charmed quark pair force to consider the possibility that they are actually smesons rather than mesons [K17]. This leads to a vision in which squarks have the same p-adic length scale as quarks but that the strong mixing between smesons and mesons makes second mass squared eigenstate tachyonic and thus unphysical. This together with the fact that shadronization is a fast process as compared to electroweak decays of squarks weak bosons and missing energy would explain the failure to observer SUSY at LHC.

6. p-Adic length scale hypothesis leads to the prediction that hadron physics should possess scaled variants. A good guess is that these scaled variants correspond to ordinary Mersenne primes $M_n = 2^n - 1$ or Gaussian (complex) Mersenne primes. $M_{89} = 2^{89} - 1$ hadron physics would be one such scaled variant of hadron physics. The mass scale of hadrons would be roughly 512 higher than for ordinary hadrons, which correspond to M_{107}. In zero energy ontology Higgs is not necessarily needed to give mass for gauge bosons and if Higgs like states are there, all of them are eaten by states which become massive. Therefore Higgs would be only trouble makers in TGD Universe.

   The neutral mesons of M_{89} hadron physics would however give rise to Higgs like signals since their decay amplitudes are very similar to those of Higgs even at quantitative level if one accepts the generalization of partially conserved axial current hypothesis [K17] [L7].

   The recent reports by ATLAS and CMS about Higgs search support the existence of Higgs like signal around about 125 GeV. In TGD framework the interpretation would be as pion like state. There is however also evidence for Higgs like signals at higher masses and standard Higgs is not able to explain this signals. Furthermore, Higgs with about 125 GeV mass is just at the border of vacuum stability, and new particles would be needed to stabilize the vacuum. The solution provided by TGD is that entire scaled up variant of hadron physics replaces Higgs. Within a year it should become clear whether the observed signal is Higgs or pionlike state of M_{89} hadron physics or something else.

6.1 Basic Differences Between QCD And TGD

The basic difference between QCD and TGD follow from different views about color, zero energy ontology, and from the notion of generalized Feynman diagram.

6.1.1 How the TGD based notion of color differs from QCD color

TGD view about color is different from that of QCD. In QCD color is spin like quantum number. In TGD Universe it is like angular momentum and one can speak about color partial waves in CP_2. Quarks and leptons must have non-trivial coupling to CP_2 Kähler gauge potential in order to obtain a respectable spinor structure. This coupling is odd multiplet of Kähler gauge potential and for $n = 1$ for quarks and $n = 3$ for leptons one obtains a geometrization of electro-weak quantum numbers in terms of induced spinor structure and geometrization of classical and color gauge potentials. This has several far reaching implications.

1. Lepton and baryon numbers are separetely conserved. This is not possible in GUTs. Despite the intense search no decays of proton predicted by GUTs have been observed: a strong support for TGD approach.

2. Infinite number of color partial waves can assigned to leptons and quarks and they obey the triality rule: $t = 0$ or leptons and $t = +1/-1$ for quarks/antiquarks. The color partial waves however depend on charge and CP_2 handedness and therefore on M^4 chirality. The correlation is not correct. Also the masses are gigantic of order CP_2 mass as eigenvalues of CP_2 Laplace operator. Only right handed covariantly constant lepton would have correct color quantum numbers.

   The problem can be cured if one accepts super-conformal invariance. Conformal generators carrying color contribute to the color quantum numbers of the particle state. p-Adic mass calculations show that if ground states have simple negative conformal weight making it tachyon, it is possible to have massless states with correct correlation between electroweak quantum numbers and color ¿ [K15].

3. Both leptons and quarks have color excited states. In leptonic sector color octet leptons are possible and there is evidence already from seventies that states having interpretation as lepto-pion are created in heavy ion collisions [K27]. During last years evidence for muo-pions and tau-pions has emerged and quite recently CDF provided additional evidence for tau-pions.

   Light colored excitations of leptons and quarks are in conflict what is known about the decay width of intermediate gauge bosons and the way out is to assume that these states are dark matter in the sense that they have effective value of Planck constant coming as integer multiple of the ordinary Planck constant [K11]. Only particles with the same value of Planck constant can appear in the same vertex of generalized Feynman diagram so that these particles are dark in the weakest possible sense of the world. The Planck constant can however change when particle tunnels between different sectors of the generalized imbedding spaces consisting of coverings of the imbedding space $M^4 \times CP_2$.

   The attribute "effective" applies in the simplest interpretation for the dark matter hierarchy based on many-valuedness of the normal derivatives of the imbedding space coordinates as functions of the canonical momentum densities of Kähler action. Many-valuedness is implied by the gigantic vacuum degeneracy of Kähler action: any 4-surfce with CP_2 projection which is Lagrangian manifold of CP_2 is vacuum extremal and preferred extremals are deformations of these. The branches co-incide at 3-D space-like ends of the space-time surface at boundaries of CD and at 3-D light-like orbits of wormhole throats at which the signature of the induced metric changes. The value of the effective Planck constant corresponds to the number of sheets of this covering of imbedding space and there are arguments suggesting that this integer is product of two integers assignable to the multiplicities of the branches of space-like 3-surfaces and light-like orbits. At partonic 2-surfaces the degeneracy is maximal since all $n = n_1 \times n_2$ sheets co-incide. This structure brings very strongly in mind the stack of branes infinitesimally near to each other appearing in AdS/CFT duality. TGD analogs of 3-branes of the stacks would be distinct in the interior of the space-time surface.

4. TGD predicts the presence of long ranged classical color gauge potentials identified as projections of CP_2 Killing forms to the space-time surface. Classical color gauge fields are proportional to induced Kähler form and Hamiltonians of color isometries: $G_A = H_A J$. Alle components of the classical gluon field have the same direction. Also long ranged classical electroweak gauge fields are predicted and one of the implications is an explanation for the large parity breaking in living matter (chiral selection of molecules).

   Long ranged classical color fields mean a very profound distinction between QCD color and TGD color and in TGD inspired hadron physics color magnetic flux tubes carrying classical color gauge fields are responsible for the strong interactions in long length scales. These color magnetic fields carrying Kähler magnetic monopole fluxes are absolutely essential in TGD based view about quark distribution functions and hadronic fragmentation functions of quarks and represent the long range hadron physics about which QCD cannot say much using analytic formulas: numerical lattice calculations provide the only manner to tackle the problem.

5. Twistorial approach to $\mathcal{N} = 4$ super-symmetric gauge theory could be seen as a diametrical opposite of jet QCD. It has been very successful but it is perturbative approach and I find it difficult to see how it could produce something having the explanatory power of color magnetic flux tubes.

6.1.2 Generalized Feynman diagrams and string-parton duality as gauge-gravity duality

Generalized Feynman diagrams reduce to generalized braid diagrams [K13]. Braid strands have unique identification as so called Legendrean braids identifiable as boundaries of string world sheets which are minimal surfaces for which area form is proportional to Kähler flux. One can speak about sub-manifold braids.

There are no $n > 2$-vertices at the fundamental braid strand level. Together with the fact that in zero energy ontology (ZEO) all virtual states consist of on mass shell massless states assignable to braid strands, this means that UV and IR infinities are absent. All physical states are massive bound states of massless on mass shell states. Even photon, gluon, and graviton have small masses. No Higgs is needed since for the generalized Feynman diagrams the condition eliminating unphysical polarizations eliminates only the polarization parallel to the projection of the total momentum of the particle to the preferred plane M^2 defining the counterpart of the plane in which one usually projects Feynman diagrams.

The crossings for the lines of non-planar Feynman diagrams represent generalization of the crossings of the braid diagrams and integrable M^2 QFT is suggested to describe the braiding algebraically. This would mean that non-planar diagrams are obtained from planar ones by braiding operations and generalized Feynman diagrams might be constructed like knot invariants by gradually trivializing the braid diagram. This would allow to reduce the construction of also non-planar Feynman amplitudes to twistorial rules.

One can interpret gluons emission by quark as an emission of meson like state by hadron. This duality is exact and does not requires $N_c \rightarrow \infty$ limit allowing to neglect non-planar diagrams as AdS/CFT correspondence requires. The interpretation is in terms of duality: one might call this duality parton-hadron duality, gauge-gravity duality, or particle-string duality.

6.1.3 Q^2 dependent quark distribution functions and fragmentation functions in zero energy ontology

Factorization of the strong interaction physics in short and long time scales is one of the basic assumptions of jet QCD and originally motivated by parton model which preceded QCD [C87, C56]. The physical motivation for the factorization in higher energy collision is easy to deduce at the level of parton model. By Lorentz contraction of colliding hadrons look very thin and by time dilation the collision time is very long in cm system. Therefore the second projectile moves in very short time through the hadron and sees the hadron in frozen configuration so that the state of the hadron can be thought of as being fixed during collision and partons interact independently. This looks very clear intuitively but it is not at all clear whether QCD predicts this picture.

1. Probabilistic description of quarks in ZEO

Probabilistic description requires further assumptions. Scattering matrix element is in good approximation sum over matrix elements describing scattering of partons of hadron from -say- the partons of another hadron or from electron. Scattering amplitudes in the sum reduce to contractions of current matrix elements with gluon or gauge boson propagator. Scattering probability is the square of this quantity and contains besides diagonal terms for currents also cross terms. Probabilistic description demands that the sum of cross terms can be neglected. Why the phases of the terms in this sum should vary randomly? Does QCD really imply this kind of factorization?

Could the probabilistic interpretation require and even have a deeper justification?

1. p-Adic real correspondence to be discussed in more detail below suggest how to proceed. Quarks with different p-adic mass scales can correspond to different p-adic number fields with real amplitudes or probabilities obtained from their p-adic counterparts by canonical identificaton. Interference makes sense only for amplitudes in the same number field. Does this imply that cross terms involving different p-adic primes cannot appear in the scattering amplitudes?

2. Should one assume only a density matrix description for the many quark states formed from particles with different values of p-adic prime p? If so the probabilistic description would be un-avoidable. This does not look an attractive idea as such. Zero energy ontology however replaces density matrix with M-matrix defined as the hermitian square root of the density matrix multiplied by a universal unitary S-matrix. The modulus squared of M-matrix element gives scattering probability.

   One can one imagine that M-matrix at least approximately decomposes to a tensor product of M-matrices in different length scales: these matrices could correspond to different number fields before the map to real numbers and probabilities could be formed as "numbers" in the tensor product of p-adic number fields before the mapping to real numbers by canonical identification.

   In finite measurement resolution one sums over probabilities in short length scales so that the square of M-matrix in short scale gives density matrix. Could this lead to a probabilistic description at quark level? Distribution functions and fragmentation functions could indeed correspond to these probabilities since they emerge in QCD picture from matrix elements between initial and final states of quark in scattering process. Now these states correspond to the positive and negative energy parts of zero energy state.

2. Q^2 dependence of distribution and fragmentation functions in ZEO

The probabilistic description of the jet QCD differs from that of parton model in that the parton distributions and fragmentation functions depend on the value of Q^2, where Q is defined as the possibly virtual momentum of the initial state of the parton level system. Q could correspond to the momentum of virtual photon annihilation to quark pair in the annihilation of e^+e^- pair to hadrons, to the virtual photon decaying to $\mu^+\mu^-$ pairs and emitted by quark after quark-quark scattering in Drell-Yan process, or to the momentum of gluon or quark giving rise to a jet, ... What is highly non-trivial is that distribution and fragmentation functions are universal in the sense that they do not depend on the scattering process. Furthermore, the dependence on Q^2 can be determined from renormalization group equations [C87, C56].

What does Q^2s dependence mean in TGD framework?

1. In partonic model this dependence looks strange. If one thinks the scattering at quantum level, this dependence is very natural since it corresponds to the dependence of the matrix elements of current operators on the momentum difference between quark spinors in the matrix element. In QCD framework Q^2 dependence is not mysterious. It is the emergence of probabilistic description which is questionable in QFT framework.

2. One could perhaps say that Q^2 represents resolution and that hadron looks different in different resolutions. One could also say that there is no hadron "an sich": what hadron looks like depends on the process used to study it.

3. In zero energy ontology the very notion of state changes. Zero energy state corresponds to physical event or quantum superposition of them with M-matrix defining the time like entanglement coefficient and equal to a hermitian square root of density matrix and S-matrix. In this framework different values of Q correspond to different momentum differences for spinor pairs appearing in the matrix element of the currents and Q^2 dependence of the probabilistic description is very natural. The universality of distribution and fragmentation functions follows in zero energy ontology if one assumes the factorization of the dynamics in different length scales. This should follow from the universality of the S-matrix in given number field (in given p-adic length scale).

6.2 P-Adic Physics And Strong Interactions

p-Adic physics provides new insights to hadron physics not provided by QCD.

6.2.1 p-Adic real correspondence as a new symmetry

The exactness of the gauge-gravity duality suggests the presence of an additional symmetry. Perhaps the non-converging perturbative expansion at long scales could make sense after all in some sense. p-Adic-real duality suggests how.

1. The perturbative expansion is interpreted in terms of p-adic numbers and the effective coupling constant g^2MN_c is interpreted as p-adic number which for some preferred primes is proportional to the p-adic prime p and therefore p-adically small. Hence the expansion converges rapidly p-adically. The p-adic amplitudes would be obtained by interpreting momenta as p-adic valued momenta. If the momenta are rationals not divisible by any non-trivial power of p the canonical identification maps the momenta to themselves. If momenta are small rationals this certainly makes sense but does so also more generally.

2. The converging p-adic valued perturbation series is mapped to real numbers using the generalization of the canonical identification appearing in quantum arithmetics [K30]. The basic rule is simple: replace powers of p with their inverses everywhere. The coefficients of powers of p are however allowed to be rationals for which neither numerator or denominator is divisible by p. This modification affects the predictions of p-adic mass calculations only in a negligible manner.

3. p-Adic-real duality has an interpretation in terms of cognition having p-adic physics as a correlate: it maps the physical system in long length scale to short length scales or vice versa and the image of the system assigning to physical object thought about it or vice versa provides a faithful representation. Same interpretation could explain also the successful p-adic mass calculations. It must be emphasized that real partonic 2-surfaces would obey effective p-adic topology and this would be due to the large number of common points shared by real and p-adic partonic 2-surfaces. Common points would be rational points in the simplest picture: in quantum arithmetics they would be replaced by quantum rationals.

p-Adic-real correspondence generalizes the canonical identification used to map the p-adic valued mass squared predicted by p-adic thermodynamics as the analog of thermal energy to a real number. An important implication is that *p-adic mass squared value is additive* [K21].

1. For instance, for mesons consisting of pairs of quark and its antiquark the values of p-adic mass squared for quark and antiquark are additive and this sum is mapped to a real number: this kind of additivity was observed already at early days of hadron physics but there was no sensible interpretation for it. In TGD framework additivity of the scaling generator of Virasoro algebra is in question completely analogous to the additivity of energy.

2. For mesons consisting of quarks labelled by different value of p-adic prime p, one cannot sum mass squared values since they belong to different number fields. One must map both of them first to real numbers and after this sum real mass values (rather than mass squared values).

This picture generalizes. Only p-adic valued amplitudes belonging to same p-adic number field and therefore corresponding to the same p-adic length scales can be summed. There is no interference between amplitudes corresponding to different p-adic scales.

1. This could allow to understand at deeper level the somewhat mysterious and ad hoc assumption of jet QCD that the strong interactions in long scales and short scales factorize at the level of probabilities. Typically the reaction rate is expressible using products of probabilities. The probability for pulling out quarks from colliding protons (non-perturbative QCD), the probability describing parton level particle reaction (perturbative QCD), and the probability that the scattering quarks fragment to the final state hadrons (non-perturbative QCD). Ordinary QCD would suggest the analog of this formula but with probability amplitudes replacing probabilities and in order to obtain a probabilistic description one must assume that various interference terms sum up to zero (de-coherence). p-Adic-real duality would predict the relative docoherence of different scales as an exact result. p-adic length scale hypothesis would also allow to define the notion of scale precisely. From the stance provided by TGD it seems quite possible that the standard belief that jet QCD follows from QCD is simply wrong. The repeated emphasis of this belief is of course part of the liturgy: it would be suicidical for a specialist of jet QCD to publicly conjecture that jet QCD is more than QCD.

2. The number theoretical de-coherence would be very general and could explain the somewhat mysterious de-coherence phenomenon. Decoherence could have as a number theoretical correlate the decomposition of space-time surfaces to regions characterized by different values of p-adic primes. In given region the amplitudes would be constructed as p-adic valued amplitudes and then mapped to real amplitudes by canonical identification. A space-time region characterized by given p would be the number theoretical counterpart of the coherence region. The regions with different value of p would behave classically with respect to each other and region with given p could understand what happens in regions with different values of p using classical probability. This would also the resolve paradoxes like whether the Moon is there when no-one is looking. It could also mean that the anti-commutative statistics for fermions holds true only for fermionic oscilator operators associated with a space-time region with given value of p-adic prime p. Somewhat ironically, p-adic physics would bring quantum reality much nearer to the classical reality.

6.2.2 Logarithmic corrections to cross sections and jets

Even in the perturbative regime exclusive cross sections for parton-parton scattering contain large logarithmic corrections of form $log(Q^2/\mu^2)$ [C87], where Q is cm energy and μ is mass scale which could be assigned to quark or - perhaps more naturally - to jet. These corrections spoil the convergence of the perturbative expansion at $Q^2 \rightarrow \infty$ limit. One can also say that the cross sections are singular at the limit of vanishing quark mass: this is the basic problem of the twistor approach.

For "infra-red safe" cross sections the logarithmic singularities can be eliminated by summing over all initial and final states not distinguishable from each other in the energy and angle resolutions available. It is indeed impossible to distinguish between quark and quark and almost collinear soft gluon and one must therefore sum over all final states containing soft gluons. A simple example about IR safe cross section is the cross section for e^+e^- annihilation to hadrons in finite measurement resolution, from which logarithms $log(Q/\mu)$ disappear.

In hadronic reactions jets are studied instead of hadrons. IR safety is one criterion for what it is to be a jet. Jet can be imagined to result as a cascade. Parton annihilates to a pair of partons, resulting partons annihilate into softer partons, and so on... The outcome is a cascade of increasingly softer partons. The experimental definition of jet ris constrained by a finite measurement resolution for energy and angle, and jet is parameterized by the cm energy Q, by the energy resolution ϵ, and by the jet opening angle δ: apart from a fraction ϵ all cm energy Q of the jet is contained within a cone with opening angle δ. According to the estimate [C87] the mass scale of the jet resulting at the k: th step of the cascade is roughly $\delta^k Q$.

What could be the counterpart for this description of jets in TGD framework?

1. Jet should be a structure with a vanishing total Kähler magnetic charge bound by flux tubes to a connected hadron like structure. By hadron-parton duality gluon emission from quark has interpretation as a meson emission from hadron: jets could be also interpreted as collections of hadrons at different space-time sheets. Reconnection process could play a key role in the decay of jet to hadrons. p-Adic length scale hypothesis suggests the interpretation of jets as hadron like objects which are off mass shell in the sense that the p-adic prime $p \simeq 2^k$ characterizing the jet space-time sheets is smaller than M_{107} characterizing the final state hadrons. One could say that jets represent p-adically hot hadron-like objects which cool and decay to hadrons. If so, the transition from M_{107} hadron physics to M_{89} hadron physics could be rather smooth. The only new thing would be the abnormally long lifetime of M_{89} hadrons formed as intermediate states in the process.

2. p-Adic length scale hypothesis suggests that the p-adic length scale assignable to the parton (hadron like object) at the $k+1$: th step is by power of $\sqrt{2}$ longer than that associated with k: th step: $p \rightarrow p_{next} \simeq 2 \times p$ is the simplest possibility. The naive formula $Q(k+1) \sim \delta \times Q(k)$ would probably require a generalization to $Q(k+1) \sim 2^{-r/2} \times Q(k)$, r integer with $\delta = 2^{-nr/2} \times 2\pi$, n an integer. $r = 1$ would be the simplest option. The cascade at the level of jet space-time sheets would stop when the p-adic length scale corresponds to M_{107}, which corresponds to.5 GeV mass scale. At the level of quarks one can imagine a similar cascade stopping at p-adic length scales corresponding to the mass scale about 5 MeV for u and d quarks.

3. Zero energy ontology brings in natural IR cutoffs since also gluons have small mass. Final and initial state quarks could emit only a finite number of gluons as brehmstrahlung and soft gluons could not produce IR divergences.

4. The notion of finite measurement resolution in QCD involves the cone opening angle δ and energy resolution characterized by ϵ. In TGD framework the notion of finite measurement resolution is fundamental and among other things implies the description in terms of braids. Could TGD simplify the QCD description for finite measurement resolution? Discretization in the space of momentum directions is what comes in mind first and is strongly suggested also by the number theoretical vision. One would not perform integral over the cone but sum over all events producing quark and a finite number of collinear gluons with an upper bound form them deducible from cm energy and gluon mass. For massive gluons the number of amplitudes to be summed should be finite and the jet cascade would have only finite number of steps.

Could number theoretical constraints allow additional insights? Are the logarithmic singularities present in the p-adic approach at all? Are they consistent with the number theoretical constraints?

1. The p-adic amplitudes might well involve only rational functions and thus be free of logarithmic singularities resulting from the loop integrals which are dramatically simplified in zero energy ontology by on mass shell conditions for massless partonic 2-surfaces at internal lines.

2. For the sheer curiousity one can consider the brehmstrahlung from a quark characterized by p-adic prime p. Do the logarithms $log((Q^2/\mu^2)$, where μ^2 is naturally p-adic mass scale, make sense p-adically? This is the case of one has $Q^2/\mu^2 = (1+O(p))$. The logarithm would be of form $O(p)$ and p-adically very small. Also its real counterpart obtained by canonical identification would be very small for $O(p) = np$, $n << p$. For $Q^2/mu^2 = m(1+O(p))$, m integer, one must introduce an extension of p-adic numbers guaranteeing that $log(m)$ exists for $1 < m < p$. Only single logarithm $log(a)$ and its powers are needed since for primitive roots a of unity one as $m = a^n \ \ mod \ \ p$ for some n. Since the powers of $log(a)$ are algebraically independent, the extension is infinite-dimensional and therefore can be questioned.

3. For the original form of the canonical identification one would have $O(p) = np$. In the real sense the value of Q^2 would be gigantic for $p = M_{107}$ (say). p-Adically Q^2 would be extremely near to μ^2. The modified form of canonical identification replaces pinary expansion $x = \sum x_n p^n$, $0 \leq x_n < p$, of the p-adic integer with the quantum rational $q = \sum q_n p^n$, where

q_n are quantum rationals, which are algebraic numbers involving only the quantum phase $e^{i2\pi/p}$ and are not divisible by any power of p [K30].

This would allow physically sensible values for $Q^2/mu^2 = 1 + qp + ..$ in the real sense for arbitrarily large values of p-adic prime. In the canonical identification they would be mapped to $Q^2/mu^2 = 1+q/p+..$ appearing in the scattering amplitude. For q/p near unity logarithmic corrections could be sizeable. If qp is of order unity as one might expect, the corrections are of order q/p and completely negligible. Even at the limit $Q^2 \to \infty$ understood in the real sense the logarithmic corrections would be always negligible if Q^2 is p-adic quantum rational. Similar extremely rapid convergence characterizes p-adic thermodynamics [K15] and makes the calculations practically exact. Smallness of logarithmic corrections quite generally could thus distinguish between QCD and TGD.

4. In p-adic thermodynamics the p-adic mass squared defined as a thermal average of conformal weight is a ratio of two quantities infinite as real numbers. Even when finite cutoff of conformal weight is introduced one obtains a ratio of two gigantic real numbers. The limit taking cutoff for conformal weight to infinity does not exist in real sense. Does same true for scattering amplitudes? Quantum arithmetics would guarantee that canonical identification respects discretized symmetries natural for a finite measurement resolution.

6.2.3 p-Adic length scale hypothesis and hadrons

Also p-adic length scale hypothesis distinguishes between QCD and TGD. The basic predictions are scaled variants of quarks and the TGD variant of Gell-Mann Okubo mass formula indeed assumes that in light hadrons quarks can appear in several p-adic mass scales. One can also imagine the possibility that quarks can have short lived excitations with non-standar p-adic mass scale. The model for tau-pion needed to explain the 3-year old CDF anomaly for which additional support emerged recently, assumes that color octet version of tau lepton appears as three different mass scales coming as octaves of the basic mass scale [K27]. Similar model has been applied to explain also some other other anomalies.

M_{89} hadron physics corresponds to a p-adic mass scale in TeV range [K17]: the proton of M_{89} hadron physics would have mass near 500 GeV if naive scaling holds true. The findings from Tevatron and LHC have provided support for the existence of M_{89} mesons and the bumps usually seen as evidence for Higgs would correspond to the mesons of M_{89} hadron physics. It is a matter of time to settle whether M_{89} hadron physics is there or not.

6.3 Magnetic Flux Tubes And And Strong Interactions

Color magnetic flux tubes carrying Kähler magnetic monopole flux define the key element of quantum TGD and allow precise formulation for the non-perturbative aspects of strong interaction physics.

6.3.1 Magnetic flux tube in TGD

The following examples should make clear that magnetic flux tubes are the central theme of entire TGD present in all scales.

1. Color magnetic flux tubes are the key element of hadron physics according to TGD and will be discussed in more detail below.

2. In TGD Universe atomic nucleus is modelled as nuclear string with nucleons connected by color magnetic flux tubes which have length of order Compton length of u and d quark [K25, L2]. One of the basic predictions is that the color flux tubes can be also charged. This predicts a spectrum of exotic nuclei. The energy scale of these states could be small and measured using keV as a natural unit. These exotic states with non-standard value of Planck constant giving to the flux tubes the size of the atom and the scaling up electroweak scale to atomic scale could explain cold fusion for which empirical support is accumulating.

3. Magnetic flux tubes are also an essential element in the model of high T_c super conductivity. The transition to super-conductivity in macroscopic scale would be a percolation type process in which shorter flux tubes would combine at critical point to form long flux tubes so that the supra currents could flow over macroscopic distances [K4]. The basic prediction is that there are two critical temperatures. Below the first one the super-conductivity is possible for "short" flux tubes and at lower critical temperature the "short" flux tubes fuse to form long flux tubes. Two critical temperatures have been indeed observed.

4. Magnetic flux tubes carrying dark matter are the corner stone of TGD inspired quantum biology, where the notion of magnetic body is in a central role. For instance, the vision about DNA as topological quantum computer is based on the braiding of flux tubes connecting DNA nucleotides and the lipids of nuclear or cellular membrane [K10].

5. In the very early TGD inspired cosmology [K24] string like objects with 2-D M^4 projection are the basic objects. Cosmic evolution means gradual thickening of their M^4 projection and flux conservation means that the flux weakens. If the lengths of the flux tubes increase correspondingly, magnetic energy is conserved. Local phase transitions increasing Planck constant locally can occur and led to a thickening of the flux tube and liberation of magnetic energy as radiation which later gives rise to radiation and matter. This mechanism replaces the decay of the energy of inflation field to radiation as a mechanism giving rise to stars and galaxies [K23]. The magnetic tension is responsible for the negative pressures explaining accelerated expansion and magnetic energy has identification as the dark energy.

6.3.2 Reconnection of color magnetic flux tubes and non-perturbative aspects of strong interactions

The reconnection of color magnetic flux tubes is the key mechanism of hadronization and a slow process as compared to quark gluon emission.

1. Reconnection vertices have interpretation in terms of stringy vertices $AB+CD \rightarrow AD+BC$ for which interiors of strings serving as representatives of flux tubes touch. The first guess is that reconnection is responsible for the low energy dynamics of hadronic collisions.

2. Reconnection process takes place for both the hadronic color magnetic flux tubes and those of quarks and gluons. For ordinary hadron physics hadrons are characterized by Mersenne prime M_{107}. For M_{89} hadron physics reconnection process takes place in much shorter scales for hadronic flux tubes.

3. Each quarks is characterized by a p-adic length scale: this scale characterizes the length scale of the magnetic bodies of the quark. Therefore reconnection at the level of the magnetic bodies of quarks take places in several time and length scales. For top quark the size scale of magnetic body is very small as is also the reconnection time scale. In the case of u and d quarks with mass in MeV range the size scale of the magnetic body would be of the order of electron Compton length. This scale assigned with quark is longer than the size scale of hadrons characterized by M_{89}. Classically this does not make sense but in quantum theory Uncertainty Principle predicts it from the smallness of the light quark masses as compared to the hadron mass. The large size of the color magnetic body of quark could explain the strange finding about the charge radius of proton [K17].

4. Reconnection process in the beginning of proton-proton collision would give rise to the formation of jets identified as big hadron like entities connected to single structure by color magnetic flux tubes. The decay of jets to hadrons would be also reconnection process but in opposite time direction and would generate the hadrons in the final state (negative energy part of the zero energy state). The short scale process would be the process in which partons scatter from each other and produce partons. These processes would have a dual description in terms of hadronic reactions.

5. Factorization theorems are the corner stone of jet QCD. They are not theorems in the mathematical sense of the word and one can quite well ask whether they really follow from QCD

or whether they represent correct physical intuitions transcending the too rigid framework provided by QCD as a gauge theory. Reconnection process would obviously represent the slow non-perturbative aspects of QCD and occur both for the flux tubes associated with quarks and those assignable to hadrons. Several scales would be present in case of quarks corresponding to p-adic length scales assigned to quarks which even in light hadrons would depend on hadron [K21]. The hadronic p-adic length scale would correspond to Mersenne prime M_{107}. One of the basic predictions of TGD is the existence of M_{89} hadron physics and there are several indications that LHC has already observed mesons of this hadron physics. p-Adic-real duality would provide a further mathematical justification for the factorization theorems as a consequence of the fact that interference between amplitudes belong to different p-adic number fields is not possible.

Reconnection process is not present in QCD although it reduces to string re-connection in the approximation that partonic 2-surfaces are replaced by braids. An interesting signature of 4-D stringyness is the knotting of the color flux tubes possible only because the strings reside in 4-D space-time. This braiding ad knotting could give rise to effects not predicted by QCD or at least its description using AdS/CFT strings. The knotting and linking of color flux tubes could give rise to exotic topological effects in nuclear physics if nuclei are nuclear strings.

6.3.3 Quark gluon plasma

A detailed qualitative view about quark-gluon plasma in TGD Universe can be found from [K13].

1. The formation of quark gluon plasma would involve a reconnection process for the magnetic bodies of colliding protons or nuclei in short time scale due to the Lorentz contraction of nuclei in the direction of the collision axis. Quark-gluon plasma would correspond to a situation in which the magnetic fluxes are distributed in such a manner that the system cannot be decomposed to hadrons anymore but acts like a single coherent unit. Therefore quark-gluon plasma in TGD sense does not correspond to the thermal quark-gluon plasma in the naive QCD sense in which there are no long range correlations. Ideal quark gluon plasma is like single very large hadron rather than a gas of partons bound to single unit by the conservation of magnetic fluxes connecting the quarks and antiquarks.

2. Long range correlations and quantum coherence suggest that the viscosity to entropy ratio is low as indeed observed [K17]. The earlier arguments suggest that the preferred extremals of Kähler action have interpretation as perfect fluid flows [K29]. This means at given space-time sheet allows global time coordinate assignable to flow lines of the flow and defined by conserved isometry current defining Beltrami flow. As a matter fact, all conserved currents are predicted to define Beltrami flows. Classically perfect fluid flow implies that viscosity, which is basically due to a mixing causing the loss of Beltrami property, vanishes. Viscosity would be only due to the finite size of space-time sheets and the radiative corrections describable in terms of fractal hierarchy CDs within CDs. In quantum field theory radiative corrections indeed give rise to the absorbtive parts of the scattering amplitudes. In the case of quark gluon plasma viscosity is very large although the viscosity to entropy ratio is near to its minimum $\eta/s = \hbar/4\pi$ predicted by AdS/CFT correspondence. In TGD framework the lower bound is smaller [K13].

3. There are good motivations for challenging the belief that QCD predicts strongly interacting quark gluon plasma having very large viscosity begin more like glass than a gas of partons. The reason for the skepticism is that classical color magnetic fields carrying magnetic monopole charges are absent. Also the notion of many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) is essential element of the description. The recent evidence for the failure of AdS/CFT correspondence in the description of jet fragmentation in plasma support the pessimistic views.

6.4 Does Color Deconfinement Really Occur?

Bee (http://backreaction.blogspot.fi/2015/08/the-origin-of-mass-or-pions-pr-problem.html) had a nice blog posting related to the origin of hadron masses and the phase transition from color confinement to quark-gluon plasma involving also restoration of chiral symmetry in the sigma model description.

The origin of hadron masses is poorly understood in QCD for the simple reason that perturbative QCD does not exist at low energies. The belief is that the couplings of pions to nucleons generate the mass and sigma model provides a Higgs model type description for this. The phase transition from color confinement to quark-gluon plasma is expected to involve the restoration of chiral symmetry for quarks. In the ideal situation the outcome should be a black body spectrum with no correlations between radiated particles. In the sigma model description nucleons and pions becomes massless in good approximation. Quark gluon plasma suggests that they disappear completely from the spectrum.

The situation is however not this. Some kind of transition occurs and produces a phase, which has much lower viscosity than expected for quark-gluon plasma. Transition occurs also in much smoother manner than expected. And there are strong correlations between opposite charged particles - charge separation occurs. The simplest characterization for these events would be in terms of decaying strings emitting particles of opposite charge from their ends. Conventional models do not predict anything like this.

TGD approach strongly suggests the existence scaled up variants of ordinary hadron physics: actually two of them assignable to Mersenne prime M_{89} and Gaussian Mersenne $M_{G,79}$ respectively should make them visible at LHC and there are indications about the predicted anomalies. This picture allows to consider the possibility that instead of de-confinement a quantum phase transition from the ordinary M_{107} hadron physics to a dark variant of M_{89} hadron physics would occur.

By quantum criticality M_{89} hadron physics would be characerized by the value of effective Planck constant $h_{eff} = n \times h$. $n \simeq 2^9 - 2^{10}$ guarantees that the sizes the scaled up sizes of M_{89} hadrons are of the size scale of nucleons or even nuclei. Quantum coherence in this scale explains the unexpected properties of what was expected to be quark-gluon plasma and explains charge asymmetries in terms of decay of string like color magnetic flux tubes associated with M_{89} pions.

6.4.1 Some background

The masses of current quarks are very small - something like 5-20 MeV for u and d. These masses explain only a minor fraction of the mass of proton. The old fashioned quark model assumed that quark masses are much bigger: the mass scale was roughly one third of nucleon mass. These quarks were called constituent quarks and - if they are real - one can wonder how they relate to current quarks.

Sigma model provide a phenomenological decription for the massivation of hadrons in confined phase. The model is highly analogous to Higgs model. The fields are meson fields and baryon fields. Now neutral pion and sigma meson develop vacuum expectation values and this implies breaking of chiral symmetry so that nucleon become massive. The existence of sigma meson is still questionable.

In a transition to quark-gluon plasma one expects that mesons and protons disappear totally. Sigma model however suggests that pion and proton do not disappear but become massless. Hence the two descriptions might be inconsistent.

The authors of the article assumes that pion continues to exist as a massless particle in the transition to quark gluon plasma. The presence of massless pions would yield a small effect at the low energies at which massless pions have stronger interaction with magnetic field as massive ones. The existence of magnetic wave coherent in rather large length scale is an additional assumption of the model: it corresponds to the assumption about large h_{eff} in TGD framework, where color magnetic fields associated with M_{89} meson flux tubes replace the magnetic wave.

In TGD framework sigma model description is at best a phenomenological description as also Higgs mechanism. p-Adic thermodynamics replaces Higgs mechanism and the massivation of hadrons involves color magnetic flux tubes connecting valence quarks to color singles. Flux tubes have quark and antiquark at their ends and are mesonlike in this sense. Color magnetic energy contributes most of the mass of hadron. Constituent quark would correspond to valence quark identified as current quark plus the associated flux tube and its mass would be in good approximation the mass of color magnetic flux tube.

There is also an analogy with sigma model provided by twistorialization in TGD sense. One can assign to hadron (actually any particle) a light-like 8-momentum vector in tangent space $M^8 = M^4 \times E^4$ of $M^4 \times CP_2$ defining 8-momentum space. Massless implies that ordinary mass squared corresponds to constant E^4 mass which translates to a localization to a 3-sphere in E^4. This localization is analogous to symmetry breaking generating a constant value of π^0 field proportional to its mass in sigma model.

6.4.2 An attempt to understand charge asymmetries in terms of charged magnetic wave and charge separation

One of the models trying to explain the charge asymmetries is in terms of what is called charged magnetic wave effect and charge separation effect related to it. The experiment [C62] (`http://arxiv.org/pdf/1504.02175.pdf`) discussed by Bee attempts to test this model.

1. So called chiral magnetic wave effect and charge separation effects are proposed as an explanation for the the linear dependence of the asymmetry of so called elliptic flow on charge asymmetry. Conventional models explain neither the charge separation nor this dependence. Chiral magnetic wave would be a coherent magnetic field generated by the colliding nuclei in a relatively long scale, even the length scale of nuclei.

2. Charged pions interact with this magnetic field. The interaction energy is roughly $h \times eB/E$, where E is the energy of pion. In the phase with broken chiral symmetry the pion mass is non-vanishing and at low energy one has $E = m$ in good approximation. In chirally symmetric phase pion is massless and magnetic interaction energy becomes large a low energies. This could serve as a signature distginguishing between chirally symmetric and asymmetric phases.

3. The experimenters try to detect this difference and report slight evidence for it. This is change of the charge asymmetry of so called elliptic flow for positively and negatively charged pions interpreted in terms of charge separation fluctuation caused by the presence of strong magnetic field assumed to lead to separation of chiral charges (left/righ handedness). The average velocities of the pions are different and average velocity depends azimuthal angle in the collision plane: second harmonic is in question (say $sin(2\phi)$).

6.4.3 Phase transition to dark M_{89} hadron physics instead of deconfinement?

In TGD framework the explanation of the un-expected behavior of should-be quark-gluon plasma is in terms of M_{89} hadron physics.

1. A phase transition indeed occurs but means a phase transition transforming the quarks of the ordinary M_{107} hadron physics to those of M_{89} hadron physics. They are not free quarks but confined to form M_{89} mesons. M_{89} pion would have mass about 135 GeV [K17]. A naive scaling gives half of this mass but it seems unfeasible that pion like state with this mass could have escaped the attention - unless of course the unexpected behavior of quark gluon plasma demonstrates its existence! Should be easy for a professional to check. Thus a phase transition would yield a scaled up hadron physics with mass scale by a factor 512 higher than for the ordinary hadron physics.

2. Stringy description applies to the decay of flux tubes assignable to the M_{89} mesons to ordinary hadrons. This explains charge separation effect and the deviation from the thermal spectrum. The color magnetic flux flux tube corresponds to chiral magnetic wave in the model tested in the experiment. Effects caused by the presence of strong color magnetic fields in nuclear length scale could be present also now but a more feasible interpretation for the observed anomalous effects is in terms of the decays of M_{89} pions. Note that in TGD framework color gauge field associated with single space-time sheet is proportional to induced Kähler form, which contribute also the classical electromagnetic field as induced gauge field. At QFT limit effective gauge fields are independent in good approximation.

3. In the experiments discussed in the article the cm energy for nucleon-nucleon system associated with the colliding nuclei varied between 27-200 GeV so that the creation of even on mass shell M_{89} pion in single collision of this kind is possible at highest energies. If several nucleons participate simultaneosly even many-pion states are possible at the upper end of the interval.

4. These hadrons must have large $h_{eff} = n \times h$ since collision time is roughly 5 femtoseconds, by a factor about 500 (not far from 512!) longer than the time scale associated with their masses if M_{89} pion has the proposed mass of 135 MeV for ordinary Planck constant and scaling factor 2×512 instead of 512 in principle allowed by p-adic length scale hypothesis. There are some indications for a meson with this mass. The hierarchy of Planck constants allows at quantum criticality to zoom up the size of much more massive M_{89} hadrons to nuclear size! The phase transition to dark M_{89} hadron physics could take place in the scale of nucleus producing several M_{89} pions decaying to ordinary hadrons.

5. The large value of h_{eff} would mean quantum coherence in the scale of nucleus explaining why the value of the viscosity was much smaller than expected for quark gluon plasma. The expected phase transition was also much smoother than expected. Since nuclei are many-nucleon systems and the Compton wavelength of M_{89} pion would be of order nucleus size, one expects that the phase transition can take place in a wide collision energy range. At lower energies several nucleon pairs could provide energy to generate M_{89} pion. At higher energies even single nucleon pair could provide the energy. The number of M_{89} pions should therefore increase with nucleon-nucleon collision energy, and induce the increase of charge asymmetry and strength of the charge asymmetry of the elliptic flow.

6. Hydrodynamical behavior is essential in order to have low viscosity classically. Even more, the hydrodynamics had better to be that of an ideal liquid. In TGD framework the field equations have hydrodynamic character as conservation laws for currents associated with various isometries of imbedding space. The isometry currents define flow lines. Without further conditions the flow lines do not however integrate to a coherent flow: one has something analogous to gas phase rather than liquid so that the mixing induced by the flow cannot be described by a smooth map.

   To achieve this given isometry flow must make sense globally - that is to define coordinate lines of a globally defined coordinate ("time" along flow lines). In this case one can assign to the flow a continuous phase factor as an order parameter varying along the flow lines. Super-conductivity is an example of this. The so called Frobenius conditions guarantee this at least the preferred extremals could have this complete integrability property making TGD an integrable theory see the appendix of the article [L21] or section of [K36] (`http://tgdtheory.fi/public_html/articles/dynatopo.pdf`). In the recent case, the dark flux tubes with size scale of nucleus would carry ideal hydrodynamical flow with very low viscosity.

6.4.4 Large parity breaking effects at RHIC?

Ulla Matfolk reminded me about an old Sciencedaily article (see this) [C1] telling about discovery of large parity breaking effects at RHIC studying collisions of relativistic heavy ions at energies at which QCD suggests the formation of quark gluon plasma. Somehing exotic is observed but it seems to be something different from quark gluon plasma in that long range correlations not characteristic for plasma phase are present and the particle production does not look like black body radiation. Similar findings are made also at LHC and also for proton-proton collisions. This suggests new physics and M_{89} hadron physics is the TGD inspired candidate for it. In any case, I took the article as a hype as I read it for four years ago.

Now I read the article again and started to wonder on what grounds authors claim large parity violation. What they claim to observed are magnetic fields in which u and d quarks with charges 2/3 and -1/3 move in opposite directions along the magnetic field lines (flux tubes in TGD). They assign these motions to the presence of strong parity breaking, much stronger than predicted by the standard model.

1. ***Instanton density as origin of parity breaking***

What says TGD? In TGD magnetic fields would form flux tubes, even flux tubes carrying monopole flux are possible. The findings suggests that magnetic field was accompanied by electric field and that both were parallel to the flux tubes and each other in average sense. Helical magnetic and electric fields parallel in average sense could be associated with flux tubes in TGD.

The helical classical field patterns would break the parity of ground state. Instanton density for Kähler field, essentially $E \cdot B$, measuring the non-orthogonality of E and B would serve as a measure for the strength of parity breaking occurring at the level of ground state and thus totally different from weak parity breaking. u and d quarks with opposite signs of em charges would move in opposite directions in the electric force.

2. The origin of instanton density in TGD Universe

What is the origin of these non-orthogonal magnetic and electric fields? Here I must dig down to a twenty years old archeological layer of TGD. Already at seventies an anomalous creation of anomalous e^+e^- pairs having axion-like properties in heavy ion collisions near Coulomb wall was observed (for references and TGD based explanation see [K27]). Effect was forgotten since it was not consistent with standard model. TGD explanation is in terms of pairs resulting from the decay of lepto-pion formed as bound states of color excited electron and positron and created in strong non-orthogonal electric and magnetic fields of colliding nuclei.

Objection: Color excited leptons do not conform with standard model view about color. In TGD this is not a problem since colored states correspond to partial waves in CP_2 and both leptons and quarks can move in higher color partial waves but usually with much higher mass.

Non-vanishing instanton density would mean that the orthogonal E and B created by colliding protons appear at the *same* space-time sheet so that a coherent instanton density $E \cdot B$ is created and gives rise to the generation of pairs. Large value of $E \cdot B$ means large parity breaking at the level of ground state. One expects that in most collisions the fields of colliding nuclei stay at different space-time sheets and therefore do not interfere directly (only their effects on charged particles sum up) but that with some property the fields can enter to the same space-time sheet and generate the physics not allowed by standard model.

Objection: Standard model predicts extremely weak parity breaking effects: this is due to the massivation of weak bosons, for massless weak bosons the parity breaking would be large. Indeed, if the non-orthogonal E and B are at different space-time sheets, no instantons are generated.

Objection: The existence of new particle in MeV scale would change dramatically the decay widths of weak bosons. The TGD solution is that colored leptons are dark in TGD sense ($h_{eff} = n \times h$, $n > 1$). Large h_{eff} would make weak bosons effectively massless below scaled up Compton length of weak bosons proportional to h_{eff} and large parity breaking could be understood also the "conventional" manner.

3. Strong parity breaking as signature of dark variant of M_{89} hadron physics

This picture would apply also now and also leads to an increased understanding of M_{89} hadron physics [K17] about which I have been talking for years and which is TGD prediction for LHC. Very strong non-orthogonal E and B fields would be most naturally associated with colliding protons rather than nuclei. The energy scale is of course much much higher than in the heavy ion experiment. Instanton-like space-time sheets, where the E and B of the colliding nuclei could be formed as magneto-electric flux tubes (a priori this of course need not occur since fields an remain at different space-time sheets).

The formation of axionlike states is expected to be possible as pairs color excited quarks. M_{89} hadron physics is a scaled up copy of the ordinary M_{107} hadron physics with mass scale which is by a factor 512 higher. The natural possibility is pions of M_{89} hadron physics but with large $h_{eff}/h \simeq 512$ so that the size of M_{89} pions could increase to a size scales of ordinary hadrons! This would explain why heavy ion collisions involve energies in TeV range appropriate for M_{89} hadrons and thus Compton scales of order weak scale whereas size scales are associated with QCD plasma of M_{107} hadron physics and is by a factor 1/512 smaller. Brings in mind a line from an biblical story: *The hands are Esau's hands but the voice is Jacob's voice* ! Quite generally, the failure estimates based on Uncertainty Principle could serve as a signature for non-standard values of h_{eff}: two great energy scale for effect as compared to its length scale.

To sum up, the strange findings about heavy ion and proton proton collisions at LHC for which I suggested M_{89} physics as an explanation would indeed make sense and one also ends up to a concrete mechanism for the emergence of dark variants of weak physics. The magnetic flux tubes playing key role in TGD inspired quantum biology [K33] would carry also electric fields not-orthonal to magnetic fields and the two fields would be twisted. As a mattter of fact, the observed strong parity breaking would be very analogous to that observed in biology if one accepts TGD based explanation of chiral selection in living matter.

4. Could this relate to non-observed SUSY somehow?

Dark matter and spartners have something in common: it is very difficult to observe them! I cannot resist typing a fleeting crazy idea, which I have managed to forfend several times but is popping up again and again from the murky depths of subconscious to tease me. TGD predicts also SUSY albeit different from the standard one: for instance, separate conservation of lepton and baryon numbers is predicted and fermions are not Majorana fermions. Whether covariantly constant right-handed neutrino mode which carries no quantum numbers except spin could be seen as a Majorana lepton is an open question.

One can however assume that covariantly constant right-handed neutrino, call it ν_R, and its antiparticle $\nu_{R,c}$ span $\mathcal{N}=2$ SUSY representation. Particles would appear as SUSY 4-plets: particle, particle+ν_R, particle +$\nu_{R,c}$, particle+ ν_R+$\nu_{R,c}$. Covariantly constant right-handed neutrinos and antineutrino would generate the least broken sub-SUSY. Sparticles should obey the same mass formula as particles but with possibly different p-adic mass scale.

But how the mass scales of particles and its spartners can be so different if right handed does not have any weak interactions? Could it be that sparticles have same p-adic mass scale as particles but are dark having $h_{eff} = n \times h$ so that the observation of sparticle would mean observation of dark matter! Particle cannot of course transform to its spartner directly: already angular momentum conservation prevents this. For $\mathcal{N}=2$ SUSY one can however consider the transformation of particle to the state particle +ν_R+$\nu_{R,c}$ representing a dark variant of particle and having same quantum numbers. It would have non-standard value $h_{eff} = n \times h$ of Planck constant. The resulting dark particles could interact and generate also states in dark SUSY 4-plet. Dark photons could be spartners of photons and decay to biophotons. SUSY would be essential for living matter!

Critical reader asks whether leptopions could be actually pairs of (possibly color excited) $\mathcal{N}=2$ SUSY partners of selectron and spositron. The masses of (color) excitations making up electropion must be indeed identical with electron and positron masses. Should one give up the assumption that color octet excitations of leptons are in question? But if color force is not present, what would bind the spartners together for form electropion? Coulomb attraction so that dark susy analog of positronium would be in question? But why not positronium? If spartner of electron is color excited, one can argue that its mass need not be the same as that of electron and could be of order CP_2! The answer comes out only by calculating. But what happens to leptohadron model if color excitation is not in question? Nothing dramatic, the mathematical structure of leptohadron model is not affected since the calculations involve only the assumption that electropion couples to electromagnetic "instanton" term fixed by anomaly considerations.

If this makes sense, the answers to four questions: *What is behind chiral selection in biology?* ; *What dark matter is?* ; *What spartners are and why they are not seemingly observed?* ; *What is behind various forgotten axion/pion-like states?* would have a lot in common!

6.5 Exotic Pion Like States: "Infra-Red" Regge Trajectories Or Shnoll Effect?

TGD based view about non-perturbative aspects of hadron physics (see this) relies on the notion of color magnetic flux tubes. These flux tubes are string like objects and it would not be surprising if the outcome would be satellite states of hadrons with string tension below the pion mass scale. One would have kind of infrared Regge trajectories satisfying in a reasonable approximation a mass formula analogous to string mass formula. What is amazing that this phenomenon could allow new interpretation for the claims for a signal interpreted as Higgs at several masses (115 GeV by ATLAS, at 125 GeV by ATLAS and CMS, and at 145 GeV by CDF). They would not be actually statistical fluctuations but observations of states at IR Regge trajectory of pion of M_{89} hadron physics!

Consider first the mass formula for the hadrons at IR Regge trajectories.

1. There are two options depending on whether the mass squared or mass for hadron and for the flux tubes are assumed to be additive. p-Adic physics would suggest that if the p-adic primes characterizing the flux tubes associated with hadron and hadron proper are different then mass is additive. If the p-adic prime is same, the mass squared is additive.

2. The simplest guess is that the IR stringy spectrum is universal in the sense that m_0 does not depend on hadron at all. This is the case if the flux tubes in question correspond to hadronic space-time sheets characterized by p-adic prime M_{107} in the case of ordinary hadron physics. This would give for the IR contribution to mass the expression

$$m^2 = \sqrt{m_0^2 + nm_1^2} \ .$$

3. The net mass of hadron results from the contribution of the "core" hadron and the stringy contribution. If mass squared is additive, one obtains $m(H_n) = \sqrt{m^2(H_0) + m_0^2 + nm_1^2}$, where H_0 denotes hadron ground state and H_n its excitation assignable to magnetic flux tube. For heavy hadrons this would give the approximate spectrum

$$m(H_n) \simeq m(H_0) + \frac{m_0^2 + nm_1^2}{2m(H_0)} \ .$$

The mass unit for the excitations decreases with the mass of the hadron.

4. If mass is additive as one indeed expects since the p-adic primes characterizing heavy quarks are smaller than hadronic p-adic prime, one obtains

$$m(H_n) = m^(H_0) + \sqrt{m_0^2 + nm_1^2} \ .$$

For $m_0^2 \gg m_1^2$ one has

$$m(H_n) = m^(H_0) + m_0 + n\frac{m_1^2}{2m_0} \ .$$

If the flux tubes correspond to p-adic prime. This would give linear spectrum which is same for all hadrons.

There is evidence for this kind of states.

The experimental claim of Tatischeff and Tomasi-Gustafsson is that pion is accompanied by pion like states with mass 60, 80, 100, 140, 181, 198, 215, 227.5, and 235 MeV means that besides spion also other pion like states should be there. Similar satellites have been observed for nucleons with ground state mass 934 MeV: the masses of the satellites are 1004, 1044, 1094 MeV. Also the signal cross sections for Higgs to gamma pairs at LHC [C21, C34] suggest the existence of several pion and spion like states, and this was the reason why I decided to to again the search for data about this kind of states (I remembered vaguely that Tommaso Dorigo had talked about them but I failed to find the posting). What is their interpretation? One can imagine two explanations which could be also equivalent.

1. The states could be "infrared" Regge trajectories assignable to magnetic flux tubes of order Compton length of u and d quark (very long and with small string tension) could be the explanation. Hadron mass spectrum would have microstructure. This is something very natural in many-sheeted space-time with the predicted p-adic fractal hierarchy of physics. This conforms with the proposal that all baryons have the satellite states and that they correspond to stringy excitations of magnetic flux tubes assignable to quarks. Similar fine structure for nuclei is predicted for nuclei in nuclear string model [L2]. In fact, the first excited state for ^4He has energy equal to 20 MeV not far from the average energy difference 17.5 MeV for the excited states of pion with energies 198, 215, and 227.5 MeV so that this state might correspond to an excitation of a color magnetic flux tube connecting two nucleons.

2. The p-adic model for Shnoll effect [K2] relies on universal modification of the notion of probability distribution based on the replacement of ordinary arithmetics with quantum arithmetics. Both the rational valued parameters characterizing the distribution and the integer or rational valued valued arguments of the distribution are replaced with quantum ratinals. Quantum arithmetics is characterized by quantum phase $q = exp(i2\pi/p)$ defined by the p-adic prime p. The primes in the decomposition of integer are replaced with quantum primes except p which remains as such. In canonical identification powers of p are mapped to their inverses. Quite generally, distributions with single peak are replaced with many peaked ones with sub-peak structure having number theoretic origin. A good example is Poisson distribution for which one has $P(n) = \lambda^n/n!$. The quantum Poisson distribution is obtained by replacing λ and $n!$ with their quantum counterparts. Quantum Poisson distribution could apply in the case of resonance bump for which the number of count in a given mass squared interval is integer valued variable.

   There are objections against Shnoll effect based explanation.

   (a) If the p-adic prime assignable to quark or hadron characterizes quantum arithmetics it is not distinguishable from ordinary arithmetics since the integers involved are certainly much smaller than say $M_{107} = 2^{107} - 1$. In the case of nuclear physics Shnoll effect involves small primes so that this argument is not water tight. For instance, if $p = 107$ defines the quantum arithmetics, the effects would be visible in good enough resolution and one might even expect variations in the bump structure in the time scale of year.

   (b) The effect is present also for nucleons but the idea about a state with large width splitting into narrower bumps does not fit nicely with the stability of proton.

   For Higgs like signals IR-Regge trajectories/Shnoll effect would be visible as a splitting of wide bumps for spion and pion of M_{89} physics to sub-bumps. This oscillatory bumpy structure is certainly there but is regarded as a statistical artefact. It would be really fascinating to see this quantum deformation of the basic arithmetics at work even in elementary particle physics.

Second piece of evidence comes from two articles by Eef van Beveren and George Rupp. The first article is titled *First indications of the existence of a 38 MeV light scalar boson* [C15]. Second article has title *Material evidence of a 38 MeV boson* [C16]. The basic observations are following. The rate for the annihilation $e^+ + e^- \rightarrow u\overline{u}$ assignable to the reaction $e^+ + e^- \rightarrow \pi^+\pi^-$ has a small periodic oscillation with a period of 78 ± 2 MeV and amplitude of about 5 per cent. The rate for the annihilation $e^+ + e^- \rightarrow b\overline{b}$, assignable to the reaction $e^+ + e^- \rightarrow \Upsilon\pi^+\pi^-$ has similar oscillatory behavior with a period of 73 ± 3 MeV and amplitude about 12.5 per cent. The rate for the annihilation $p\overline{p} \rightarrow c\overline{c}$ assignable to the reaction $e^+ + e^- \rightarrow J/\Psi\pi^+\pi^-$ has similar oscillatory behavior with period of 79 ± 5 MeV and amplitude.75 per cent.

In these examples universal Regge slope is consistent with the experimental findings and supports additive mass formula and the assignment of IR Regge trajectories to hadronic flux tubes with fixed p-adic length scale. There is also consistency with the experiments of Tatitscheff and Tomasi-Gustafsson.

What does one obtain if one scales up the IR Regge trajectories to the M_{89} which replaces Higgs in TGD framework?

1. In the case of M_{89} pion the mass differences 20 MeV and 40 MeV appearing in the IR Regge trajectories of pion would scale up to 10 GeV and 20 GeV respectively. This would suggest the spectrum of pion like states with masses 115, 125, 145, 165 GeV. What makes this interesting that ATLAS reported during last year evidence for a signal at 115 GeV taken as evidence for Higgs and CDF reported before this signal taken as evidence for Higgs around 145 GeV! 125 GeV is the mass of the the most recent Higgs candidate. Could it be that all these reported signals have been genuine signals - not for Higgs- but for M_{89} pion and corresponding spion consisting of squark pair and its IR satellites?

2. I the case of M_{89} hadron physics the naive scaling of the parameters m_0 and m_1 by factor 512 would scale 38 MeV to 19.5 GeV.

7 Cosmic Rays And Mersenne Primes

Sabine Hossenfelder has written two excellent blog postings about cosmic rays. The first one is about the GKZ cutoff for cosmic ray energies and second one about possible indications for new physics above 100 TeV. This inspired me to read what I have said about cosmic rays and Mersenne primes- this was around 1996 - immediately after performing for the first time p-adic mass calculations. It was unpleasant to find that some pieces of the text contained a stupid mistake related to the notion of cosmic ray energy. I had forgotten to take into account the fact that the cosmic ray energies are in the rest system of Earth- what a shame! The recent version should be free of worst kind of blunders. Before continuing it should be noticed I am now living year 2012 and this section was written for the first time for around 1996 - and as it became clear - contained some blunders due to the confusion with what one means with cosmic ray energy. The recent version should be free of worst kind of blunders.

TGD suggests the existence of a scaled up copy of hadron physics associated with each Mersenne prime $M_n = 2^n - 1$, n prime: M_{107} corresponds to ordinary hadron physics. Also lepto-hadrons are predicted. Also Gaussian Mersennes $(1+i)^k - 1$, could correspond to hadron physics. Four of them ($k = 151, 157, 163, 167$) are in the biologically interesting length scale range between cell membrane thickness and the size of cell nucleus. Also leptonic counterparts of hadron physics assignable to certain Mersennes are predicted and there is evidence for them [K27].

The scaled up variants of hadron physics corresponding to $k < 107$ are of special interest. $k = 89$ defines the interesting Mersenne prime at LHC, and the near future will probably tell whether the 125 GeV signal corresponds to Higgs or a pion of M_{89} physics. Also cosmic ray spectrum could provide support for M_{89} hadrons and quite recent cosmic ray observations [C91] are claimed to provide support for new physics around 100 TeV. M_{89} proton would correspond to.5 TeV mass considerably below 100 TeV but this mass scale could correspond to a mass scale of a scaled up copy of a heavy quark of M_{107} hadron physics: a naive scaling of top quark mass by factor 512 would give mass about 87 TeV. Also the lighter hadrons of M_{89} hadron physics should contribute to cosmic ray spectrum and there are indeed indications for this.

The mechanisms giving rise to ultra high energy cosmic rays are poorly understood. The standard explanation would be acceleration in huge magnetic fields. TGD suggests a new mechanism based on the decay cascade of cosmic strings. The basis idea is that cosmic string decays *cosmic string* $\rightarrow$ M_2 *hadrons* $\rightarrow$ M_3 *hadrons* ....$\rightarrow$ $M_{61} \rightarrow M_{89} \rightarrow M_{107}$ *hadrons* could be a new source of cosmic rays. Also variants of this scenario with decay cascade beginning from larger Mersenne prime can be considered. One expects that the decay cascade leads rapidly to extremely energetic ordinary hadrons, which can collide with ordinary hadrons in atmosphere and create hadrons of scaled variants of ordinary hadron physics. These cosmic ray events could serve as a signature for the existence of these scale up variants of hadron physics.

1. Centauro events and the peculiar events associated with $E > 10^5$ GeV radiation from Cygnus X-3. E refers to energy in Earth's rest frame and for a collision with proton the cm energy would be $E_{cm} = \sqrt{2EM} > 10$ TeV in good approximation whereas M_{89} variant of proton would have mass of.5 TeV. These events be understood as being due to the collisions of energetic M_{89} hadrons with ordinary hadrons (nucleons) in the atmosphere.

2. The decay $\pi_n \rightarrow \gamma\gamma$ produces a peak in the spectrum of the cosmic gamma rays at energy $\frac{m(\pi_n)}{2}$. These produce peaks in cosmic gamma ray spectrum at energies which depend on the energy of π_n in the rest system of Earth. If the pion is at rest in the cm system of incoming proton and atmospheric proton one can estimate the energy of the peak if the total energy of the shower can be estimated reliably.

3. The slope in the hadronic cosmic ray spectrum changes at $E = 3 \cdot 10^6$ GeV. This corresponds to the energy $E_{cm} = 2.5$ TeV in the cm system of cosmic ray hadron and atmospheric proton. This is not very far from M_{89} proton mass .5 TeV. The creation of M_{89} hadrons in atmospheric collisions could explain the change of the slope.

4. The ultra-higher energy cosmic ray radiation having energies of order 10^9 GeV in Earth's rest system apparently consisting of protons and nuclei not lighter than Fe might be actually dominated by gamma rays: at these energies γ and p induced showers have same muon

content. $E = 10^9$ GeV corresponds to $E_{cm} = \sqrt{2Em_p} = 4 \times 10^4$ GeV. M_{89} nucleon would correspond to mass scale 512 GeV.

5. So called GKZ cutoff should take place for cosmic gamma ray spectrum due to the collisions with the cosmic microwave background. This should occur around $E = 6 \times 10^{10}$ GeV, which corresponds to $E_{cm} = 3.5 \times 10^5$ GeV. Cosmic ray events above this cutoff are however claimed. There should be some mechanism allowing for ultra high energy cosmic rays to propagate over much longer distances as allowed by the limits. Cosmic rays should be able to propagate without collisions. Many-sheeted space-time suggests manners for how gamma rays could avoid collisions with microwave background. For instance, gamma rays could be dark in TGD sense and therefore have large value of Planck constant. One can even imagine exotic variants of hadrons, which differ from ordinary hadrons in that they do not have quarks and therefore no interactions with the microwave background.

6. The highest energies of cosmic rays are around $E = 10^{11}$ GeV, which corresponds to $E_{cm} = 4 \times 10^5$ GeV. M_{61} nucleon and pion correspond to the mass scale of 6×10^6 GeV and 8.4×10^5 GeV. These events might correspond to the creation of M_{61} hadrons in atmosphere.

The identification of the hadronic space-time sheet as super-symplectic mini black-hole [K21] suggests the science fictive possibility that part of ultra-high energy cosmic rays could be also protons which have lost their valence quarks. These particles would have essentially same mass as proton and would behave like mini black-holes consisting of dark matter. They could even give a large contribution to the dark matter. Since electro-weak interactions are absent, the scattering from microwave background is absent, and they could propagate over much longer distances than ordinary particles. An interesting question is whether the ultrahigh energy cosmic rays having energies larger than the GZK cut-off of 5×10^{10} GeV in the rest system of Earth are super-symplectic mini black-holes associated with M_{107} hadron physics or some other copy of hadron physics.

7.1 Mersenne Primes And Mass Scales

p-Adic mass calculations lead to quite detailed predictions for elementary particle masses. In particular, there are reasons to believe that the most important fundamental elementary particle mass scales correspond to Mersenne primes $M_n = 2^n - 1$, $n = 2, 3, 7, 13, 17, 19, ...$

$$\begin{aligned} m_n^2 &= \frac{m_0^2}{M_n} \ , \\ m_0 &\simeq 1.41 \cdot \frac{10^{-4}}{\sqrt{G}} \ , \end{aligned} \tag{7.1}$$

where $\sqrt{G}$ is Planck length. The lower bound for n can be of course larger than $n = 2$. The known elementary particle mass scales were identified as mass scales associated identified with Mersenne primes $M_{127} \simeq 10^{38}$ (leptons), M_{107} (hadrons) and M_{89} (intermediate gauge bosons). Of course, also other p-adic length scales are possible and it is quite possible that not all Mersenne primes are realized. On the other hand, also Gaussian Mersennes could be important (muon and atomic nuclei corresponds to Gaussian Mersenne $(1+i)^k - 1$ with $k = 113$).

Theory predicts also some higher mass scales corresponding to the Mersenne primes M_n for $n = 89, 61, 31, 19, 17, 13, 7, 3$ and suggests the existence of a scaled up copy of hadron physics with each of these mass scales. In particular, masses should be related by simple scalings to the masses of the ordinary hadrons.

An attractive first working hypothesis hypothesis is that the color interactions of the particles of level M_n can be described using the ordinary QCD scaled up to the level M_n so that that masses and the confinement mass scale Λ is scaled up by the factor $\sqrt{M_n/M_{107}}$.

$$\Lambda_n = \sqrt{\frac{M_n}{M_{107}}}\Lambda \ . \tag{7.2}$$

In particular, the naive scaling prediction for the masses of the exotic pions associated with M_n is given by

$$m(\pi_n) = \sqrt{\frac{M_n}{M_{107}}} m_\pi \ . \quad (7.3)$$

Here $m_\pi \simeq 135\ MeV$ is the mass of the ordinary pion. This estimte is of course extremely naive and the recent LHC data suggests that the 125 GeV Higgs candidate could be M_{89} pion. The mass would be two times higher than the naive estimate gives. p-Adic scalings by small powers of $\sqrt{2}$ must be considered in these estimates.

The interactions between the different level hadrons are mediated by the emission of electroweak gauge bosons and by gluons with cm energies larger than the energy defined by the confinement scale of level with smaller p. The decay of the exotic hadrons at level M_{n_k} to exotic hadrons at level $M_{n_{k+1}}$ must take place by a transition sequence leading from the effective M_{n_k}-adic space-time topology to effective $M_{n_{k+1}}$-adic topology. All intermediate p-adic topologies might be involved.

7.2 Cosmic Strings And Cosmic Rays

Cosmic strings are fundamental objects in quantum TGD and dominated during early cosmology.

7.2.1 Cosmic strings

Cosmic strings (not quite the same thing in TGD as in GUTs) are basic objects in TGD inspired cosmology [K6, K24].

1. In TGD inspired galaxy model galaxies are regarded as mass concentrations around cosmic strings and the energy of the string corresponds to the dark energy whereas the particles condensed at cosmic strings and magnetic flux tubes resulting from them during cosmic expansion correspond to dark matter [K6, K24]. The galactic nuclei, often regarded as candidates for black holes, are the most probable seats for decaying highly entangled cosmic strings.

2. Galaxies are known to organize to form larger linear structures. This can be understood if the highly entangled galactic strings organize around long strings like pearls in necklace. Long strings could correspond to galactic jets and their gravitational field could explain the constant velocity spectrum of distant stars in the galactic halo.

3. In [K6, K24, K23] it is suggested that decaying cosmic strings might provide a common explanation for the energy production of quasars, galactic jets and gamma ray bursters and that the visible matter in galaxies could be regarded as decay products of cosmic strings. The magnetic and Z^0 magnetic flux tubes resulting during the cosmic expansion from cosmic strings allow to assign at least part of gamma ray bursts to neutron stars. Hot spots (with temperature even as high as $T \sim \frac{10^{-3,5}}{\sqrt{G}}$) in the cosmic string emitting ultra high energy cosmic rays might be created under the violent conditions prevailing in the galactic nucleus.

The decay of the cosmic strings provides a possible mechanism for the production of the exotic hadrons and in particular, exotic pions. In [C68] the idea that cosmic strings might produce gamma rays by decaying first into "X" particles with mass of order $10^{15}\ GeV$ and then to gamma rays, was proposed. As authors notice this model has some potential difficulties resulting from the direct production of gamma rays in the source region and the presence of intensive electromagnetic fields near the source. These difficulties are overcome if cosmic strings decay first into exotic hadrons of type M_{n_0}, $n_0 \geq 3$ of energy of order $2^{-n_0+2}10^{25}\ GeV$, which in turn decay to exotic hadrons corresponding to M_k, $k > n_0$ via ordinary color interaction, and so on so that a sequence of M_k: s starting some value of n_0 in $n = 2, 3, 7, 13, 17, 19, 31, 61, 89, 107$ is obtained. The value of n remains open at this stage and depends on the temperature of the hot spot and much smaller temperatures than the $T \sim m_0$ are possible: favored temperatures are the temperatures $T_n \sim m_n$ at which M_n hadrons become unstable against thermal decay.

7.2.2 Decays of cosmic strings as producer of high energy cosmic gamma rays

In [C86] the gamma ray signatures from ordinary cosmic strings were considered and a dynamical QCD based model for the decay of cosmic string was developed. In this model the final state particles were assumed to be ordinary hadrons and final state interactions were neglected. In the recent case the string decays first to M_{n_0} hadrons and the time scale of for color interaction between M_{n_0} hadrons is extremely short (given by the length scale defined by the inverse of π_{n_0} mass) as compared to the time time scale in case of ordinary hadrons. Therefore the interactions between the final state particles must be taken into account and there are good reasons to expect that thermal equilibrium sets on and much simpler thermodynamic description of the process becomes possible.

A possible description for the decaying part of the highly tangled cosmic string is as a "fireball" containing various M_{n_0} ($n \geq 3$) partons in thermal equilibrium at Hagedorn temperature T_{n_0} of order $T_{n_0} \sim m_{n_0} = 2^{-2+n_0}\frac{10^{-4}}{k\sqrt{G}}$, $k \simeq 1.288$. The experimental discoveries made in RHIC suggest [C84] that high energy nuclear collisions create instead of quark gluon plasma a liquid like phase involving gluonic BE condensate christened as color glass condensate. Also black hole like behavior is suggested by the experiments.

RHIC findings inspire a TGD based model for this phase as a macroscopic quantum phase condensed on a highly tangled color magnetic string at Hagedorn temperature. The model relies also on the notion of dynamical but quantized $\hbar$ [K7] and its recent form to the realization that super-symplectic many-particle states at hadronic space-time sheets give dominating contribution to the baryonic mass and explain hadronic masses with an excellent accuracy.

This phase has no direct gauge interactions with ordinary matter and is identified in TGD framework as a particular instance of dark matter. Quite generally, quantum coherent dark matter would reside at magnetic flux tubes idealizable as string like objects with string tension determined by the p-adic length scale and thus outside the "ordinary" space-time. This suggests that color glass condensate forms when hadronic space-time sheets fuse to single long string like object containing large number of super-symplectic bosons.

Color glass condensate has black-hole like properties by its electro-weak darkness and there are excellent reasons to believe that also ordinary black holes could by their large density correspond to states in which super-symplectic matter would form single connected string like structure (if Planck constant is larger for super-symplectic hadrons, this fusion is even more probable).

This inspires the following mechanism for the decay of exotic boson.

1. The tangled cosmic string begins to cool down and when the temperature becomes smaller than $m(\pi_{n_0})$ mass it has decayed to M_{n_1} matter which in turn continues to decay to M_{n_2} matter. The decay to M_{n_1} matter could occur via a sequence $n_0 \rightarrow n_0 - 1 \rightarrow ...n_1$ of phase transitions corresponding to the intermediate p-adic length scales $p \simeq 2^k$, $n_1 \geq k > n_0$. Of course, all intermediate p-adic length scales are in principle possible so that the process would be practically continuous and analogous to p-adic length scale evolution with $p \simeq 2^k$ representing more stable intermediate states.

2. The first possibility is that virtual hadrons decay to virtual hadrons in the transition $k \rightarrow k-1$. The alternative option is that the density of final state hadrons is so high that they fuse to form a single highly entangled hadronic string at Hagedorn temperature T_{k-1} so that the process would resemble an evaporation of a hadronic black hole staying in quark plasma phase without freezing to hadrons in the intermediate states. This entangled string would contain partons as "color glass condensate".

3. The process continues until all particles have decayed to ordinary hadrons. Part of the M_n low energy thermal pions decay to gamma ray pairs and produce a characteristic peak in cosmic gamma ray spectrum at energies $E_n = \frac{m(\pi_n)}{2}$ (possibly red-shifted by the expansion of the Universe). The decay of the cosmic string generates also ultra high energy hadronic cosmic rays, say protons. Since the creation of ordinary hadron with ultra high energy is certainly a rare process there are good hopes of avoiding the problems related to the direct production of protons by cosmic strings (these protons produce two high flux of low energy gamma rays, when interacting with cosmic microwave background [C68]).

7.2.3 Topologically condensed cosmic strings as analogs super-symplectic black-holes?

Super-symplectic matter has very stringy character. For instance, it obeys stringy mass formula due the additivity and quantization of mass squared as multiples of p-adic mass scale squared [K21]. The ensuing additivity of mass squared defines a universal formula for binding energy having no independence on interaction mechanism. Highly entangled strings carrying super-symplectic dark matter are indeed excellent candidates for TGD variants of black-holes. The space-time sheet containing the highly entangled cosmic string is separated from environment by a wormhole contact with a radius of black-hole horizon. Schwartschild radius has also interpretation as Compton length with Planck constant equal to gravitational Planck constant $\hbar/\hbar_0 = 2GM^2$. In this framework the proposed decay of cosmic strings would represent nothing but the TGD counterpart of Hawking radiation. Presumably the value of p-adic prime in primordial stage was as small as possible, even $p = 2$ can be considered.

7.2.4 Exotic cosmic ray events and exotic hadrons

One signature of the exotic hadrons is related to the interaction of the ultra high energy gamma rays with the atmosphere. What can happen is that gamma rays in the presence of an atmospheric nucleus decay to virtual exotic quark pair associated with M_{n_k}, which in turn produces a cascade of exotic hadrons associated with M_{n_k} through the ordinary scaled up color interaction. These hadrons in turn decay $M_{n_{k+1}}$ type hadrons via mechanisms to be discussed later. At the last step ordinary hadrons are produced. The collision creates in the atmospheric nucleus the analog of quark gluon plasma which forms a second kind of fireball decaying to ordinary hadrons. RHIC experiments have already discovered these fireballs and identified them as color glass condensates [C84]. It must be emphasized that it is far from clear whether QCD really predicts this phase.

These showers differ from ordinary gamma ray showers in several respects.

1. Exotic hadrons can have small momenta and the decay products can have isotropic angular distribution so that the shower created by gamma rays looks like that created by a massive particle.

2. The muon content is expected to be similar to that of a typical hadronic shower generated by proton and larger than the muon content of ordinary gamma ray shower [C82].

3. Due to the kinematics of the reactions of type $\gamma + p \rightarrow H_{M_n} + ... + p$ the only possibility at the available gamma ray energies is that M_{89} hadrons are produced at gamma ray energies above 10 TeV. The masses of these hadrons are predicted to be above 70 GeV and this suggests that these hadrons might be identified incorrectly as heavy nuclei (heavier than ^{56}Fe). These signatures will be discussed in more detail in the sequel in relation to Centauro type events, Cygnus X-3 events and other exotic cosmic ray events. For a good review for these events and models form them see the review article [C60].

Some cosmic ray events [C76, C50] have total laboratory energy as high as 3000 TeV which suggests that the shower contains hadron like particles, which are more penetrating than ordinary hadrons.

1. One might argue that exotic hadrons corresponding M_k, $k > 107$with interact only electro-weakly (color is confined in the length scale associated with M_n) with the atmosphere one might argue that they are more penetrating than the ordinary hadrons.

2. The observed highly penetrating fireballs could also correspond super-symplectic dark matter part of incoming, possibly exotic, hadron fused with that for a hadron of atmosphere. Both hadrons would have lost their valence quarks in the collision just as in the case of Pomeron events. Large fraction of the collision energy would be transformed to super-symplectic quanta in the process and give rise to a large color spin glass condensate. These condensates would have no direct electro-weak interactions with ordinary matter which would explain their long penetration lengths in the atmosphere. Sooner or later the color glass condensate would decay to hadrons by the analog of blackhole evaporation. This process is different from QCD type hadronization process occurring in hadronic collisions and this might allow to understand the anomalously low production of neutral pions.

Exotic mesons can also decay to lepton pairs and neutral exotic pions produce gamma pairs. These gamma pairs in principle provide a signature for the presence of exotic pions in the cosmic ray shower. If M_{89} proton is sufficiently long-lived enough they might be detectable.The properties of Centauro type events however suggest that M_{89} protons are short lived.

Jester told in his blog "Resonaances" about an evidence for anomalies in the decays of B meson to K meson and lepton pair. There exist several anomalies.

1. The 3.7 sigma [C47] deviation from standard model predictions in the differential distribution of the $B \to K^*\mu^+\mu^-$ decay products.

2. The 2.6 sigma [C39] violation of lepton flavor universality in $B^+ \to K^+l^+l^-$ decays.

The reported violation of lepton universality (, which need not be real) is especially interesting. The branching ratio $B(B^+ \to K^+e^+e^-)/B(B^+ \to K^+\mu^+\mu^-) \simeq .75$ holds true. Standard model expectation is very near to unity.

Scalar lepto-quark [C37] has been proposed as an explanation of the anomaly. The lowest order diagram for lepton pair production in standard model is penguin diagram obtained from the self energy diagram for b quark involving tW^- intermediate in which W emits γ/Z decaying to lepton pair. Lepton universality is obvious. The penguin diagram involves 4 vertices and 4 propagators and the product of CKM matrix elements $V_{tb}V_{st}^*$.

In TGD framework, and very probably also in the model studied in the article, the diagram involving lepto-quark is obtained from the tW^- self-energy loop by allowing W^- to decay to virtual antineutrino $\overline{\nu}_\mu \equiv \overline{\nu}(g=1)$ and on mass shell charged lepton $L^-(g_1)$. Virtual antineutrino in turn decays to on-shell s quark and lepto-quark of type $\sum_g D(g)\overline{\nu}(g)$, which combines with t quark to form $l^+(g_2)$. The amplitude is proportional to the product $V_{tb}V_{tD(g_2)}^*$ implying breaking of lepton universality. The amplitude for production of e^+l^- pair is considerably smaller than that for μ^+l_- and τ^+l_-. If neutrino CKM mixing is taken into account, there is also a proportionality to the matrix element $V^L_{l(g_1)\nu_{g=1}}$. In absence of leptonic CKM mixing only $\mu^-l^+(g)$ pairs are produced and the possibility to have $g \neq 1$ is also a characteric of lepton non-universality which is however induced by the hadronic CKM mixing: lepto-quark couplings are universal. The penguin diagram is expected to be proportional to the resonance factors $m_t^2/(m_t^2 - m_W^2)$ and $m_X^2/(m_X^2 - m_t^2)$ so that the dependence on the mass of X is not expected to be strong.

The diagram would induce the reported effective four-fermion coupling $\overline{b}_L\gamma^\mu s_L\mu_L^+\gamma_\mu\mu_L^-$ representing neutral current breaking universality. Authors propose a heavy scalar boson exchanges with quantum numbers of lepto-quark and mass of order 10 TeV to explain why no anomalous weak interactions between leptons and quarks by lepto-quark exchange have not been observed. Scalar nature would suggest Higgs type coupling proportional to mass of the lepton and this could explain why the effect of exchange is smaller in the case of electron pair. The effective left-handed couplings would however suggest vector lepto-quarks with couplings analogous to W boson coupling. Note that the effect should reduce the rate: the measured rate for $B_s \to \mu^-\mu^+$ is $.79 \pm .20$: reduction would be due to destructive interference of amplitudes.

7.3 General Ideas

Some general ideas about TGD [K17] are needed in the model and are listed in order to avoid the impression that the model is just ad hoc construct.

1. In TGD all elementary particle can be regarded as pairs of wormhole contacts through which monopole magnetic flux flows: two wormhole contacts are necessary to get closed magnetic field lines. Monopole flux in turn guarantees the stability of the wormhole contact. In the case of weak bosons second wormhole contact carries fermion and antifermion at opposite throats giving rise to the net charges of the boson. The neutrino pair at the second wormhole contact neutralize the weak charges and guarantees short range of weak interactions.

2. The TGD inspired explanation of family replication phenomenon [K5] is in terms of the genus of the partonic 2-surfaces (wormhole throat) at the end of causal diamond. There is topological mixing of partonic topologies which depend on weak quantum numbers of the

wormhole throat leading to CKM mixing. Lepton and quark families obvious correspond to each other: $L(g) \leftrightarrow q(g)$ and this is important in the model to be considered.

The genera of the opposite wormhole throats are assumed to be identical for bosonic wormhole contacts. This can be assumed also for fermionic wormhole contacts for which only second throat carries fermion number. The universality of standard model couplings inspires the hypothesis that bosons are superpositions of the three lowest genera forming singlets with respect effective symmetry group $SU(3)_g$ associated with the 3 lowest genera. Gauge bosons involve also superpositions of various fermion pairs with coefficients determined by the charge matrix.

3. p-Adic length scale hierarchy is one of the key predictions of TGD [K15]. p-Adic length scale hypothesis (to be used in the sequel) stating that p-adic primes are near powers of of 2: $p \simeq 2^k$, k integer, relies on the success of p-adic mass calculations. p-Adic length scale hypothesis poses strong constraints on particle mass scales and one can readily estimate the mass of possible p-adically scaled up variants of masses of known elementary particles.

   One of the basic predictions is the possibility of p-adically scaled up variants of ordinary hadron physics and also of weak interaction physics. One such prediction is M_{89} hadron physics, which is scaled up variant of the ordinary M_{107} hadron physics with mass scale which is by a factor 512 higher and corresponds to the energy scale relevant at LHC. Hence LHC might eventually demonstrate the feasibility of TGD.

   Quite generally, one can argue that one should speak about M_{89} physics [K17] in which exotic variants of weak bosons and scaled up variants of hadrons appear. There would be no deep distinction between weak bosons and M_{89} hadrons and elementary particles in general: all of them would correspond to string like objects involving both magnetic flux tubes carrying monopole flux between two wormhole throats and string world sheets connecting the light-like orbits of wormhole throats at which the signature of the induced metric changes.

4. TGD predicts dark matter hierarchy based on phases with non-standard value $h_{eff} = n \times h$ of Planck constant [K11]. The basic applications are to living matter but I have considered also particle physics applications.

   (a) Dark matter in TGD sense provides a possible explanation for the experimental absence of super partners of ordinary particles: sparticles would be dark and would be characterized by the same p-adic mass scales as sparticles [K32].

   (b) TGD predicts also colored leptons and there is evidence for meson like bound states of colored leptons [K27]. Light colored leptons are however excluded by the decay widths of weak bosons but also now darkness could save the situation.

   (c) I have also proposed that RHIC anomaly observed in heavy ion collisions and its variant for proton heavy ion collisions at LHC suggesting string like structures can be interpreted in terms of low energy M_{89} hadron physics but with large value of h_{eff} meaning that the M_{89} p-adic length scale increases to M_{107} p-adic length scale (ordinary hadronic length scale) [K17].

   One can consider also the adventurous possibility that vector lepto-quarks are dark in TGD sense.

5. TGD view about gauge bosons allows to consider also lepto-quark type states. These bosons would have quark and lepton at opposite wormhole throats. One can consider bosons which are $SU(3)_g$ singlets defined by superpositions of $L(g)q(g)$ or $L(g)\overline{q}(g)$. These states can be either M^4 vectors or scalars (all bosons are vectors in 8-D sense in TGD by 8-D chiral symmetry guaranteeing separate conservation of B and L). Left handed couplings to quarks and leptons analogous to those of W bosons are suggested by the model for the anomalies. Vector lepto-quarks can be consistent with what is known about weak interactions only if they are dark in TGD sense. Scalar lepto-quarks could have ordinary value of Planck constant.

7.4 A TGD Based Model For The B Anomaly In Terms Of Lepto-Quarks

It is natural to approach also the anomaly under discussion by assuming the basic framework just described. The anomaly in the decay amplitude of $B \rightarrow K\mu^-\mu^+$ could be due to an additional contribution based on a simple modification for the standard model amplitude.

1. In TGD framework, and very probably also in the model studied in the article, the starting point is the penguin diagram [C94] for lepton pair production in $B \rightarrow K\mu^-\mu^+$ decay involving only the decay $b \rightarrow sl^+l^-$ by virtual tW state emitting virtual γ/Z decaying to lepton pair and combining with t to form s.

   (a) The diagram for lepton pair production involving virtual lepto-quark is obtained from the tW^- self-energy loop for b. One can go around the W^- branch of the loop to see what must happen. The loop starts with $b \rightarrow tW^-$ followed by $W^- \rightarrow l^-(g_1)\overline{\nu}(g_1)$ producing on mass shell charged lepton $l^-(g_1)$. This is followed by $\overline{\nu}(g_1) \rightarrow sX(\overline{D}\overline{\nu})$ producing on mass shell s. The genus of the virtual neutrino must ge $g = 1$ unless leptonic CKM mixing is allow in the W decay vertex.

   After this one has $X = \sum \overline{D}(g)\overline{\nu}(g) \rightarrow \overline{D}(g_2)\overline{\nu}(g_2)$. Any value of g_2 is possible. Finally, one has $t\overline{D} \rightarrow W^+$ and $W^+\overline{\nu}(g_2) \rightarrow l^+(g_2)$. There are two loops involved and four lines contain a heavy particle (two W bosons, t, and X). The diagram contains 6 electroweak vertices whereas the standard model diagram has 4 vertices.

   (b) All possible lepton pairs can be produced. The amplitude is proportional to the product $V_{tb}V^*_{tD(g_2)}$ implying breaking of lepton universality. The amplitude for production of $e^+\mu^-$ pair is considerably smaller than that for $\mu^+\mu^-$ and $\tau^+\mu^-$ as the experimental findings suggest. If neutrino CKM mixing is taken into account, there is also a proportionality to the matrix element $V^L_{l(g_1)\nu_{g=1}}$.

   In absence of leptonic CKM mixing (mixing explains the recently reported production of μ^+e^- pairs in the decays of Higgs) only $\mu^-l^+(g)$ pairs are produced. The possibility to have $g_2 \neq 1$ is also a characteristic of lepton non-universality, which is however induced by the hadronic CKM mixing: lepto-quark couplings are universal.

   Note that flavour universality of the gauge couplings means in the case of lepto-quarks that Lq pairs superpose to single $SU(3)_g$ singlet as for ordinary gauge bosons. If $L(g)q(g)$ would appear as separate particles, only $\mu^+\mu^-$ pairs would be produced in absence of leptonic CKM mixing.

2. A rough estimate for the ratio r of lepto-quark amplitude $A(b \rightarrow sl^-(g_1)l^+(g_2)$ to the amplitude $A(b \rightarrow sl^-(g)l^+(g)$ involving virtual photon decaying to l^+l^- pair is

$$z = \frac{X_1}{X_2} \times \frac{F_1(x_X, x_t)}{F_2(x_t)}$$

$$X_1 = V_{tD(g_2)}V^L_{l_1\nu(g=1)}[\textstyle\sum_g V^L_{l^-(g_2)\nu(g)}V^*_{D(g)t}]g_X^2 g_W^2 \quad , X_2 = V^*_{dt}e^2 \quad ,$$

$$x_X = \frac{m^2(X)}{m^2(W)} \quad , \quad x_t = \frac{m^2(t)}{m^2(W)} \quad .$$

   The functions F_i correspond come from the loop integral and depend on mass ratios appearing as the argument. The factors X_i collect various coupling parameters together.

   The functions F_i correspond come from the loop integral and depend on mass ratios appearing as the argument.

3. The objection is that the model predicts a contribution to the scattering of leptons and quarks of the same family ($L(g) - q(g)$ scattering) by the exchange of lepto-quark, which is of the same order of magnitude as for ordinary weak interactions. This should have been observed in high precision experiments testing standard model if the mass of the lepto-quark is of the same magnitude as weak boson mass. 10 TeV mass scale for lepto-quarks should guarantee that this is not the case and is probably the basic motivation for the estimate of [C37]. This requires that the ratio of the loop integrals appearing in z is of the order of

unity. For a processional it should be easy to check this. Since the loop integral in the case of scalar lepto-quark studied in [C37] has the desired property and should not depend on the spin of the particles in the loops, one has good reasons to expect that the same holds true also for vector lepto-quarks.

Without a precise numerical calculation one cannot be sure that the loop integral ratio is not too large. In this case one could reduce the gauge coupling to lepto-quarks (expected to be rather near to weak coupling constant strength) but this looks like ad hoc trick. A more adventurous manner to overcome the problem would be to assume that lepto-quarks represent dark matter in TGD sense having effective Planck constant $h_{eff} = n \times h$. Therefore they would not be visible in the experiments, which do not produce dark matter in elementary particle length scales.

4. The proposal of the article is that lepto-quark is scalar so that its coupling strength to leptons and quarks would increase with mass scale. If I have understood correctly, the motivation for this assumption is that only in this manner the effect on the rate for e^+e^- production is smaller than in the case of $\mu^+\mu^-$ pair. As found, the presence of CKM matrix elements in lepto-quark emission vertices at which quark charge changes, guarantees that both anomalous contributions to the amplitude are for electron pair considerably smaller than for muon pair.

5. Can one say something interesting about the mass of the lepto-quark using p-adic length scale hypothesis?

   Consider first a mass estimate for *dark vector lepto-quark* expected to have weak boson mass scale. Even the estimate $m(X) \sim m(W)$ is much higher than the very naive estimate as a sum of μ^- and s masses would suggest. Quite generally, if weak bosons, lepto-quarks, and M_{89} hadrons are all basic entities of same M_{89} physics, the mass scale is expected to be that of M_{89} hadron physics and of the order of weak mass scale. A very naive scaling estimate for the mass would be by factor 512 and give an estimate around 50 GeV. If μ^- mass is scaled by the same factor 512, one obtains mass of order 100 GeV consistent with the estimate for the magnitude of the anomaly.

   Second p-adic mass scale estimate assumes vector or scalar lepto-quark with mass scale not far from 10 TeV. Ordinary μ^- corresponds to Gaussian Mersenne $M_{G,k}$, $k = 113$. If p-adically scaled up variant of lepton physics is involved, the electron of the p-adically scaled up lepton physics could correspond to M_{89}. If muons correspond to Gaussian primes then the scaled up muon would correspond to the smallest Gaussian Mersenne prime below M_{89}, which is $M_{G,79}$. The mass of the scaled up muon would be obtained from muon mass by scaling by a factor $2^{(113-79)/2} = 2^{17} = 1.28 \times 10^5$ giving mass of order 10 TeV, which happens to be consistent with the conservative estimate of the article [C37].

6. An interesting possibility is that light leptoquarks (using CP_2 mass scale as unit) actually consist of quark and lepton, which is right-handed neutrino apart from possible mixing with left-handed antineutrino, whose addition to the one-particle state generates broken $\mathcal{N} = \in$ supersymmetry in TGD. The above model could be consistent with this interpretation since the scalar leptoquark is assumed to consist of right-handed neutrino and quark ($D\nu_R$). This would resolve the long-standing issue about the p-adic mass scale of sparticles in TGD. I have made also other proposals - in particular the idea that sparticles could have same p-adic mass scales as particles but appear only as dark in TGD sense- that is having non-standard value of Planck constant.

Leptoquarks have received considerable attention in blogs. Both Jester (see `http://resonaances.blogspot.fi/2015/11/leptoquarks-strike-back.html`) and Lubos (see `http://motls.blogspot.fi/2015/11/leptoquarks-may-arrive-lhc-to-prove-e6.html`) have written about the topic. Jester lists 3 B-meson potential anomalies, which leptoquarks could resolve:

- A few sigma deviation in differential distribution of $B \rightarrow K^*\mu^+\mu^-$ decays.
- 2.6 sigma violation of lepton flavor universality in $B \rightarrow D\mu^+\mu^-$ *vs.* $K \rightarrow De^+e^-$ decays.
- 3.5 sigma violation of lepton flavor universality, but this time in $B \rightarrow D\tau\nu$ *vs.* $B \rightarrow D\mu\nu$ decays.

There is also a 3 sigma discrepancy of the experimentally measured muon magnetic moment, one of the victories of QED. And old explanation has been in terms of radiative corrections brought in by SUSY. In TGD framework one can consider an explanation in terms of $\mathcal{N}=2$ SUSY generated by right-handed neutrino. It has been claimed (see `http://arxiv.org/abs/1511.01900`) that leptoquark with quantum numbers of $D\nu_R$, where D denotes D type quark actually s quark, which in TGD framework corresponds to genus $g=1$ for the corresponding partonic 2-surface, could explain all these anomalies.

An alternative model would explain the breaking of lepton universality in terms of bosonic analogs of higher fermion generations. The charge matrix of ordinary gauge boson is unit matrix in the 3-D state space assignable with the three generations representing various fermion families. Gauge bosons correspond to charge 3×3 matrices, which must be orthogonal with respect to the inner product defined by trace. Hence fermion universality is broken for the 2 higher gauge boson generations. The first guess is that the mass scale of the second boson generation corresponds to Gaussian Mersenne $M_{G,79}$ [K17] [L23].

The model for the breaking of universality in lepton pair production is in terms of $M_{G,79}$ bosons. In standard model the production of charged lepton pairs would be due to the decay of virtual W bosons appearing in self-energy loop of penguin diagram. W emits Z^0 or γ decaying to a charged lepton pair. If a virtual higher generation W_{79} boson appears in self energy loop, it can transform to W by emitting Z^0_{79} or γ_{79} decaying to lepton pair and inducing a breaking of lepton universality. Direct decays of W_{79} to $l\overline{\nu}_L$ pairs imply a breaking of lepton universality in lepton-neutrino pair production.

The breaking of the universality is characterized by charge matrices of weak bosons for the dynamical SU(3) assignable with family replication. The first generation corresponds to unit matrix whereas higher generation charge matrices can be expressed as orthogonal combinations of isospin and hypercharge matrices I_3 and Y. I_3 distinguishes between tau and lower generations (third experiment) but not between the lowest two generations. There is however evidence for this (the first two experiments above). Therefore a mixing the I_3 and Y should occur.

The coupling to second generation Z boson could thus explain the breaking of universality in the decays of B boson. In TGD Z′ would correspond to second generation Z boson. p-Adic length scale hypothesis plus assumption that new Z boson corresponds to Gaussian Mersenne $M_{G,79} = (1+i)^{79} - 1$ predicts that its mass is by factor 32 higher than mass of ordinary Z boson making 2.9 TeV for 91 GeV mass for Z. There are indications for a bump at this mass value. Leptoquark made of right handed neutrino and quark is less plausible explanation but predicted by TGD as squark.

Recently additional more direct evidence for the existence of this kind of weak boson has emerged (see `http://tinyurl.com/gqrg9zt`). If I understood correctly, the average angle between the decay products of B meson is not quite what it is predicted to be. This is interpreted as an indication that Z′ type boson appears as an intermediate state in the decay.

Does the breaking of universality occurs also for color interactions? If so, the predicted M_{89} and $M_{G,79}$ hadron physics would break universality in the sense that the couplings of their gluons to quark generations would not be universal. This also forces to consider to the possibility that there are new quark families associated with these hadron physics but only new gluons with couplings breaking lepton universality. This looks somewhat boring at first.

On the other hand, there exist evidence for bumps at masses of M_{89} hadron physics predicted by scaling to be 512 time heavier than the mesons of the ordinary M_{107} hadron physics. According to the prevailing wisdom coming from QCD, the meson and hadron masses are however known to be mostly due to gluonic energy and current quarks give only a minor contribution. In TGD one would say that color magnetic body gives most of the meson mass. Thus the hypothesis would make sense. One can also talk about constituent quark masses if one includes the mass of corresponding portion of color magnetic body to quark mass. These masses are much higher than current quark masses and it would make sense to speak about constituent quarks for M_{89} hadron physics. Constituent quarks of the new hadron physics would be different from those of the standard hadron physics.

With a lot of good luck both mechanisms are involved and leptoquarks are squarks in TGD sense. If also M_{89} and M_{79} hadron make themselves visible at LCH (there are several pieces of evidence for this), a breakthrough of TGD would be unavoidable. Or is it too optimistic to hope that the power of truth could overcome academic stupidity, which is after all the strongest force of Nature?

8 New Indications For The New Physics Predicted By TGD

TGD predicts a lot of physics in LHC scales. Two scaled up copies of hadron physics, higher families of gauge bosons and Higgs particles, and fundamental sfermions identifiable as bound states of fermions and right handed neutrino or antineutrino or their pair giving rise to leptoquarks states in quark sector, are suggestive. The predictive power of TGD approach comes from the p-adic length scale hypothesis allowing to predict the masses of new states from known ones by simple scaling argument. One knows precisely what to search for unlike in the case of a typical model containing large number of unknown parameters. The key prediction are two spectroscopies of new hadrons rather than a couple of some exotic particles and sooner or later their existence should become manifest. In this article I summarize the recent indications for the existence of these states. In particular, the identification of the recently reported bump at 750 GeV as $\eta(755\ GeV)$ meson of M_{89} hadron physics, of the reported 2 TeV bump as pion of $M_{G,79}$ physics, and of the reported 4 TeV bump as Higgs of M_{79} electroweak physics assignable to the second generation of weak gauge bosons. The existence of M_{89} neutral pion with mass around 67.5 GeV is now a rather firm prediction.

8.1 Some Almost Predictions Of TGD

TGD predicts a lot of new physics at LHC energy scale.

1. TGD suggests the existence of two scaled up copies of the ordinary hadron physics labelled by Mersenne prime $M_{107} = 2^{107} - 1$ [K17]. The first copy would corresponds to M_{89} with mass spectrum of ordinary hadrons scale by factor $2^9 = 512$ and second one to Gaussian Mersenne $M_{G,179} = (1 + i)^{79} - 1$ with mass spectrum of ordinary hadrons scaled by 2^{14}. The signature of the this new physics is the existence of entire hadronic spectroscopy of new states rather than just a couple of exotic elementary particles. If this new physics is there it is eventually bound to become visible as more information is gathered. What is especially interesting that in heavy ion collisions at RHIC and in proton heavy ion collisions at LHC dark variants of M_{89} hadrons with Compton length scaled up by $h_{eff}/n = n$ to hadronic or even nuclear dimensions could have been produced. This might be the case in all collisions of ordinary hadrons.

2. TGD also suggests [K17, K5] the existence of copies of various gauge bosons analogous to higher fermion generations assigned to the genus $g = 0, 1, 2$ of boundary topology of partonic 2-surface: genus is actually the of partonic 2-surface whose light-like orbit is the surface at which the induced metric changes its signature from Minkowskian to Euclidian. Copies of gauge bosons (electroweak bosons and gluons) and Higgs correspond to octet representations for the dynamical "generation color" group SU(3) assignable to 3 fermion generations. The 3 gauge bosons with vanishing "color" are expected to be the lightest ones: for them the opposite throats of wormhole contact have same genus. The orthogonality of charge matrices for bosons implies that the couplings of these gauge bosons (gluons and electroweak bosons) to fermions break universality meaning that they depend on fermion generations. There are indications for the breaking of the universality. TGD differs from minimal supersymmetric extension of standard model in that all these Higgses are almost eaten by weak gauge bosons so that only the neutral Higgses remain.

   One can ask whether the three lightest copies of weak and color physics for various boson families could correspond M_{89}, $M_{G,79}$ and M_{61}.

3. TGD SUSY is not $\mathcal{N} = 1$ [K32]. Instead superpartners of particle is added by adding right handed neutrino or antineutrino or pair of them to the state. In quark sector one obtains leptoquark like states and the recent indications for the breaking of lepton universality has been also explained in terms of leptoquarks which indeed have quantum numbers of bound states of quark and right-handed neutrino also used to explain the indications for the breaking of lepton universality.

8.2 Indications For The New Physics

During last years several indications for the new physics suggested by TGD have emerged. Recently the first LHC Run 2 results were announced and there was a live webcast (see `http://tinyurl.com/p7kwtjy`).

1. The great news was the evidence for a two photon bump at 750 GeV about which there had been rumors. Lubos told earlier about indications for diphoton bump around 700 GeV. If the scaling factor is the naive 512 so that M_{89} pion would have mass about 70 GeV, there are several meson candidates. The inspection of the experimental meson spectrum (see `http://tinyurl.com/z6ayt2h`) shows that there is quite many resonances with desired quantum numbers. The scaled up variants of neutral scalar mesons $\eta(1405)$ and $\eta(1475)$ consisting of quark pair would have masses 719.4 GeV and 755.2 GeV and could explain both 700 GeV and 750 bump. There are also neutral exotic mesons which cannot be quark pairs but pairs of quark pairs (see `http://tinyurl.com/gl3nby8`) $f_0(400)$, $f_0(980)$, $f_2(1270)$, $f_0(1370)$, $f_0(1500)$, $f_2(1430)$, $f_2(1565)$, $f_2(1640)$, $f_?(1710)$ (the subscript tells the total spin and the number inside brackets gives mass in MeVs) would have naively scaled up masses 204.8, 501.8, 650.2, 701.4, 768.0, 732.2, 801.3, 840.0, 875.5 GeV. Thus f_0 meson consisting of two quark pairs would be also a marginal candidate. The charged exotic meson $a_0(1450)$ scales up to 742.4 GeV state.

2. There is a further mystery involved. Matt Strassler (see `http://tinyurl.com/hvz2qd8`) emphasizes the mysterious finding fact that the possible particle behind the bump does not seem to decay to jets: only 2-photon state is observed. Situation might of course change when data are analyzed. Jester (`http://tinyurl.com/j7t3ab4`) in fact reports that 1 sigma evidence for $Z\gamma$ decays has been observed around 730 GeV. The best fit to the bump has rather large width, which means that there must be many other decay channels than digamma channels. If they are strong as for TGD model, one can argue that they should have been observed.

   As if the particle would not have any direct decay modes to quarks, gluons and other elementary particles. If the particle consists of quarks of M_{89} hadron physics it could decay to mesons of M_{89} hadron physics but we cannot directly observe them. Is this enough to explain the absence of ordinary hadron jets: are M_{89} jets somehow smoothed out as they decay to ordinary hadrons? Or is something more required? Could they decay to M_{89} hadrons leaking out from the reactor volume before a transition to ordinary hadrons?

   Or could a more mundane explanation work? Could 750 GeV states be dark M_{89} eta mesons decaying only via digamma annihilation to ordinary particles be in question? For ordinary pion the decays to gamma pairs dominate over the decays to electron pairs. Decays of ordinary pions to lepton or quark pairs must occur either by coupling to axial weak current or via electromagnetic instanton term coupling pseudo-scalar state to two photon state. The axial current channel is extremely slow due to the large mass of ordinary weak bosons but I have proposed that variants of weak bosons with p-adically scaled down masses are involved with the decays recently called X bosons [L25] and perhaps also with the decays of ordinary pion to lepton pairs). Pseudoscalar can also decay to virtual gamma pair decaying to fermion pair and for this the rate is much lower than for the decay to gamma pair. This would be the case also for M_{89} mesons if the decays to lepton or quark pair occurs via these channels. This might be enough to explain why the decay products are mostly gamma pairs.

3. In the previous section arguments suggesting the production of dark M_{89} hadrons with $h_{eff}/h = 512$ at quantum criticality were developed. The TGD inspired idea that M_{89} hadrons are produced at RHIC in heavy ion collisions and in proton heavy ion collisions at LHC as dark variants with large value of $h_{eff} = n \times h$ with scaled up Compton length of order hadron size or even nuclear size conforms with finding that the decay of string like objects identifiable as M_{89} hadrons in TGD framework explains the unexpected properties of what was expected to be simple quark gluon plasma analogous to blackbody radiation.

   Quantum criticality [K35] suggests that the production of dark M_{89} mesons (responsible for quantal long range correlations) is significant only near the threshold for their production (the energy transfer would take place in scale of proton to dark M_{89} meson with size of proton). Note that in TGD inspired biology dark EEG photons would have energies in bio-photon energy range (visible and UV) and would be exactly analogous to dark M_{89} hadrons. The criticality could correspond to the phase transition from confined to de-confined phase (at criticality confinement with much larger mass but with scaled up Compton wavelength!).

The bad news is that the rate for the production of M_{89} mesons with standard value of Planck constant at higher LHC energies could be undetectably small. If this is the case, there is no other way than tolerate the ridicule, and patiently wait that quantum criticality finds its place in the conceptual repertoire of particles physicists. There have been "reliable" rumors that 750 GeV bump is disappearing and Lubos Motl (see `http://tinyurl.com/h9gx2ep`) announced 5 August in the commentary ICHEP 2016 conference held in Chicago that the bump has indeed disappeared. If the bump is real but disappears at higher energies, it would provide support for quantum criticality.

This explanation might indeed apply to lighter M_{89} meson candidates detected in the earlier runs at lower energies but not to 750 GeV bump as I thought first. 750 GeV bump was announced in December 2015 on basis of the first analysis of data gathered since May 15 2015 (see `http://tinyurl.com/hfvhjtj`). Hence the diphoton bump that I identified as M_{89} eta meson is lost if one takes the outcome of the analysis as the final word.

One should not give up so easily. If the production mechanism is same as for electro-pion [K27] (see `http://tinyurl.com/zvk3umn`), the production amplitude is by anomaly considerations proportional to the Fourier transform of the classical "instanton density" $I = E \cdot B$. In head-on collisions one tends to have $I = 0$ because E (nearly radial in cylindrical coordinates) and B (field lines rotating around z-axis) for given proton are orthogonal and differ only apart from sign factors when the protons are in same position. For peripheral collisions in which also strange looking production of string like configurations parallel to beams was observed in both heavy ion and proton-proton collisions, $E_1 > \cdot B_2$ can be vanishing as one can understand by figuring out what the electric and magnetic fields look like in the cm coordinates. There is clearly a kind of quantum criticality involved also in this sense. Could these events be lost by posing various reasonable looking constraints on the production mechanism? But why the first analysis would have shown the presence of these events? Have some criteria changed?

To find M_{89} pseudoscalars one should study peripheral collisions in which protons do not collide quite head-on and in which M_{89} pseudoscalars could be generated by em instanton mechanism (see `http://tinyurl.com/hxges8w`). In peripheral situation it is easy to measure the energy emitted as particles since strong interactions are effectively absent - only the $E \cdot B$ interaction plus standard em interaction if TGD view is right. Unfortunately peripheral collisions are undesired since the beams are deflected from head-on course! These events are however detected but data end up to trash bin usually as also deflected protons!! Luckily, the team led by my finnish colleague Risto Orava (we started as enthusiastic physics students at the same year and were coffee table friends) is studying just those p-p collisions, which are peripheral (see `https://arxiv.org/abs/1604.05778` and `http://tinyurl.com/hxges8w`) to find if Cernettes could be found in trashbin! It would be wonderful if they would find Cernettes and maybe also other M_{89} pseudo-scalars from the trashbin!

4. Lubos mentions in his posting `http://tinyurl.com/p7muf9p` several excesses, which could be assigned with the above mentioned states. The bump at 750 GeV could correspond to scaled up copy of $\eta(1475)$ or - less probably - $f_0(1500)$. Also the bump structure around 700 GeV for which there are indications (see `http://tinyurl.com/jjuuuzj`) could be explained as a scaled up copy of $\eta(1405)$ or $f_0(1370)$ with mass around 685 GeV. Lubos mentions also a 662 GeV bump (see `http://tinyurl.com/jl7sksof`). If it turns out that there are several resonances in 700 TeV region (and also elsewhere) then the only reasonable explanation relies on hadron like states since one cannot expect a large number of Higgs like elementary particles. One can of course ask why the exotic states should be seen first.

5. Remarkably, for the somewhat ad hoc scaling factor $2 \times 512 \sim 10^3$ one does not have any candidates so that the M_{89} neutral pion should have the naively predicted mass around 67.5 GeV. Old Aleph anomaly [**?**]ad mass 55 GeV. This anomaly did not survive. I found from my

old writings [K32] that Delphi and L3 have also observed 4-jet anomaly with dijet invariant mass about 68 GeV: M_{89} pion? There is indeed an article about search of charged Higgs bosons in L3 (see `http://arxiv.org/pdf/hep-ex/0105057.pdf`) telling about an excess in $c\bar{s}\tau^-\overline{\nu}_\tau$ production identified in terms of H^+H^- annihilation suggesting charged Higgs mass 68 GeV. TGD based interpretation would in terms of the annihilation of charged M_{89} pions.

The gammas in 130-140 GeV range detected by Fermi telescope [E1] (see `http://arxiv.org/pdf/1205.1045.pdf`) were the motivation for assuming that M_{89} pion has mass twice the naively scaled up mass. The digammas could have been produced in the annihilation of a state with mass 260 GeV. The particle would be the counterpart of the ordinary η meson $\eta(548)$ with scaled up mass 274 GeV thus decaying to two gammas with energies 137 GeV. An alternative identification of the galactic gamma rays in terms of gamma ray pairs resulting in the annihilation of two dark matter particles nearly at rest. It has been found that this interpretation cannot be correct (see `http://tinyurl.com/zve4fap`).

Also scaled up eta prime should be there. Also an excess in the production of two-jets above 500 GeV dijet mass has been reported (see `http://tinyurl.com/o6hmry4`) and could relate to the decays of $\eta'(958)$ with scaled up mass of 479 GeV! Also digamma bump should be detected.

6. What about M_{89} kaon? It would have scaled up mass 250 GeV and could also decay to digamma. There are indications for a Higgs like state with mass of 250 GeV from ATLAS (see `http://tinyurl.com/z5vzzl4l`! It would decay to 125 GeV photons - the energy happens to be equal to Higgs mass. There are thus indications for both pion, kaon, all three scaled up η mesons and kaon and η' with predicted masses! The low lying M_{89} meson spectroscopy could have been already seen!

7. Lubos mentions (see `http://tinyurl.com/hzxsnmy`) also indications for 285 GeV bump decaying to gamma pair. The mass of the eta meson of ordinary hadron physics is .547 GeV and the scaling of eta mass by factor 512 gives 280.5 GeV : the error is less than 2 per cent.

8. Lubos tells (see `http://tinyurl.com/jpunanb`) about 3 sigma bump at 1.650 TeV assigned to Kaluza-Klein graviton in the search for Higgs pairs hh decaying to $b\overline{b}$ $+b\overline{b}$. Kaluza-Klein gravitons are rather exotic creatures and in absence of any other support for superstring model they are not the first candidate coming into my mind. I do not know how strong the evidence for spin 2 is but I dare to consider the possibility of spin 1 and ask whether M_{89} hadron physics could allow an identification for this bump.

   (a) Very naively the scaled up J/Psi of the ordinary M_{107} hadron physics having spin $J = 1$ and mass equal to 3.1 GeV would have 512 times higher mass 1.585 TeV: error is about 4 per cent. The effective action would be based on gradient coupling similar in form to Zhh coupling. The decays of scaled up Ψ/J could take place via $hh \rightarrow b\overline{b}b + b\overline{b}$ also now.

   (b) This scaling might be too naive: the quarks of M_{89} hadron physis might be same as those of ordinary hadron physics so that only the color magnetic energy would be scaled up by factor 512. c quark mass is equal 1.29 GeV so that the magnetic energy of ordinary J/Psi would be equal to .52 GeV. If so, M_{89} version of J/Psi would have mass of only 269 GeV. Lubos tells also about evidence for a 2 sigma bump at 280 GeV identified as CP odd Higgs - this identification of course reflects the dream of Lubos about standard SUSY at LHC energies. However, the scaling of η meson mass 547.8 MeV by 512 gives 280.4 GeV so that the interpretation as η meson proposed already earlier is convincing. The naive scaling might be the correct thing to do also for mesons containing heavier quarks.

9. In his latest posting Lubos (see `http://tinyurl.com/z8np2lc`) tells about an excess (I am grateful for Lubos for keeping book about the bumps: this helps enormously), which could have interpretation as the lightest M_{89} vector meson - ρ_{89} or ω_{89}. Mass is the predicted correctly with 5 per cent accuracy by the familiar p-adic scaling argument: multiply the mass of ordinary meson with 512.

This 375 GeV excess might indeed represent the lightest vector meson of M_{89} hadron physics. ρ and ω of standard hadron physics have mass 775 MeV and the scaled up mass is about 397 GeV, which is about 5 per cent heavier than the mass of $Z\gamma$ excess.

The decay $\rho \rightarrow Z + \gamma$ describable at quark level via quark exchange diagram involving emission of Z and γ. The effective action would be proportional to $Tr(\rho * \gamma * Z)$, where the product and trace are for antisymmetric field tensors. This kind effective action should describe also the decay to gamma pair. By angular momentum conservation the photons of gamma pairs should be in relative $L = 1$ state. Since Z is relativistic, $L = 1$ is expected to be favored also for $Z + \gamma$ final state. Professional could immediately tell whether this is correct view. Similar argument applies to the decay of ω which is isospin singlet. For charged ρ also decays to $W\gamma$ and WZ are possible. Note that the next lightest vector meson would be K* with mass 892 MeV. $K*_{89}$ should have mass 457 GeV.

10. Lubos (see `http://tinyurl.com/hweqnnu`) tells also that ATLAS sees charged boson excess manifesting via decay to tb in the range 200-600 TeV. Here Lubos takes the artistic freedom to talk about charged Higgs boson excess since Lubos still believes in standard SUSY predicting copies several Higgs doublets. TGD does not allow them. In TGD framework the excess could be due to the presence of charged M_{89} mesons: pion, kaon, ρ, ω.

11. A smoking gun evidence would be detection of production of pairs of M_{89} nucleons with masses predicted by naive scaling to be around 470 GeV. This would give rise to dijets above 940 GeV cm energy with jets having total quantum numbers of ordinary nucleons. Each M_{89} nucleon consisting of 3 quarks of M_{89} hadron physics could also transform to ordinary quarks producing 3 ordinary hadron jets.

What about exotic mesons not allowed by the standard quark model?

1. Lubos Motl told in his blog about very interesting new bumps reported by CMS in ZZ channel (see `http://tinyurl.com/hl9au3p`). There is 3-4 sigma evidence in favor of a 650 GeV boson (see `http://tinyurl.com/hd2pcug`). Lubos suggests an interpretation as bulk graviton of Randall-Sundrum model. Lubos mentions also evidence for a boson of gamma-gamma resonance with mass 975 GeV.

   M_{89} hadron physics explains the masses for a variety of bumps observed hitherto. The first guess therefore that mesons of M_{89} hadron physics are in question. By performing the now boringly familiar scaling down of masses by factor 1/512 for the masses one obtains the masses of corresponding mesons of ordinary hadron physics: one obtains 1270 MeV and 1904 MeV corresponding to 650 GeV and 975 GeV. Do ordinary mesons with these masses exist?

2. To see that this is the case, one can go to the table of exotic mesons (see `http://tinyurl.com/gl3nby8`). There indeed is exotic graviton like meson $f_2^{++}(1270)$ with correct mass. There is also exotic meson $f_2^{++}(1910)$: the mass differs from the predicted 1904 MeV by .15 per cent. Graviton like states understandable as tetraquark states not allowed by the original quark model would be in question. The interested reader can scale up the masses of other exotic mesons identifiable as candidates for tetraquarks to produce predictions for new bumps to be detected at LHC.

   Both states have spin 2 as also Randall-Sundrum bulk gravitons. What distinguishes the explanations that TGD predicts the masses of these states with an excellent accuracy and predicts a lot of more: just take the table of mesons and multiply by 512 and you can tell your grand children that you predicted entire spectroscopy correctly!

3. In TGD framework these states are indeed possible. All elementary particles and also meson like states correspond to pairs of wormhole contacts. There is closed monopole flux tube with the shape of highly flattened square with long sides of the order of Compton length in question and short sides of the order of CP_2 size. The wormhole throats of both wormhole contact carry quark and antiquark and and one can see the structure either as a pair of gauge boson like states associated with the contacts or as a pair of mesonlike states at the two space-time sheets involved.

Is there any evidence for $M_{G,79}$ hadron physics? Tommaso Dorigo (see http://tinyurl.com/ngdhwhf) told about indications for a neutral di-boson bump at 2 TeV (see http://arxiv.org/pdf/1512.03371v1.pdf). The mass of M_{79} pion is predicted to be 2.16 TeV by a direct scaling of the mass 135 MeV of the ordinary neutral pion!

What about higher generations of gauge bosons?

1. There has been also a rumour about a bump at 4 TeV. By scaling Higgs mass 125 GeV by 32 one obtains 4 TeV! Maybe the Higgs is there but in different sense than in standard SUSY! Could one have copy of weak physics with scale up gauge boson masses and Higgs masses waiting for us! Higgs would be second generation Higgs associated with second generation of weak bosons analogous to that for fermions predicted by TGD? Actually one would have octet associated with dynamical "generation color" symmetry SU(3) but neutral members of the octet are expected to be the lightest states. This Higgs would have also only neutral member after massivation and differ from SUSY Higgs also in this respect. The scaled up weak boson masses would be by scaling with factor 32 from 80.4 GeV for W and 91 GeV for Z would be 2.6 TeV and 2.9 TeV respectively. Lubos (see http://tinyurl.com/zjbdn7a) mentions also 2.9 GeV dilepton event: decay of second generation Z^0?!

2. There is already evidence for second generation gauge bosons from the evidence for the breaking of lepton universality [K17]. The couplings of second generation weak bosons depend on fermion generation because their charge matrices must be orthogonal to those of the ordinary weak bosons. The outcome is breaking of universality in both lepton and quark sector. An alternative explanation would be in terms leptoquarks (see http://tinyurl.com/oat538m), which in TGD framework are super partners of quarks identifiable as pairs of right-handed neutrinos and quarks.

3. New evidence for the existence of this kind of weak boson has emerged (see http://tinyurl.com/gqrg9ztl). If I understood correctly, the average angle between the decay products of B meson is not quite what it is predicted to be. This is interpreted as an indication that Z' type boson appears as an intermediate state in the decay.

4. Lubos Motl told in his blog (see http://tinyurl.com/jpunanb) about direct evidence for Z′ boson now: earlier the evidence was only indirect: breaking of universality and anomaly in angle distribution in B meson decays. Z′ bump has mass around 3 TeV. TGD predicts 2.94 TeV mass for second generation Z breaking universality (mass would differ by scaling factor 32 from that of ordinary Z). The decay width would be by direct scaling .08 TeV and is is larger than deviation .06 TeV from 3 TeV. Lubos reported half year ago (see http://tinyurl.com/zqsdpvw about excess at 2.9 GeV which is also consistent with TGD prediction.

We are living exciting times! Evidence for three new branches of physics predicted by TGD is accumulating! As such each bump is not convincing but when large number of bumps has just the predicted masses, situation changes. If TGD is right, experimenters and theorists are forced to change their paradigm completely. Instead of trying to desperately to identify elementary particle predicted by already excluded theories like SUSY they must realize that there is entire zoo of hadron resonances whose existence and masses are predicted by scaled up hadron physics. Finding a needle in haystack is difficult. In the recent situation one does not even know what one is searching for! Accepting TGD framework one would know precisely what to search for. The enormous institutional inertia of recent day particle physics community will not make the paradigm shift easy. The difficult problem is how to communicate bi-directionally with the elite of particle physics theorists, which refuses to take seriously anyone coming outside the circles.

8.3 Muon surplus in high energy cosmic ray showers as an indication for new hadron physics

The latest twistor in the story comes from cosmic ray physics. According to the article "Viewpoint: Cosmic-Ray Showers Reveal Muon Mystery" in APS Physics (see http://tinyurl.com/q86hnte) Pierre Auger Observatory reports that there is at least 30 per cent muon surplus in cosmic rays at ultrahigh energy around 10^{19} eV [C53] (see `http://tinyurl.com/ol8ardk`). These events are at the knee of cosmic ray energy distribution: at higher energies the flux of cosmic rays should be reduced due to the loss of energy with cosmic microwave background. There are actually indications that this does not take place but this is not the point now. The article [C92] at `http://tinyurl.com/nw5hnqt` tells about how these showers are detected and also provides a simple model for the showers.

This energy is estimated in the rest system of Earth and corresponds to the energy of 130 TeV in cm mass system for a collision with nucleon. This is roughly 10 times the cm energy of 14 TeV at LHC. The shower produced by the cosmic ray is a cascade in which high energy cosmic rays gradually loses its energy via hadron production. The muons are relatively low energy muons resulting in hadronic decays, mostly pion decays, since most of the energy ends up to charged pions producing muons and electrons and neutral pions decaying rapidly to gamma pairs. The electron-positron pairs produced in the electromagnetic showers from neutral pions mask the electrons produced in neutral pion decay to electrons so that the possible surplus can be detected only for muons.

Since cosmic rays are mostly protons and nuclei the primary collisions should involve a primary collision of cosmic ray particle with a nucleon of atmosphere. The anomalously large muon yield suggests an anomalous yield of proton-antiproton pairs produced in the first few collisions. Protons and antiprotons would then collide with nuclei of atmosphere and lose their energy and give rise to anomalously large number of pions and eventually muons.

Unless the models for the production (constrained by LHC data) underestimate muon yield, new physics is required to explain the source of proton-antiproton pairs is needed.

In TGD framework one can consider two scaled up variants of hadron physics as candidates for the new physics.

1. The first candidate corresponds to M_{89} hadron physics for which hadron masses would be obtained by a scaling with factor 512 from the masses of ordinary hadrons characterized by Mersenne prime $M_{1+07} = 2^{107} - 1$. There are several bumps bumps identifiable as pseudo-scalar mesons with predicted masses also some bumps identifiable as some scaled up vector mesons [?] (see `http://tinyurl.com/o92aq4g`). Also the unexpected properties of what was expected to be quark gluon plasm suggest M_{89} hadron physics. In particular, the evidence for string like states suggests M_{89} mesons. If the situation is quantum critical, M_{89} have scaled up Compton length. The natural guess is that it corresponds to the size of ordinary hadrons.

   The proton of M_{89} hadron physics would have mass of 512 GeV so that the production of M_{89} hadrons could take place at energies, which for ordinary hadrons would correspond to 260 GeV meaning that perturbative M_{89} QCD could be used. The quarks of this hadron physics would hadronize either directly to ordinary M_{107} or to M_{89} hadrons. In both cases a phase transition like process would lead from M_{89}- or M_{107}-hadrons and produce a surplus of protons and antiprotons, whose collisions with the nuclei of atmosphere would produce a surplus of pions.

2. One can also consider M_{79} hadron physics, where $M_{G,79}$ corresponds to Gaussian Mersenne $(1+i)^{79} - 1$. The mass scale would be 32 times higher than that for M_{89} hadron physics and correspond to 8 GeV for ordinary hadron collisions. Also now perturbative QCD would apply.

One can argue that M_{89} and/or $M_{G,79}$ hadron physics comes in play for collisions with small enough impact parameter and gives an additive contribution to the total rate of protons and antiproton production. The additional contribution would be of the same order of magnitude as that from M_{107} hadron physics.

Could quantum criticality play some role now?

1. What is the situation is quantum critical with $h_{eff}/h > 1$? The first naive guess is that at the level of tree diagrams corresponding to classical theory the production rate has has no dependence on Planck constant so that nothing happens. A less naive guess is that something similar to that possibly taking place at LHC happens. Quantum critical collisions in which protons just pass by each other could yield dark pseudo-scalar mesons.

2. If quantum criticality corresponds to peripheral collisions, the rate for pseudo-scalar production would be large unlike for central collisions. The instanton action determined to a high degree by anomaly considerations would be determined the rate of production for pseudo-scalar mesons. Vector boson dominance would allow to estimate the rate for the production of vector bosons. Peripherality could make the observation of these collisions difficult: especially so if the peripheral collisions are rejected because they are not expected to involve strong interactions and be therefore uninteresting. This might explain the disappearance of 750 GeV bump.

3. Suppose that quantum criticality for peripheral collisions at LHC and RHIC enters into game arbove the mass scale of M_{89} pion with mass about $65\times; m_p \simeq 65$ GeV and leads to creation of M_{89} mesons. By a simple scaling argument the same would happen in the case of $M_{G,79}$ hadron physics above $65 \times m_p(89) = 3.3 \times 10^4$ TeV to be compared with the collision energy of ultrahigh energy cosmic rays about 13×10^4 TeV.

8.4 Is the new physics really so elementary as believed?

I think that that many colleagues have been thinking about the situation in particle physics. Is it really true that the "nightmare scenario" is realized: no deviations from the standard model. The basic disappointment of course comes from the fate 750 GeV Cernette, which does not exist anymore officially. I am personally puzzled. Various bumps about which Lubos have kept count fit nicely to the spectrum of mesons of M_{89} hadron physics (almost)-predicted by TGD [?]. They have precisely the predicted masses differing by a factor 512 from those of M_{107} hadron physics, the good old hadron physics. Is it really possible that Universe has made a conspiracy to create so many statistical fluctuations just to the correct places? Could it be that something is wrong in the basic philosophy of experimental particle physics, which leads to the loss of information?

First of all, it is clear that new physics is badly needed to solve various theoretical problems such as fine tuning problem for Higgs mass to say nothing about the problem of understanding particle mass scales. New physics is necessary but it is not found. What goes wrong? Could it be that we are trying to discover wrong type of new physics?

Particle physics is thought to be about elementary objects. There would be no complications like those appearing in condensed matter physics: criticality or even quantum criticality, exotic quasiparticles, ... This simplifies the situation enormously but still one is dealing with a gigantic complexity. The calculation of scattering rates is technically extremely demanding but basically application of well-defined algorithms; Monte Carlo modelling of the actual scattering experiments such as high energy proton-proton collisions is also needed. One must also extract the signal from a gigantic background. These are extremely difficult challenges and LHC is a marvellous achievement of collaboration and coherence: like string quartet but with 10,000 players.

What one does is however not to just look what is there. There is no label in the particle telling "I am the exotic particle X that you are searching for". What one can do is to check whether the small effects - signatures - caused by a given particle candidate can be distinguished from the background noise. Finding a needle in haystack is child's play when compared with what one must achieve. If some totally new physics not fitting into the basic paradigms behind search algorithms is there, it is probably lost.

Returning to the puzzle under consideration: the alarming fact is that the colliding protons at LHC form a many-particle system! Could it happen that the situation is even more complex than believed and that phenomena like emergence and criticality encountered in condensed matter physics could be present and make life even more difficult?

As a matter of fact, already the phase transition from confined phase to perturbative QCD involving thermodynamical criticality would be example of this complexity. The surprise from RHIC and later LHC was that something indeed happened but was different than expected. The transition did not seem to take place to perturbative QCD predicting thermal "forgetfulness" and isotropic particle distributions from QCD plasma as black body radiation. For *peripheral* collisions - colliding particles just touching - indications for string like objects emerged. The notion of color glass was introduced and even AdS/CFT was tried (strings in 10-D space-time!) but without considerable success. As if a new kind of hadron physics with long range correlation in proton scale but with energy scale of hundreds of proton masses would have been present. This is mysterious since Compton lengths for this kind of objects should be of order weak boson Compton length.

In TGD Universe this new phase would be M_{89} hadron physics with large value $h_{eff} = n \times h$, with $n = 512$ to scale up M_{89} hadron Compton length to proton size scale to give long range correlations and fluctuation in proton scale characterizig quantum criticality. Instanton density I $\propto E \cdot B$ for colliding protons would appear as a state variable analogous to say pressure in condensed matter and would be large just for the *peripheral* collisions. The production amplitude for pseucoscalar mesons of new hadron physics would by anomaly arguments be obtained as Fourier transform of I. The value of I would be essentially zero for head-on collisions and large only for peripheral collisions - particles just touching - in regions where E and B tend to be parallel. This would mean criticality. There could be similar criticality with respect to energy. If experimenter poses kinematical cutoffs - say pays attention only to collisions not too peripheral - the signal would be lost.

This would not be new. Already at seventies anomalous production of electron-positron pairs perhaps resulting from pseudoscalar state created near collision energy allowing to overcome Coulomb wall where reported: criticality again. The TGD model was in terms of leptopions (electro-pions) [K27] and later evidence for their muonic and tau counterparts have been reported. The model had of course a bad problem: the mass of leptopion is essentially twice that of lepton and one expects that colored lepton is also light. Weak boson decay widths do not allow this. If the leptopions are dark in TGD sense, the problem disappears. These exotic bumps where later forgotten: a good reason for this is that they are not allowed by the basic paradigms of particle physics and if they appear only at criticality they are bound to experience the fate of being labelled as statistical fluctuations.

This has served as an introduction to a heretic question: Could it be that LHC did not detect 750 GeV bosons because the kinematical cuts of the analysis eliminate the peripheral collisions for which protons just touch each other? Could these candidates for pseudo-scalars of M_{89} hadron physics be created by the instanton anomaly mechanism and only in periphery? And more generally, should particle physicists consider the possibility that they are not anymore studying collisions of simple elementary systems?

One can make this more concrete (I am repeating what I already wrote once because I see this as really important). To find M_{89} pseudoscalars one should study peripheral collisions in which protons do not collide quite head-on and in which M_{89} pseudoscalars could be generated by em instanton mechanism. In peripheral situation it is easy to measure the energy emitted as particles since strong interactions are effectively absent - only the $E \cdot B$ interaction plus standard em interaction if TGD view is right (note that for neutral vector mesons the generalization of vector meson dominance based on effective action coupling neutral vector boson linearly to em gauge potential is highly suggestive). Unfortunately peripheral collisions are undesired since beams are deflected from head-on course! These events are however detected but the data end up to trashbin usually as also the deflected protons! Luckily, Risto Orava's team (see `https://arxiv.org/abs/1604.05778` and `http://tinyurl.com/hxges8w`) is studying just those p-p collisions, which are peripheral! It would be wonderful if they would find Cernettes and maybe also other M_{89} pseudo-scalars from the trashbin! Same is true in gravitational sector: reductionism demands that string model leads to GRT and the various anomalies challenging GRT are simply forgotten.

Large statistical fluctuation certainly occurred. The interpretation for the large statistical fluctuation giving rise to Cernette boom could be as the occurrence of un-usually large portion of peripheral events allowing the production of M¡sub¿89¡/sub¿ mesons, in particular Cernettes.

To sum up, the deep irony is that particle physicists are trying desperately to find new physics although it has been found long ago but put under the rug since it did not conform with QCD and standard model. The reductionistic dogma dictates that the acceptable new physics must be consistent with the standard model: no wonder that everything indeed continues to be miraculously consistent with standard model and no new physics is found! Same is true in gravitational sector: reductionism demands that string model leads to GRT and the various anomalies challenging GRT are simply forgotten.

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