M_{89} Hadron Physics and Quantum Criticality

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Abstract

I have been working for years with M_{89} hadron physics hypothesis inspired originally by p-adic length scale hypothesis around 1995 and also by strange cosmic ray event. Later I realized that the strange and unexpected findings about the properties of quark gluon plasma could be perhaps understand in terms of M_{89} hadron physics. This inspired to consider also the possibility that the the candidates for M_{89} mesons are produced as dark particles having Compton length which is of same order of magnitude as proton Compton length.

If dark variants of particles are produced only at quantum criticality, it might happen that the production of M_{89} mesons occurs considerably only around critical collision energy for the proton beams at LHC and the bumps could disappear at higher LHC energies. Unfortunately, quantum criticality does not belong to the vocabulary of particle physicists so that I must be ready to tolerate merciless ridicule also in future! This seems to be the universal fate of all who see farther off than others.

Contents

1 Introduction

I have been working for years with M_{89} hadron physics hypothesis inspired originally by p-adic length scale hypothesis around 1995 and also by strange cosmic ray event [K2]. Later I realized that the strange and unexpected findings about the properties of quark gluon plasma could be perhaps understand in terms of M_{89} hadron physics. This inspired to consider also the possibility that the the candidates for M_{89} mesons are produced as dark particles having Compton length which is of same order of magnitude as proton Compton length.

If dark variants of particles are produced only at quantum criticality [K5], it might happen that the production of M_{89} mesons occurs considerably only around critical collision energy for the proton beams at LHC and the bumps could disappear at higher LHC energies. Unfortunately, quantum criticality does not belong to the vocabulary of particle physicists so that I must be ready to tolerate merciless ridicule also in future! This seems to be the universal fate of all who see farther off than others.

I collect here what looks like the quintessence of the comments about M_{89} hadron physics. I have not edited the old comments and it I cannot exclude the possibility of some small internal inconsistencies.

1.1   Some background for M_{89} hadron physics hypothesis

"Large Hadron Collider May Have Produced New Matter" is the title of popular article (see `http://tinyurl.com/zkxws89`) 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 $M_{107} = 2^{107} - 1$.

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 (see `http://tinyurl.com/golcgxq`). Also I wrote a short comment about the finding (see `http://tinyurl.com/zpz6clf`). Now the findings have been published: preprint can be found in arXiv (see `http://xxx.lanl.gov/abs/1210.5482`). 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.

Second highly attractive explanation discussed by Lubos Motl (see `http://tinyurl.com/golcgxq`) 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 $T_p = 1$ for M_{89} (see [K1]).

   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 (see `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.

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

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 [K5] 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 [K3] 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 physicists, one cannot expect that the notion of M_{89} hadron would be accepted easily by the community. There are indeed "reliable" rumors that 750 GeV bump is disappearing

(see `http://tinyurl.com/h3nphzc`). A group led by Risto Orava (see `http://tinyurl.com/hxges8w`) is studying old data to see whether 750 GeV bump is there. Its presence in data at lower energies would give support for the criticality hypothesis.

2 Summary about the indications for the New Physics

During last years several indications for the new physics suggested by TGD have emerged.

2.1 Indications for the mesons of M_{89} hadron physics

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 (see `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 [L1] 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 [K5] 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 [K3] (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 the data end up to trashbin 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 [C1] had mass 55 GeV. This anomaly did not survive. I found from my old writings [K4] 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://tinyurl.com/glq5654`) telling about an excess in $c\bar{s}\tau^-\bar{\nu}_\tau$ 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/z5vzzl4`! 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 $b\bar{b} + b\bar{b}$. 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 $hh \to b\bar{b}b + b\bar{b}$ 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 $\rho \to Z + \gamma$ 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?

   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!

2. 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.

2.2 What about $M_{G,79}$ hadron physics and higher generations of gauge bosons?

TGD predicts also $M_{G,79}$ hadron physics with mass scale scaled up from that for M_{89} hadron physics by factor 32. 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://tinyurl.com/hbevkmx`). 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!

   Also higher generations of gauge bosons are highly suggestive. Fermionic generations correspond to a triplet assignable to a dynamical symmetry defined by either SU(3) or SO(3) consisting of the three genera $g = 0, 1, 2$ explaining family replication topologically. Higher generation bosons would as pairs of fermions correspond either to color octet of SU(3) or to triplet and singlet of SO(3) (possibly also 5-plet). In both cases states with vanishing quantum numbers are expected to be the lightest states and there are two of them. Are there any indications for these states.

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 [K2]. 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.

2.3 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 [C2] (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 [C3] 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 [L2] (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.

3 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 also 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) [K3] 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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