The asymmetry of antimatter in proton from TGD point of view

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Abstract

1 Introduction

I encountered a highly interesting popular article *"Decades-Long Experiment Finds Strange Mix of Antimatter in The Heart of Every Proton"* (https://cutt.ly/BlZtNne).

The popular article tells about the article " *The asymmetry of antimatter in the proton*" of Dove et al [C1] published in Nature (https://cutt.ly/BlZt8sV). This article is behind the paywall but the same issue of Nature has an additional article "*Antimatter in the proton is more down than up*" [C2] (https://cutt.ly/blZyT4u) explaining the finding.

What is found is an asymmetry for u and antiquarks in the sense that there are slightly more d-type antiquarks (anti-d) than u type antiquarks (anti-u) in quark sea. This asymmetry does not seem to depend on the longitudinal momentum fraction of the antiquark: the ratio of anti-down and anti-up distribution functions is smaller than one and constant.

A model assuming that proton is part of time in a state consisting of neutron and virtual pion seems to fit at qualitative level into the picture. Unfortunately, the old-fashioned strong interaction theory based on nuclei and pions does not converge by the quite too large value of proton pion coupling constant.

I looked at the situation in more detail and developed a simple TGD based model based on the already existing picture developed by taking seriously the so called X boson as 17.5 MeV particle and the empirical evidence for scaled down variants of pion predicted by TGD [L2]. What TGD can give is the replacement of virtual mesons with real on mass shell mesons but with p-adically scaled down mass and a concrete topological description of strong interactions at the hadronic and nuclear level in terms of reconnections of flux tubes.

2 TGD inspired model for the asymmetry

2.1 Basic data about quark and nucleon masses

To get a quantitative grasp about the situation, one can first see what is known about masses of u and d quarks.

1. One estimate for u and d quark masses (one must taken the proposals very cautiously) can be found (`https://cutt.ly/dlZukKC`).

   The mass ranges are for u 1.7-3.3 MeV and and for d 4.1-5.8 MeV.

2. In the first approximation n-p mass difference 1.3 MeV would be just d-u mass difference varying in the range 1.2 MeV-4.1 MeV and has a correct sign and a correct order of magnitude. 4.1 MeV for d and 3.3 MeV for u would produce the n-p mass difference correctly.

3. Coulomb interactions give a contribution E_c, which is vanishing por proton and and negative for neutron

$$E_c(p) = 0 \ , \quad E_c(n) = -\alpha \times \hbar/3R_e \ .$$

   R_e is proton's electromagnetic scale.

   This contribution reduces neutron mass. If R_e is taken to be proton Compton radius this gives about $E_c \simeq -3.2$ MeV. This would predict mass n-p difference in the range -1.1-0.9 MeV. This favors maximal n-p mass difference 4.1 MeV and m(u)= 1.7 MeV and md =5.8 MeV: d-u mass difference would be 4.1 MeV roughly 4 times electron mass.

2.2 TGD based picture about hadronic an nuclear interactions

Consider first the TGD inspired topological model for hadronic an nuclear interactions implicitly contained in the model of nuclei as nuclear strings [K2] further developed in applications to "cold fusion" [L1, L3, L6] and by using input from the anomaly assignable to the nuclear physics of solar core [L5, L4].

1. The notion of magnetic body (MB) assignable to color and em and electroweak interactions is essential. The interactions are described by virtual particle exchanges in quantum field theory (QFT). In TGD they are described by reconnections of U-shaped flux tubes which are like tentacles.

   In interaction these tentacles reconnect and give rise to a pair of flux tubes connecting the particles. The flux tubes would carry monopole flux so that single flux tube cannot be split. These flux tube pairs serve also as correlates of entanglement replacing wormholes as their correlates in ER-EPR picture.

   This picture looks rather biological and was developed first as a model of bio-catalysis [L7] [K1]: reconnections of U-shaped tentacles would make possible for reactants to find each other and their shortening in phase transitions reducing h_{eff} would bring them near to each other. The picture should apply quite generally to short range interactions at least.

2. The U-shaped flux tubes of color MB replace virtual pion and and ρ meson exchanges in the old fashioned picture about strong interactions. They represent in TGD framework real particles but with p-adically scaled down mass. For instance, pions are predicted to have scaled down variants with masses different by a negative power of 2 from pion mass. Same is true for rho. Now the masses would be below MeV range, which is the energy scale of nuclear strong interactions. Also nuclear strong interactions would occur in this manner [K2] [L5].

2.3 A model for the anti-quark asymmetry

Consider now a model anti-quark asymmetry for sea quarks.

1. Quarks and antiquarks would appear at these flux tubes. The natural first guess is that meson like states are in question.

   The generation of u-anti-d type pion or ρ would transform proton to neutron if the valence u transforms to valence d and W boson with scaled down mass.

   Note that the scaling down would make weak interaction stronger since weak boson exchange amplitude is proportional to $1/m_W^2$ and scaled by up by a factor of order 10^{10} if m_W has mass in MeV range.

This would give the analog of neuron plus charge virtual pion. Taking two sea quarks would lead to trouble with the too large Coulomb interaction energy about -10 MeV of negatively charged sea with positively charged valence part of proton if the sea is of the same size as proton.

2. Does the scaled down W^+ decay to u-anti-d forming a scaled down meson π^+ or ρ^+? Or should one regard u-anti-d as a scaled down W^+ having also the spin zero state analogous to pion since it is massive?

3. Here comes a connection with old-fashioned and long ago forgotten hadron physics. Thep-artially conserved axial current hypothesis (PCAC) gives a connection between strong and weak interactions forgotten when QCD emerged as the final theory. PCAC says that the divergence of axial weak currents associated with weak bosons are proportional to pions.

   Are the two pictures more or less equivalent? Virtual pion exchange could be regarded as a weak interaction! Also conserved vector current hypothesis (CVC) is part of this picture. This is not new: I have developed this picture earlier in an attempt to understand what the reported X boson with 17.5 MeV mass is in the TGD framework. Scaled down pion would be in question [L2].

4. What about the masses of quarks and proton? Since the flux loop would have considerably greater size than proton, the mass scale of u-anti-d state would be smaller than say MeV, and the contribution to mass of proton would be small.

5. Why the asymmetry for anti-quarks of sea? The generation u-anti-d loop would increase the charge of the core region by two 2 units and transform it to Δ. This looks neither plausible nor probable. Proton would be a superposition consisting mostly of the proton of good old QCD and neutron plus flux loop with quantum numbers of a scaled down pion.

6. Also the presence of scaled down ρ meson loops can be considered. Their presence would turn the spin of the core part of the proton opposite for some fraction of time. One can wonder whether this could relate to the spin puzzle of proton.

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