The implications of .5 MeV and 3.5 keV monochromatic lines for TGD based nuclear model

M. Pitkänen
Email: matpitka6@gmail.com.
http://tgdtheory.com/.

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Abstract

Monochromatic lines around .5 MeV and 3.5-keV X rays have no standard identification. The recent findings exclude the possibility that these particles reside in the conjectured galactic dark matter halo. The detailed consideration of these findings led to an unexpected further progress in TGD based vision about nuclear physics. A correct prediction for the energy of 3.5 eV line emerges and also the .5 MeV line is predicted correctly in terms of TGD based nuclear physics.

CVC and PCAC hypothesis, M^8-H duality, and p-adic length scale hypothesis support the view that hadron and nuclear physics could allow a description dual to QCD like picture in terms scaled down weak interaction physics. This picture finds concrete quantitative support. Several p-adic length scales would be involved and the active scale would depend on interaction energy. In particular, a pseudoscalar having interpretation as X boson with mass about 17 MeV is also predicted.

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1 Introduction

Very interesting popular article (http://tinyurl.com/scuddeg) in Nature tells about very interesting new results found by Safti et al [E1] (http://tinyurl.com/um3jreb). The findings challenge the prevailing particle physics view about existence of galactic dark matter halo and consisting of some exotic new particles behaving like dark matter. These findings add to a long list of negative results related to the existence of dark matter halo and the attempts to find predicted dark matter particles.

There are two observed candidates for particles what would form the speculative galactic dark matter halo. They would have as decay products monochromatic gamma rays at energy of around .5 MeV and 3.5-keV X rays having no standard identification. The recent findings exclude the possibility that these particles reside in the conjectured galactic dark matter halo. They could however reside in galactic centers so that their existence is not challenged.

The detailed consideration of these findings led to an unexpected further progress in TGD based vision about nuclear physics summarized in [L6]. A correct prediction for the energy of 3.5 eV line emerges, and also the .5 MeV line is predicted correctly in terms of TGD based nuclear physics [L1, K3, L5] [L6].

CVC and PCAC hypothesis, $M^8 - H$ duality, and p-adic length scale hypothesis support the view that hadron and nuclear physics could allow a description dual to QCD like picture in terms scaled down weak interaction physics. This picture finds concrete quantitative support. Several p-adic length scales would be involved and the active scale would depend on interaction energy. In particular, a pseudoscalar having interpretation as X boson with mass about 17 MeV is also predicted.

2 .5 MeV gamma ray signal

There is an old gamma ray signal from Milky Way at gamma ray energy of slightly more than electron mass. It has been proposed that it results as dark particle and antiparticle almost at res with respect to each other annihilate. Now it seems that the interpretation as in the proposed sense seems to be excluded.

One can of course, why not a particle which has mass nearly twice the electron mass could not decay to two gamma rays. For some reason this option haven not been experienced as interesting.

1. Support from the existence of pseudo-scalar with this mass emerged already at seventies but because it did not fit witht he standard model picture it was forgotten. Later evidence for a particle with masses twice the mass of muon and tau lepton with similar interpretation emerged. For the same reason also these pieces of evidence were forgotten.

2. TGD led long time ago to what I call lepto-pion hypothesis [K6] (`http://tinyurl.com/vr2ynhp`). In TGD color is not spin-like but angular momentum-like quantum number. Color correspond to the analog of angular momentum for the analog of rigid body rotation in CP_2 degrees freedom. In particular, TGD allows colored excitations of leptons: for instance, electron could appear in color octet state. Color excited electron and positron might form a pion-like color confined pion with mass very nearly 2 times electron mass. Same for muon and tau.

3. These states could be dark in the sense that they have non-standard value of effective Planck constant $h_{eff} = n \times h_0$. This would explain why they are not produced in the decays of Z^0 boson and therefore do not affect its decay rate. Otherwise Z^0 and W decays widths exclude leptopions.

4. This darkness has however nothing to do with the darkness of galactic matter, which reside as energy and possibly dark matter at long very cosmic strings to which linear structures formed by galaxies can be assigned. These cosmic strings can locally thicken to flux tubes and liberate energy as particles forming galaxies. They generate radial gravitational force predicting the flat velocity spectrum of distant stars.

TGD picture would explain why these particles have not been observed outside galactic nucleus. It also turns out that TGD inspired nuclear physics provides an explanation for 1 MeV electropion as a scaled down variant of electroweak pseudoscalar P for which evidence as 96 GeV bump exists. Muonic and tau leptopions would correspond to higher families of P. Also other weak bosons as also gluons would have higher families [K1, K2] as suggested also by the evidence for the breaking of universality of standard model interactions. The p-adically scaled down electroweak bosons would appear as flux tube bonds between nucleons in nuclear string model [L1, L6].

3 3.5-keV X ray signal

Can one imagine any standard physics identification for the 3.5-keV line?. An interesting atomic physics based identification is as X ray emitted in the capture of electron by sulphur ion with principal quantum number $n \geq 9$, which is rather high (`http://tinyurl.com/w9jaqvv`this and `http://tinyurl.com/r6uvwlb`). This requires plasma at temperature of order 3 keV plus cold dense cloud moving at few hundred km/s .

3.5-keV X rays appearing as an un-identified mono-chromatic line in X ray spectrum have been proposed to result from the annihilation of dark particles having mass about 7 keV: annihilation of inert neutrinos is one proposal. The experimental findings exclude the possibility that these X rays are produced in the proposed galactic halo.

3.1 TGD based explanations for 3.5-keV X ray signal

TGD suggests two alternative explanations based on the notion of monopole flux tube.

1. In TGD framework also 3.5-keV X rays could result in a decay of pion-like state with mass of 7 keV. TGD indeed predicts new nuclear physics in keV scale.

   As a matter fact, TGD leads to a new vision about nuclear physics on basis of model of "cold fusion" [L1, L6, L5] (`http://tinyurl.com/s8gzrfe`) . Magnetic flux carrying monopole flux serve as basic building bricks also now: TGD Universe is indeed fractal.

2. Nuclear string model [L1, K3, L5] relies on the assumption that nuclei are sequences of nucleons connected by pionlike bonds - loopy flux tubes much longer than the M^4 distance between nucleons. These loopy flux tubes have length of order electron Compton length are essential for the TGD based model of nuclear reactions [L6] and also of "cold fusion" [L4].

3. This model allows to consider two options concerning the interpretation of 3.5-keV line.

   Option I: These flux tubes would be like pions with mass about 7 keV decaying to two X rays with energy 3.5-keV. They might be produced even in nuclear physics laboratory. Also now darkness in TGD sense ($h_{eff} = n \times h_0 > h$) is essential and one can talk about dark nuclei.

   In the annihilation of pion like bond to X ray pair, fission of the nucleus would take place. There is no dependence on environmental parameters like temperature.

   Option II:

   The 3.5-keV energy could correspond to a cyclotron transition of for a light quark with mass scale of E=5 MeV assignable to the flux tube having cyclotron energy of this order of magnitude. [Recall that cyclotron frequency is determined by the radius of the monopole flux tube and from the quantization of magnetic flux assumed to be minimal plus the from the fact that $B_{end} = .2$ Gauss for electron is .6 MHz].

   In this case however the pion-like long flux tube bonds between nucleons would have mass about 2 quark masses, which would be of the order of nuclear binding energy of order E rather than being in keV range. The energy differences for subsequent states at nuclear IR Regge trajectories assignable to nucleons are predicted also to have energy of order E. Both the intra-nucleon bonds and inter-nucleon bonds would have the same mass scale. The model for nucleus constructed recently [L6] (`http://tinyurl.com/s8gzrfe`) however assumed that the mass scale for the bond is keV. The masses of ibonds ncreasing mass could be compensated by downwards shifts at IR Regge trajectories of nucleons.

   The cyclotron transitions emitting 3.5-keV X ray would naturally correspond to the return to the ground state after thermal excitation. Temperature would correspond to thermal energy of order 3 keV. The line intensity depends on the temperature of environment.

   Remark: For Option I the cyclotron energies for quarks with masses in keV range would be of order eV, which is also predicted to be a nuclear energy scale in the proposal for TGD based nuclear physics discussed in [L6].

4. The intensity of 3.5-keV lines depends on environment. This excludes Option I but saves Option II. For instance, it is known that 3.5 keV line is associated with galactic clusters and galactic nuclei but not with spheroidal dwarf galaxies with little or no star dust, no recent star formation, and low luminosity (`http://tinyurl.com/wh8lcx4`) . The presence of plasma at temperature of order 3 keV distinguishing between these options seems necessary. This temperature is possible for several astrophysical X-ray sources (`http://tinyurl.com/te9e7rq`. Also celestial sources such as the surfaces of stars with surface temperature of this order of magnitude are possible (for Sun the surface temperature is 3 orders of magnitude lower).

The temperature of order 3.5 keV makes possible for hot fusion to start- in solar core the temperature is 1.5 keV) so that 3.5 keV line could serve as a signature for regions, where star formation is beginning. In TGD framework, where dark fusion explaining "cold fusion" serves as a "warm-up band" for hot fusion, this correlation is especially natural.

5. One should be able to predict correct value of the cyclotron energy with natural assumptions. The loopy flux tube would correspond to $k = 127$ for electron. The endogenous magnetic field carrying monopole flux corresponds to $B_{end} = .2$ Gauss assignable to $k = 167$ flux tube. The cyclotron of $f_e = B_{end}/m_e$ of is electron $f_J = 6 \times 10^5$ Hz for $h_{eff} = h$. f_e is scaled up by a factor $2^{20} \simeq 10^{12}$ in the replacement $k = 167 \rightarrow 127$.

   Proton cyclotron frequency is scaled $f_p = (m_e/m_p)f_e$. For proton cyclotron energy one obtains $(h_{eff}/h) \times (m_e/m_p) \times (g_p/2) \times f_J$. Proton has magnetic oment $\mu_p = 2.79e/2m_p$. For $h_{eff}/h = 2^{11}$ this gives $E_{c,p)} \simeq 3.78$ keV, which is sligthly higher than 3.5 keV. If one has $h_{eff}/h \simeq m_p/m_e \simeq 1876$ one obtains 3.46 keV quite near to 3.5 keV! For $h_{eff} = h$ one have in this case 1.8 eV so that eV scale emerges and would correspond to the cyclotron energy of single sheet of covering. Therefore proton's cyclotron energy for $h_{eff}/h \simeq m_p/m_e$ or electron's cyclotron frequency for $h_{eff} = h$ could be in question in B_{end} scaled up from $k = 167$ to $k = 127$.

   For neutron the dipole momenta is $\mu_n = -1.91 \times e/2m_p$ and cyclotron energy would be $E_{c,n} = 2.46$ keV, which might be a testable prediction. Cyclotron energy per single sheet would be $E_{c,n} = 1.31$ eV.

3.2 Questions raised by the interpretation of 3.5-keV signal

These interpretation of 3.5-keV signal raises several questions.

1. The earlier proposal has been that nuclear neutrons could correspond to pairs of proton and pion-like flux tube carrying negative charge. The observation above forces to ask whether the intra-nucleon flux tubes carry electrons and have $h_{eff} = h$. Could nuclear proton transform effectively to neutron by the presence of flux tube carrying electron so that the idea about neutrons as pairs of proton and electron-neutrino pair could make sense inside nuclei.

2. Could also interpret the bonds as scaled down analogs of weak bosons? I have actually considered the possibility of scaled down variants of electroweak gauge bosons earlier in the model [L3] for the so called X boson anomaly [L3, C2]. The inspiration for this came from CVC *resp.* PCAC hypothesis relates the conserved vectorial *resp.* partially conserved axial electroweak currents to strong interactions. This hypothesis is encouraged also by $M^8 - H$ duality strongly suggesting that QCD type description provides the quark-gluon description at high energies at the level of $H = M^4 \times CP_2$ and $M^8 = M^4 \times E^4$ description provides the description of hadron physics in terms of $O(4) = SU(2) \times SO(3)$ symmetry group acting as isometries of E^4 of old-fashioned hadron physics appearing in CVC and PCAC.

   What is important is that weak bosons would be effectively massless below the scaled up weak scale $L(127)$, and depending on the situation also to some other scales as p-adic length scale hypothesis suggests, and being as strong as electromagnetic interactions below this scale. Could one interpret strong interactions in hadronic and nuclear scales as scaled-down weak interactions?

This hypothesis combined with p-adic length scale hypothesis is very powerful and can be tested.

1. Higgs boson with mass 125 GeV would correspond to $k = 89$. Higgs mass would be minimal possible if p-adic mass squared is of order $O(p)$ so that real mass squared is $m_R^2 = 1/p$. Contrary to the long-held expectations W and Z bosons with standard values of Weinberg angle naturally correspond to $k = 90$ if pure U(1) boson would have Higgs mass.

   TGD predicts also pseudo-scalar variant of Higgs. For $k = 90$ the minimal mass would be 88 GeV. LHC has observed a bump at about 96 GeV (`http://tinyurl.com/yyqwlh44`), and this could correspond to pseudo-scalar Higgs, call it P, and assume its mass is indeed 96 GeV. The masses of weak bosons would be therefore $(m(H), m(P), m(W), m(Z)) = (125, 96, 80.4, 91.2)$ GeV and masses for other p-adic length scales follow by simple scaling.

2. The masses of Higgs and W and Z bosons with same Weinberg angle for $k = 127$ would be obtained by scaling with a factor $2^{(-127+k)/2}$, $k = 89$ for Higgs and $k = 90$ for P, W and Z. This would give $(m(H), m(P), m(W), m(Z)) = (.238, .129, .11, .12)$ MeV. What is nice is that these scales are considerably below the nuclear binding energy scale about 7-8 MeV per nucleon for heavier and 1.1 MeV for D so that one could indeed assign nuclear binding and excitation energies to the nucleon flux tubes as proposed in [L6].

This raises questions.

1. Could also the intra-nuclear flux tube bonds have scaled-down weak boson masses but with different p-adic length scale? Can one regard the electrons in these bonds effectively as free electrons as far as cyclotron energies are considered? Could the old-fashioned hadron physics at least partially reduce to weak interaction physics below electron Compton length and possible other p-adic length scales assignable to the flux tubes involved?

2. Intra-nucleon flux tubes have been assumed to have intra-nucleon binding energy scale about 7-8 MeV (1.1 MeV for neutron-proton pair)? The proposal is that binding energy scale corresponds to the energy scale of IR Regge trajectories for nucleons and is thus single nucleon property (or that of the MB of nucleon). Nuclear strings would be strings formed from ^{4}He strings a units, possible D type string, and lonely nucleons (protons or neutrons depending on the sign of $Z - N$.

   Nuclear binding energy scale 7-8 MeV would be assignable to the MB of nucleons of ^{4}He and of heavier nuclei and 1 MeV energy scale to the MBs of p and n in D. The binding energy scale and energy scale of excitations would be determined by the p-adic length scale assignable to the intra-nucleon flux tubes and depending on environment via the value of k defining the p-adic lengths scale.

3. What would this mean p-adically? The scaling of weak boson masses with mass scale .1 MeV to larger mass scale should correspond to that for the binding energy scale and give binding energy scale 1 MeV for D and 8 MeV for ^{4}He.

   (a) Consider first 1 MeV scale assignable to intra-nucleon flux tubes in D. $k = 127 - 6 = 121$ would give $(m_H, m_P, m_W, m_Z) = (1.90, 1.06, .877, .8)$ MeV. The mass of P is quite near the the D binding energy 1.11 MeV.

   A connection with lepto-hadron hypothesis [K6] (`http://tinyurl.com/vr2ynhp`) suggests itself. For $k = 121 = 11^2$ the mass of P would be 1.06 MeV and very nearly twice the electron mass 1.022 MeV. The mass of the electr-pion proposed to explain the pseudo-scalar resonance observed in heavy ion collisions is very very near to $2m_e$. Could electro-pion identified as a pair of color octet leptons correspond scaled down P? Also evidence for muon-pion and tau-pion exists. Could these correspond to higher generations of weak bosons predicted by TGD?

   Recall that there were to alternative interpretations for 3.5-keV line as cyclotron energy of proton with $h_{eff}/h \simeq m_p/m_e$ or of electron with $h_{eff}/h = 1$. The interpretation of the flux tube as electro-pion/P selects the latter interpretation. This modifies the model of "cold fusion" based on quantum criticality and the model of bio-catalysis, and also explains why the flux tubes with radius about electron Compton length are of special importance as the work of Holmlid shows [L2] [L2]. One would have $h_{eff}/h \simeq 2^{11}$ for the quantum critical flux tubes with nanometer length scale central also for TGD inspired quantum biology and giving rise to dark variant of DNA as dark nuclei consisting of dark proton sequences providing fundamental representation of genetic code [L7]. This would also explain biofusion [C1, C5] as a special case of "cold fusion". Note that the magnetic field strength would be smaller by factor 2^{-11} by the reduction of the length scale dependent cosmological constant Λ and cyclotron energy would be same. A deep connection between biology and nuclear physics would emerge.

   (b) What about 7-8 MeV scale? $k = 113$ is basic candidate for nuclear scale and the corresponding masses would be scaled by factor $2^7 = 128$ giving $(m_H, m_P, m_W, m_Z) = (30.5, 16.5, 14.1, 15.4)$ MeV. These scales are too large by a factor of order 2 that $k = 111$ looks more appropriate.

4. There exists evidence for so called X boson with mass of 17 MeV [L3, C2]. One interpretation would be in terms of pion like state which could corresponds to the electroweak pseudo-scalar predicted by TGD. The mass of $k = 113$ P-boson would be 16.5 MeV and quite near to X boson mass. This would suggest that several p-adic length scales are indeed possible. This interpretation can be tested by checking whether other exotic bosons in this range exist.

To sum up, the TGD inspired model for nucleus predicts correctly the 3.5-eV X ray energy as cyclotron energy with using the earlier assumptions of the model. Also other predictions and tests follow. For instance, the model could be tested by irradiating nuclei in laboratory using 3.5 eV X rays and looking whether this has effects. For instance, nuclear decay rates could be affected.

What $M^8 - H$ duality together with CVC and PCAC suggests and the above observations quantitatively support is that p-adic length scale hierarchy could allow a description of hadronic and nuclear physics in terms of p-adically scaled down variants of weak interactions such that the value of k for weak bosons would depend on the energy scale of the strong interactions.

REFERENCES

Particle and Nuclear Physics

[C1] Kervran CL. *Biological transmutations, and their applications in chemistry, physics, biology, ecology, medicine, nutrition, agriculture, geology.* Swan House Publishing Co., 1972.

[C2] Feng JL et al. Evidence for a protophobic fifth force from ^{8}be nuclear transitions. Available at: `http://arxiv.org/abs/1604.07411`, 2015.

[C3] Krasznahorkay A et al. Observation of anomalous internal pair creation in 8be: A possible indication of a light, neutral boson. Available at: `https://arxiv.org/abs/1504.0152`, 2016.

[C4] Holmlid L and Kotzias B. Phase transition temperatures of 405-725 K in superfluid ultra-dense hydrogen clusters on metal surfaces. *AIP Advances.* Available at: `http://tinyurl.com/hxbvfc7`, 6(4), 2016.

[C5] Bird C Tompkins P. *The secret life of plants.* Harper & Row, New York, 1973.

Cosmology and Astro-Physics

[E1] Safti R Dessert C, Rodd NL. The dark matter interpretation of the 3.5-keV line is inconsistent with blank-sky observations. *Science.* Available at: *https://science.sciencemag.org/content/367/6485/1465*, 367(6485):1465–1467, 2020.

Books related to TGD

[K1] Pitkänen M. New Particle Physics Predicted by TGD: Part I. In *p-Adic Physics.* Available at: `http://tgdtheory.fi/pdfpool/mass4.pdf`, 2006.

[K2] Pitkänen M. New Particle Physics Predicted by TGD: Part II. In *p-Adic Physics.* Available at: `http://tgdtheory.fi/pdfpool/mass5.pdf`, 2006.

[K3] Pitkänen M. Cold Fusion Again. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: `http://tgdtheory.fi/pdfpool/coldfusionagain.pdf`, 2019.

[K4] Pitkänen M. Nuclear String Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: http://tgdtheory.fi/pdfpool/nuclstring.pdf, 2019.

[K5] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: http://tgdtheory.fi/pdfpool/darkcore.pdf, 2019.

[K6] Pitkänen M. The Recent Status of Lepto-hadron Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: http://tgdtheory.fi/pdfpool/leptc.pdf, 2019.

[K7] Pitkänen M. Could TGD provide new solutions to the energy problem? In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: http://tgdtheory.fi/pdfpool/proposal.pdf, 2020.

Articles about TGD

[L1] Pitkänen M. Further Progress in Nuclear String Hypothesis. Available at: http://tgdtheory.fi/public_html/articles/nuclstring.pdf, 2007.

[L2] Pitkänen M. Strong support for TGD based model of cold fusion from the recent article of Holmlid and Kotzias. Available at: http://tgdtheory.fi/public_html/articles/holmilidnew.pdf, 2016.

[L3] Pitkänen M. X boson as evidence for nuclear string model. Available at: http://tgdtheory.fi/public_html/articles/Xboson.pdf, 2016.

[L4] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: http://tgdtheory.fi/public_html/articles/krivit.pdf, 2017.

[L5] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: http://tgdtheory.fi/public_html/articles/darkcore.pdf, 2019.

[L6] Pitkänen M. Could TGD provide new solutions to the energy problem? Available at: http://tgdtheory.fi/public_html/articles/proposal.pdf, 2020.

[L7] Pitkänen M. New results about dark DNA inspired by the model for remote DNA replication. Available at: http://tgdtheory.fi/public_html/articles/darkdnanew.pdf, 2020.