Reactor antineutrino anomaly as indication for new nuclear physics predicted by TGD

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The motivation for this short note was a highly interesting new neutrino anomaly. The anomaly appears in two experiments and is referred to as reactor antineutrino anomaly. There is a popular article Symmetry Magazine (see http://tinyurl.com/jaqrmdx) about the discovery of the anomaly in Daya Bay experiment [C3] (see http://tinyurl.com/z7b63ua). Bee mentioned in Backreaction blog (see http://arxiv.org/pdf/1511.05849v2.pdf) Reno expriment [C2] exhibiting the same anomaly. What happens that more antineutrinos with energies around 5 MeV are produced as should: the anomaly seems to extend to antineutrino energy about 6.3 MeV.

What makes me happy is that this anomaly might provide a new evidence for TGD based model of atomic nuclei.

1. In nuclear string model [K2]) nucleons are assumed to be bonded to nuclear strings by color magnetic flux tubes with quarks at ends. These nuclear quarks are different from hadronic quarks and can have different p-adic mass scales. Nuclear d quark is expected to be heavier than nuclear d quark and can decay to nuclear u quark by emission of a virtual$W$ boson decaying to electron antineutrino pair. These decays are anomalous from the point of view of standard nuclear physics.

2. The virtual W boson decaying to electron antineutrino pair in the anomalous region around 5 MeV should have energy which is two times neutrino energy since electron is relativistic. Since the upper boundary of anomalous region corresponds to about 6.3 MeV antineutrino energy, W energy should be below d-u mass difference, which must be therefore around 12.6 MeV . This is a highly valuable bit of information.

To proceed one can use p-adic mass calculations.

1. The topological mixing of quark generations (characterized by handle number for partonic two surfaces) must make u and d quark masses almost but quite not identical in the lowest p-adic order. In the model for CKM mixing of hadronic quarks they would be identical in this order.

2. p-Adic mass squared can be expressed as $m^2(q)/m(e)^2 = 2^{(k-127)/2}(s(q) + X(q))/(s(e) + X(e))$, where s is positive integer and and $X < 1$ is a parameter characterizing the poorly known second order contribution in p-adic mass calculations. For topologically unmixed u and d quarks one has $s(d) = 8$ and $s(u) = 5 = s(e)$. $p =\simeq 2^k$ characterizes the p-adic scale of quark (for p-adic mass calculations see [K1]).

Assume first that there is no breaking of isospin symmetry so that the p-adic mass scales of u and d type nuclear quarks are same.

1. By using the information about the mass difference $m(d) - m(u) \leq 12.3$ MeV and the above p-adic mass squared formula one can estimate the common p-adic mass scale of the nuclear quarks to be k=113. This is nothing but the p-adic mass scale assigned with nuclei and corresponds to Gaussian Mersenne $M_{G,113} = (1 + i)^{113} - 1$. Looks very natural!

2. The maximal value 6.3 MeV for mass difference would be obtained for $s(d) = 8$ and $s(u) = 7$ and $X(e) = X(u) = X(d) = 0$ one obtains mass $m(d) - m(u) = 5.49$ MeV. Interestingly, figure 2 of the Reno article(see `http://arxiv.org/pdf/1511.05849v2.pdf`) shows a sharp downwards shoulder at 5.5 MeV.

   $m(d) - m(u) = 6.3$ MeV can be reproduced accurately for $X(d)/8^{1/2} - X(u)/7^{1/2} \simeq .01$. There are several manners to reproduce the estimate for d-u mass difference by varying second order contributions. Mixing with higher quark generations would occur for both u quark. The mass of nuclear u (d) quark would be $(s(q)/5)^{1/2} \times 64$ MeV, $s(u) = 7$ ($s(d) = 8$) for $m(d) - m(u) = 5.5$ MeV. This mass is assumed to include the color magnetic energy of the color magnetic body of quark and would correspond to constituent quark mass rather than current quark mass, which is rather small.

   What is interesting that the sum of the u and d quark masses $m(d) + m(u) = 144.95$ MeV in absence of topological mixing is about 4 per cent larger than the charged pion mass $m(\pi^+) = 139.57$ MeV. In any case, it is difficult to see how this large additional mass could be compensated.

In an alternative scenario, which is in accordance with the original picture, the isospin symmetry would be broken in the sense that p-adic mass scales of u and d would be different so that the mass difference would corresponds to the mass scale of (say) d quark and could be much smaller.

1. For $k(d) = 119$, $s(d) = 10$ (small topological mixing) and $s(u) = 5$, $k(u) = 127$ (say) one would have $m(d) - m(u) = 10.8$ MeV so that neutrino energy would be below 5.4 MeV, which is near to the steep shoulder. One would have $m(d) = 11.3$ MeV and $m(u) = .5$ MeV (electron mass) in absence of topological mixing. Now $k(d) = 119$ is however not prime as the strongest form of p-adic length scale hypothesis would demands. $k(u) = 127$ is only the first guess. Also $k(u) = 137$corresponding to atomic length scale can be considered.

2. The accepted values for hadronic current quark masses deduced from lattice calculations are about m(u)=2 MeV for m(d)=5 MeV and smaller than the values deduced above suggesting the interpretation of the masses estimate above as nuclear constituent quark masses.

3. Beta stable configurations would correspond to $u\overline{u}$ bonds with total energy about $2m(e) = 1$ MeV, which is consistent with the general view about nuclear binding energy scale. Also exotic nuclear excitations containing charged color bonds with quark or antiquark or both transformed to d type state are predicted. The first guess for the excitation energy of charged color bond is $m(d) - m(u) \simeq 10.8$ MeV. Each charged color bond increases the nuclear charge by one unit but proton and neutron numbers remain the same as for the original nucleus: I have called these states exotic nuclei [K2].

4. The so called leptohadron hypothesis [K3] postulates color excitations of leptons having as bound states leptopions with mass equal to $2m(e)$ in good approximation. An alternative option would replace colored leptons with quarks and assumes that unmixed u quark has electron mass and their production in heavy ion collisions would be natural if they appear as color bonds between nucleons. This would fix $s(u)$ to $s(u) = 5$ (no topological mixing).

5. X rays from Sun have anomalous effects on the observed nuclear decay rate with a periodicity of year and with magnitude varying like inverse of the distance from the Sun with which also solar X ray intensity varies [C1] (see `http://tinyurl.com/y8ponx6`): this is known as GSI anomaly. I have proposed earlier that the energy scale of the excitations of nuclear color bonds is 1-10 keV on basis of these findings [K2]. Nuclei could be in exited states with excitation energies in 1-10 keV range and the X ray radiation would affect the fraction of excited states thus changing also the average decay rates.

   One can try to understand the keV energy scale to the 1 MeV energy scale of beta stable color bonds in terms of fractal scaling. Above it was found that for $k = 113$ charged color bond would have energy $m(d) + m(u) = 144.95$ MeV if quarks are free. Since the actual charged pion mass is $m(\pi^+) = 139.57$ MeV, the pionic binding energy would be 5.38 MeV which makes about 3.7 per cent of the total mass. If one applies same fractal logic to the $k = 127$ color bond with $2m(u) = 1$ MeV, one obtains 37 keV, which has somewhat too high value. The Coulombic interaction is attractive between u and $\overline{u}$ in $k = 127$ pion with broken isospin symmetry. The naive perturbative estimate is as $\alpha/m_e \simeq 3.6$ keV reducing the estimate to 34.4 keV. The fact that π^+ has positive Coulombic interaction energy reduces the estimate further but this need not be enough.

For $k(u) = 137$ (atomic length scale) one would obtain binding energy scale, which is by factor 1/32 lower and about 1.2 keV. The simplest model for color bond would be as harmonic oscillator predicting multiples of 1.2 keV as excitation energies. This would conform with the earlier suggestion that color magnetic flux tubes are loops with size of even atom. This cold also explain the finding that the charge radius of proton is not quite what it is expected to be.

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