TGD based explanation of two new neutrino anomalies

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

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Abstract

This article was inspired by two anomalies. ICECUBE Collaboration has found that there is tension between predictions and experimental facts concerning the predicted flavor ratio (approximately 1:1:1) for neutrinos observed in ICECUBE. The standard model production mechanism would be the decay of pions to muonic and electron lepton-neutrino pairs.

Second anomaly has been discovered by ANITA collaboration and also the ICECUBE data show it. Cosmic ray showers with total energy about 1 EeV from the interior of Earth not possible in standard model are detected. In this article possible TGD based explanations of these anomalies are discussed.

The TGD based explanation of the first anomaly assumes that the lepton-neutrino pairs are produced by third generation weak bosons having correct mass scale about 1.5 PeV if they correspond to Mersenne prime M_{61}. This would predict neutrino flavor ratio differing from the flavor ratio 1:1:1 predicted by the standard model based on the decays of pions.

The TGD based explanation of ANITA anomaly assumes that primary cosmic rays have energy about 1 EeV and are $M_{G,47}$ protons, possibly dark. These protons must have long enough free path of order Earth radius before an interaction with the ordinary matter inside Earth in which they would transform to ordinary M_{107} protons or possibly dark M_{89} protons, which in turn transform to ordinary protons in strong interactions with the ordinary matter. Pions are produced abundantly and they produce lepton-neutrino pairs and neutrinos with flavor ratio 1:1:1.

The prediction is that peaks at energies corresponding to the masses of protons of fractal copies of hadron physics assignable to Mersenne primes and Gaussian Mersenne primes could be observed and give direct support for p-adic length scale hypothesis.

Contents

1 Introduction

This article was inspired by two anomalies. ICECUBE Collaboration has found that there is tension between predictions and experimental facts concerning the predicted flavor ratio (approximately 1:1:1) for neutrinos observed in ICECUBE [C2] (see http://tinyurl.com/ycvwehmr). The standard model production mechanism would be the decay of pions to muonic and electron lepton-neutrino pairs.

Second anomaly has been discovered by ANITA collaboration [C1] (see https://arxiv.org/pdf/1809.09615.pdf) and also the ICECUBE data show it. Cosmic ray showers with total energy about 1 EeV from the interior of Earth not possible in standard model are detected. In this article possible TGD based explanations of these anomalies are discussed.

Before continuing it is good to summarize the basic differences between TGD and standard model at the level of elementary particle physics. TGD differs from standard model by three basic new elements: p-adic length scale hypothesis predicting a fractal hierarchy of hadron physics and electroweak physics; topological explanation of family replication phenomenon; and TGD view about dark matter.

1. p-Adic length scale hypothesis states that Mersenne primes M_n and Gaussian Mersennes $M_{G,n}$ give rise to scaled variants of ordinary hadron and electroweak physics with mass scale proportional to $\sqrt{M_n} = 2^{n/2}$. M_{127} would correspond to electron and possibly also to what I have called lepto-hadron physics [K3]. Muon and nuclear physics would correspond to $M_{G,113}$ and τ and hadron physics would correspond to M_{107}. Electroweak gauge bosons would correspond to M_{89}. $n_G = 73, 47, 29, 19, 11, 7, 5, 3, 2$ would correspond to Gaussian Mersennes and $n = 61, 31, 19, 17, 13, 7, 5, 3, 2$ to ordinary Mersennes. There are four Gaussian Mersennes corresponding to $n_G \in \{151, 157, 163, 167\}$ in biologically relevant length scale range 10 nm-2.5 μm (from cell membrane thickness to nucleus size): this can be said to be a number theoretical miracle.

2. The basic assumption is that the family replication phenomenon reduces to the topology of partonic 2-surfaces serving as geometric correlates of particles. Orientable topology is characterized by genus - the number of handles attached to sphere to obtain the topology. 3 lowest genera are assumed to give rise to elementary particles. This would be due to the Z_2 global conformal symmetry possible only for $g = 0, 1, 2$ [K1]. By this symmetry single handle behaves like particle and two handles like a bound state of 2 particles. Sphere corresponds to a ground state without particles. For the higher genera handles and handle pairs would behave like a many-particle states with mass continuum.

3. The model of family replication is based on $U(3)$ as dynamical "generation color" acts as a combinatorial dynamical symmetry assignable to the 3 generations so that fermions correspond to SU(3) multiplet and gauge bosons to U(3) octet with lowest generation associated with U(1). Cartan algebra of U(2) would correspond to two light generations with masses above intermediate boson mass scale.

   3 "generation neutral" (g-neutral) weak bosons (Cartan algebra) are assigned with $n = 89$ (ordinary weak bosons), $n_G = 79$ and $n_G = 73$ correspond to mass scales $m(79) = 2.6$ TeV and $m(73) = 20.8$ TeV. I have earlier assigned third generation with $n = 61$. The reason is that the predicted mass scale is same as for a bump detected at LHC and allowing interpretation as g-neutral weak boson with $m(61) = 1.3$ PeV.

   3+3 g-charged weak bosons could correspond to $n = 61$ with $m(61) = 1.3$ PeV (or $n_G = 73$ boson with $m(73) = 20.8$ TeV) and to $n_G = 47, 29, 19$ and $n = 31, 19$. The masses are $m(47) = .16$ EeV, $m(31) = 256 \times m(47) = 40$ EeV, $m(29) = 80$ EeV, $m(19) = 256$ EeV, $m(17) = .5 \times 10^3$ EeV, and $m(13) = 2 \times 10^3$ EeV. This corresponds to the upper limit for the energies of cosmic rays detected at ANITA.

   In TGD framework the most natural identification of Planck length would be as CP_2 length R which is about $10^{3.5}$ times the Planck length as it is usually identified [L4]. Newton's constant would have spectrum and its ordinary value would correspond to $G = R^2/\hbar_{eff}$ which $\hbar_{eff} \sim 10^7$. UHE cosmic rays would allow to get information about physics near Planck length scale in TGD sense!

4. TGD predicts also a hierarchy of Planck constants $h_{eff} = n \times h_0$, $h = 6h_0$, labelling phases of ordinary matter identified as dark matter. The phases with different values of n are dark matter relative to each other but phase transitions changing the value of n are possible. The hypothesis would realize quantum criticality with long length scale quantum fluctuations and it follows from what I call adelic physics [L1, L2].

   n corresponds to the dimension of extension of rationals defining one level in the hierarchy of adelic physics defined by extensions of rationals inducing extensions of p-adic number fields serving as correlates for cognition in TGD inspired theory of consciousness [L3]. p-Adic physics would provide extremely simple but information rich cognitive representations of the real number based physics and the understanding of p-adic physics would be easy manner to understand the real physics. This idea was inspired by the amazing success of p-adic mass calculations [K4], which initiated the progress leading to adelic physics.

The TGD based explanation of the first anomaly assumes that the lepton-neutrino pairs are produced by third generation weak bosons having correct mass scale about 1.5 PeV if they correspond to Mersenne prime M_{61}. This would predict neutrino flavor ratio differing from the flavor ratio 1:1:1 predicted by the standard model based on the decays of pions.

The TGD based explanation of ANITA anomaly assumes that primary cosmic rays have energy about 1 EeV and are $M_{G,47}$ protons, possibly dark. These protons must have long enough free path of order Earth radius before an interaction with the ordinary matter inside Earth in which they would transform to ordinary M_{107} protons or possibly dark M_{89} protons, which in turn transform to ordinary protons in strong interactions with the ordinary matter. Pions are produced abundantly and they produce lepton-neutrino pairs and neutrinos with flavor ratio 1:1:1.

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2 New indications for third generation weak bosons

There are indications (see `http://tinyurl.com/y8cwb98b`) that electron neutrinos appear observed by ICECUBE more often than other neutrinos. In particular, the seems to be a deficit of τ neutrinos. The results are very preliminary. In any case, there seems to be an inconsistency between two methods observing the neutrinos. The discrepancy seems to come from higher energy end of the energy range [13 TeV, 7.9 PeV] from energies above 1 PeV.

The article "Invisible Neutrino Decay Could Resolve IceCubes Track and Cascade Tension" by Peter Denton and Irene Tamborra tries to explain this problem by assuming that τ and μ neutrinos can decay to a superparticle called majoron [C2] (see `http://tinyurl.com/ycvwehmr`).

The standard model for the production of neutrinos is based on the decays of pions producing $e^+\nu_e$ and $\mu^+\nu_\mu$. Also μ^+ can travel to the direction of Earth and decay to $e^+\nu_e\overline{\nu}_\mu$ and double the electron neutrino fraction. The flavor ratio would be 2:1:0.

Remark: The article at (see `http://tinyurl.com/ycvwehmr`) claims that the flavor ratio is 1:2:0 in pion decays, which is wrong: the reason for the lapsus is left as an exercise for the reader.

Calculations taking into account also neutrino oscillations during the travel to Earth to be discussed below leads in good approximation to a predicted flavor ratio 1:1:1. The measurement teams suggest that measurements are consistent with this flavor ratio.

There are however big uncertainties involved. For instance, the energy range is rather wide [13 TeV, 7.9 PeV] and if neutrinos are produce in decay of third generation weak boson with mass about 1.5 PeV as TGD predicts, the averaging can destroy the information about branching fractions.

In TGD based model [L5] [K2] (see `http://tinyurl.com/y94zru7s`) third generation weak bosons - something new predicted by TGD - at mass around 1.5 TeV corresponding to mass scale assignable to Mersenne prime M_{61} (they can have also energies above this energy) would produce neutrinos in the decays to antilepton neutrino pairs.

1. The mass scale predicted by TGD for the third generation weak bosons is correct: it would differ by factor $2^{(89-61)/2} = 2^{14}$ from weak boson mass scale. LHC gives evidence also for the second generation: also now mass scale comes out correctly. Note that ordinary weak bosons would correspond to M_{89}.

2. The charge matrices of 3 generations must be orthogonal and this breaks the universality of weak interactions. The lowest generation has generation charge matrix proportional to (1,1,1) - this generation charge matrix describes couplings to different generations. Unit matrix codes for universality of ordinary electroweak and also color interactions. For higher generations of electro-weak bosons and also gluons universality is lost and the flavor ratio for the produced neutrinos in decays of higher generation weak bosons differs from 1:1:1.
   One example of charge matrices would be $\sqrt{3/2}(0,1,-1)$ for second generation and $(2,-1,-1)/\sqrt{2}$ for the third generation. In this case electron neutrinos would be produced 2 times more than muon and tau neutrinos altogether. The flavor ratio would be 0:1:1 for the second generation and 4:1:1 for the third generation in this particular case.

3. This changes the predictions of the pion decay mechanism. The neutrino energies are above the energy about 1.5 PeV in the range defined by the spectrum of energies for the decaying weak boson. If they are nearly at rest the energie are a peak around the rest mass of third generation weak boson. The experiments detect neutrinos at energy range [13 TeV, 7.9 PeV] having the energy of the neutrinos produced in the decay of third generation weak bosons in a range starting from 1.5 PeV and probably ending below 7.9 PeV. Therefore their experimental signature tends to be washed out if pion decays are responsible for the background.

These fractions are however not what is observed at Earth.

1. Suppose that $L + \nu_L$ pair is produced. It can also happen that L^+, say μ^+ travels to the direction of Earth. It can decay to $e^+\overline{\nu}_\mu\nu_e$. Therefore one obtains both ν_μ and ν_e. From the decy to $\tau^+\nu_\tau$ one obtains all three neutrinos. If the fractions of the neutrinos from the generation charge matrix are (X^e, X^μ, X^τ), the fractions travelling to each are proportional to

$$\{x^\alpha\} \leftrightarrow \{X^\alpha\} = (X^e, X^\mu, X^\tau) = (x^e + x^\mu + x^\tau, x^\mu + x^\tau, x^\tau) \ . \tag{2.1}$$

   and the flavor ratio in the decays would be

$$X^e : X^\mu : X^\tau = x^e + x^\mu + x^\tau : x^\mu + x^\tau : x^\tau \ . \tag{2.2}$$

   The decays to lower neutrino generations tend to increase the fraction of electronic and muonic neutrinos in the beam.

2. Also neutrino oscillations due to different masses of neutrinos (see `http://tinyurl.com/oov344k`) affect the situation. The analog of CKM matrix describing the mixing of neutrinos, the mass squared differences, and the distance to Earth determines the oscillation dynamics. One can deduce the mixing probabilities from the analog of Schrödinger equation by using approximation $E = p + m^2/2p$ which is true for energies much larger than the rest mass of neutrinos. The masses of mass eigenstates, which are superpositions of flavour eigenstates, are different.

   The leptonic analog of CKM matrix $U_{\alpha i}$ (having in TGD interpretation in terms of different mixings of topologies of partonic 2-surfaces associated with different charge states of various lepton families [K1]) allows to express the flavor eigenstates ν_α as superpositions of mass eigenstates ν_i. As a consequence, one obtains the probabilities that flavor eigenstate ν_α transforms to flavour eigenstate ν_β during the travel. In the recent case the distance is very large and the dependence on the mass squared differences and distance disappears in the averaging over the source region.

   The matrix $P_{\alpha\beta}$ telling the transformation probabilities $\alpha \rightarrow \beta$ is given in Wikipedia article (see `http://tinyurl.com/oov344k`) in the general case. It is easy to deduce the matrix at the limit of very long distances by taking average over source region to get exressions having no dependence

$$P_{\alpha\beta} = \delta_{\alpha\beta} - 2\sum_{i>j} Re[U_{\beta i}U^\dagger_{i\alpha}U_{\alpha j}U^\dagger_{j\beta}] \ . \tag{2.3}$$

   Note that $\sum_\beta P_{\alpha\beta} = 1$ holds true since in the summation second term vanishes due to unitary condition $U^\dagger U = 1$ and $i > j$ condition in the formula.

3. The observed flavor fraction is $Y_e : Y_\mu : Y_\tau$, where one has

$$Y_\alpha = P_{\alpha\beta}X^\beta \ . \tag{2.4}$$

   It is clear that if the generation charge matrix is of the above form, the fraction of electron neutrinos increases both the decays of τ and μ and by this mechanism. Of course, the third generation could have different charge matrix, say $\sqrt{3/2}(0, 1, -1)$. In this case the effects would tend to cancel.

3 TGD view about ANITA anomalous events

I read an article [C1] (see https://arxiv.org/pdf/1809.09615.pdf) telling about 2 anomalous cosmic ray events detected by ANITA (The Antarctic Impulsive Transient Antenna) collaboration. Also ICECUBE collaboration has observed 3 events of this kind. What makes the events anomalous is that the cosmic ray shower emanates from Earth: standard model does not allow the generation of this kind of showers. The article proposes super-partner of tau lepton known as stau as a possible solution of the puzzle.

It is natural to ask what TGD could say about the Anita anomaly serving as very strong (5 sigma) evidence for new physics beyond standard model. Consider first the basic empirical constraints on the model.

1. According to the article [C1], there are 2 anomalous events detected by ANITA collaboration and 3 such events detected by ICECUBE collaboration. For these events there is cosmic ray shower coming Earth's interior. Standard model does not allow this kind of events since the incoming particle - also neutrino - would dissipate its energy and never reach the detector.

   This serves as a motivation for the SUSY inspired model of the article proposing that stau, super-partner of tau lepton, is created and could have so weak interactions with the ordinary matter that it is able to propagate through the Earth. There must be however sufficiently strong interaction to make the detection possible. The mass of stau is restricted to the range .5-1.0 TeV by the constraints posed by LHC data on SUSY.

2. The incoming cosmic rays associated with anomalous events have energies around $\epsilon_{cr} = .5 \times 10^{18}$ eV. A reasonable assumption is that the rest system of the source is at rest with respect to Earth in an energy resolution, which corresponds to a small energy EeV scale. No astrophysical mechanism producing higher energy cosmic rays about 10^{11} GeV based on standard physic is known, and here the p-adic hierarchy of hadron physics and electroweak physics suggests mechanisms.

In TGD framework the natural question is whether the energy scale correspond to some Mersenne or Gaussian Mersenne so that neutrino and corresponding lepton could have been produced in a decay of W boson labelled by this prime. By scaling of weak boson mass scale Gaussian Mersenne $M_{G,47} = (1+i)^{47}-1$ would correspond to a weak boson mass scale $m(47) = 2^{(89-47)/2}\times 80$ GeV = .16 EeV. This mass scale is about roughly a factor 1/3 below the energy scale of the incoming cosmic ray. This would require that the temperature of the source is at least $6 \times m(47)$ at source if neutrino is produced in the decay of $M_{G,47}$ W boson. This option does not look attractive to me.

Could cosmic rays be (possibly dark) protons of $M_{G,47}$ hadron physics.

1. The scaling of the mass of the ordinary proton about $m_p(107) \simeq 1$ GeV gives $m_p(47) = 2^{(107-47)/2}$ GeV $\simeq 1$ EeV! This is encouraging! Darkness in TGD sense could make for them possible to propagate through matter. In the interactions with matter neutrinos and leptons would be generated.

   The article tells that the energy ϵ_{cr} of the cosmic ray showers is $\epsilon_{cr} \sim .6$ EeV, roughly 60 per cent the rest mass of cosmic ray proton. I do not how precise the determination of the energy of the shower is. The production of dark particles during the generation of shower could explain the discrepancy.

2. What could one say about the interactions of dark $M(47)$ proton with ordinary matter? Does $p(47)$ transform to ordinary proton in stepwise manner as Mersenne prime is gradually reduced or in single step. What is the rate for the transformation to ordinary proton. The free path should be a considerable fraction of Earth radius by the argument used in [C1] for stau.

   The transformation to ordinary proton would generate a shower containing also tau leptons and tau neutrinos coming pion decays producing muons and electrons and their neutrinos. Neutrino oscillations would produce tau neutrinos: standard model predicts flavor ratio about 1:1:1.

3. What could happen in the strong interactions of dark proton with nuclei? Suppose that dark proton is relativistic with $E_p = xM_p = x$ EeV, $x > 1$, say $x \sim 2$. The total cm energy E_{cm} in the rest system of ordinary proton is for a relativistic)!) EeV dark proton + ordinary proton about $E_{cm} = (3/2)\sqrt{x}\sqrt{m_p M_p} = \sqrt{x} \times 5$ TeV, considerably above the rest energy $m_p(89) = 512 m_p = .48$ TeV of M_{89} dark proton. The kinetic energy is transformed to rest energy of particles emanating from the collision of dark and ordinary proton.

   If the collision takes place with a quark of ordinary proton with mass $m_q = 5$ MeV, E_{cm} is reduced by a factor of $\sqrt{5}10^{-3/2}$ giving $E = \sqrt{x}1.3$ TeV, which is still above for the threshold for transforming the cosmic ray dark proton to M_{89} dark proton.

   This suggests that the interaction produce first dark relativistic M_{89} protons, which in further interactions transform to ordinary protons producing the shower and neutrinos. I have proposed already more than two decades ago that strange cosmic ray events such as Centauros generate hot spot involving M_{89} hadrons. At LHC quite a number of bumps with masses obtained by scaling from the masses of mesons of ordinary hadron physics are observed. I have proposed that they are associated with quantum critically assignable to a phase transition analogous to the generation of quark gluon plasma, and are dark in TGD sense having $h_{eff}/h = 512$ so that their Compton wavelengths are same as for ordinary hadrons [K2].

4. The free path of (possibly) dark $M_{G,47}$ proton in ordinary matter should be a considerable fraction of the Earth's radius since the process of tau regeneration based on standard physics cannot explain the findings. The interaction with ordinary matter possibly involving the transformation of the dark proton to ordinary one (or vice versa!) must be induced by the presence of ordinary matter rather than being spontaneous.

   Also the flux of cosmic ray protons at EeV energies must be high enough. It is known that UHE cosmic rays very probably are not gamma rays. Besides neutrinos dark $M_{G,47}$ protons would be a natural candidate for them.

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