Non-Uniform Pion Tetrahedron Aether and Electron Tetrahedron Model

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Abstract: We propose that the QCD vacuum pion tetrahedron condensate density may vary in space and drop to extremely low values in the Kennan, Barger and Cowie (KBC) void in analogy to earth's atmospheric density drop with elevation from earth. We propose a formula for the gravitation acceleration based on the non-uniform pion tetrahedron condensate. The MOND acceleration limit may be due to the extremely low pion tetrahedron condensate density at the galaxies' edges. Gravity may be due to the underlying microscopic attraction between quarks and antiquarks, which are part of the vacuum pion tetrahedron condensate. We propose an electron tetrahedron model, where electrons are comprised of tetraquark tetrahedrons, $d\tilde{u}\tilde{d}d$ and $d\tilde{u}\tilde{u}u$. The $d\tilde{u}$ quarks determine the charge and the $\tilde{d}d$ or $\tilde{u}u$ quarks determine the spin state. The electron tetrahedron and the pion tetrahedron condensate may perform high frequency quark exchange reactions by tunneling through the condensation gap and form a delocalized electron cloud with a fixed spin state. The pion tetrahedron may act as a "QCD glue" bonding electron pairs and protons and neutrons in the nuclei with opposite spins. The central roles of antimatter and the non-uniform pion tetrahedron Aether were not anticipated by general relativity and quantum mechanics and are not fully understood still.

Keywords: Standard Model (SM), QCD vacuum condensate, electric dipole moment (EDM), KBC Void, Antimatter, MOND Theory, Aether, Superfluid and Pion tetrahedron condensate.

1. Non-Uniform Universe – the KBC Giant Voids

Kennan, Barger and Cowie (KBC)[1] found that galaxy counts and measurements of the luminosity density in the near infrared indicate the possibility that the local universe may be under-dense on scales of several hundred megaparsecs. The presence of a largescale under-density in the local universe could introduce significant biases into the interpretation of cosmological observables and into the inferred effects of dark energy on the expansion rate.

According to Banik[2,3], we live in a giant void in space, an area with below average density that could inflate local measurements through outflows of matter from the void. Outflows would arise when denser regions surrounding a void pull it apart – they'd exert a bigger gravitational pull than the lower density matter inside the void. We are near the center of a huge void about a billion light years in radius and with density about 20% below the average for the universe. The Cosmic Microwave Background (CMB) suggests that matter should be uniformly spread out. However, directly counting the number of galaxies in different regions suggests that we are in a local void contradicting the CMB uniform and isotropic universe. Such a huge deep void was not expected in the standard model and is controversial. If the universe is not uniform and isotropic, what about its underlying QCD vacuum quark condensate, can it also be non-uniform?

2. QCD Vacuum Quark Condensate

Brodsky et al[4,5] presented a new perspective on the nature of quark and gluon condensates in quantum chromodynamics where the QCD condensates are restricted to the interiors of hadrons. According to Brodsky these condensates arise due to the interactions of confined quarks and gluons leaving the external QCD vacuum empty, devoid of vacuum condensates that fill space-time. Lee[6] argues in favor of the non-vanishing QCD vacuum quark condensate and refutes the notion of Brodsky in-hadron only quark and gluon condensates. Halle et al presented equations that reveal effects of modified gravity and dark matter with a non-uniform dark energy fluid[7].

Buballa and Carignano studied an inhomogeneous chiral condensate, which is constant in vacuum and may become spatially modulated at moderately high densities where in the traditional picture of the QCD phase diagram a first-order chiral phase transition occurs[8].

We propose that the QCD vacuum pion tetrahedron condensate[9] density in space is non-uniform and should drop in the KBC giant voids in analogy to earth's atmospheric density drop[10]. We propose to calculate the gravitation acceleration from the non-uniform pion tetrahedron condensate density variation. In the extreme MOND limit at the galaxies' edges with r > $\lambda,$ the gravitational acceleration is stronger and given by $\frac{GM}{\lambda r}$ [11] and not $\frac{GM}{r^2}$.

3. Non-Uniform Pion Tetrahedron Condensate

In 1983 Milgrom proposed the Modified Newtonian Dynamics theory, MOND[12-15], explaining the observed rotational curves of galaxies without adding dark matter, which Kroupa et al suggest does not exist[16]. MOND is a phenomenological theory and does not provide a microscopic mechanism explaining the crossover to the extremely low accelerations limit far from the galaxy center. Milgrom proposed a new acceleration constant $a_0 = 1.2 * 10^{-10}$ cm/sec^2 that fits well the observed galaxy rotation curves. The MOND gravitational force and acceleration in the MOND limit where a << a_0 is -

$$F = m\,\frac{a^2}{a_0} \qquad (1)$$

In a previous paper[9] we assumed that the QCD vacuum pion tetrahedron condensate drops like the atmospheric density due to gravity as shown in the figure 1 on the left hand side. We proposed that similar to ideal gas kinetic theory, the pressure difference on a virtual box top and bottom surfaces that contains an infitisimal volume of the pion tetrahedron condensate is due to the difference in the number of collisions at the top and the bottom surfaces due to the non-uniform pion tetrahedron condensate density induced by a massive stars, where M is the star mass, r is the distance to the star, and ρ is the pion tetrahedron condensate density. A and dr are the surface area and height of the virtual integration box -

$$p_{up}A - p_{bottom}A = -\frac{\rho A dh GM}{r^2} \tag{3}$$

Assuming an ideal gas state equation ($PV = nk_BT$) for the pion tetrahedron condensate ρ with particle mass m_π–

$$\rho = \frac{m_\pi n}{V} = \frac{m_\pi p}{k_B T} \tag{4}$$

The differential equation for the non-uniform condensate pressure is -

$$\frac{dp}{p} = -\frac{G\, m_\pi M}{k_B T\, r^2}\, dr \tag{5}$$

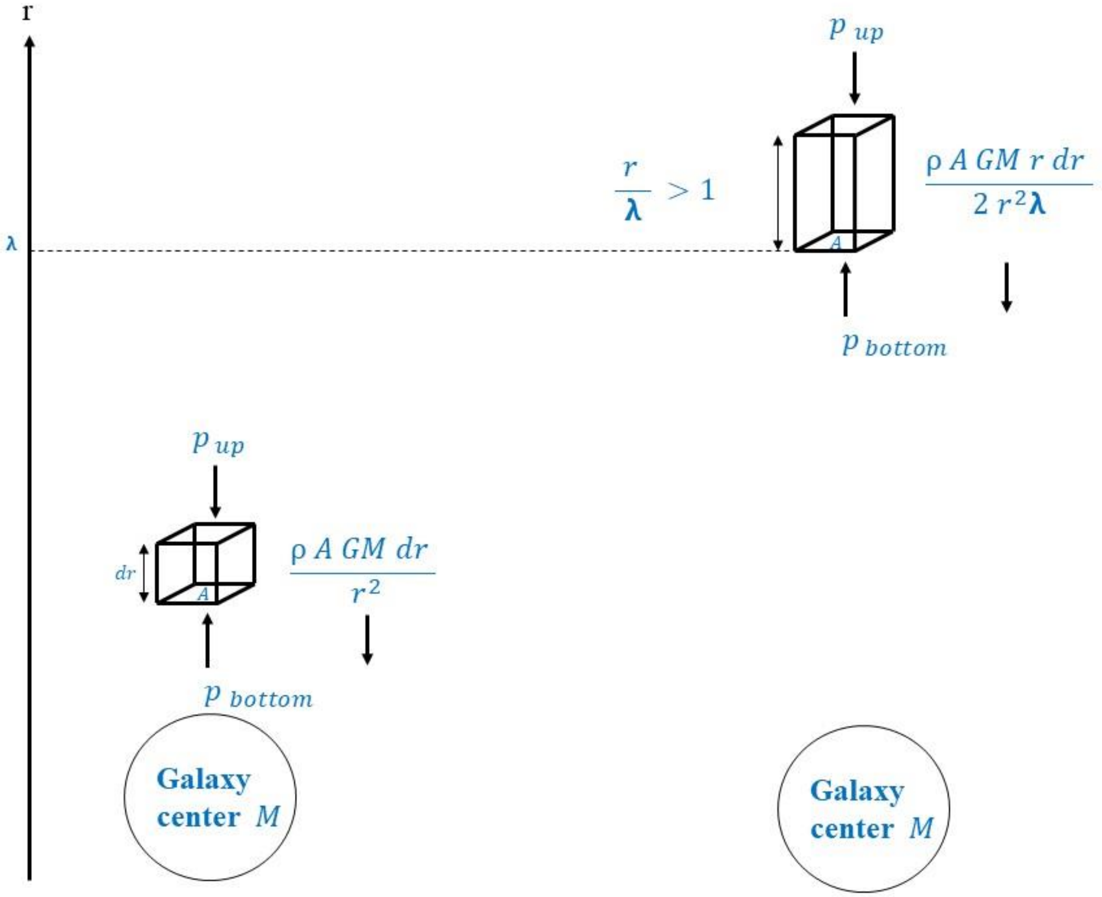

Figure 1 illustrates on the left-hand-side the pressure difference on a virtual box of area A and height dr that contains the pion tetrahedron condensate close to the galaxy center and on the right-hand-side, the box height element dr is stretched by the term r/**λ** > 1 at the MOND limit.

We can rewrite equation 5 as

$$\frac{1}{p}\frac{dp}{dr} = -\frac{G\, m_{\pi} M}{k_B T\, r^2} \qquad (6)$$

The gravitational acceleration applied on a mass m inside the virtual box of figure 1 above due to the non-uniform pion tetrahedron condensate density is-

$$g_N = -\frac{k_B T}{m_{\pi}}\, \frac{1}{p}\, \frac{dp}{dr} = \frac{GM}{r^2} \qquad (7)$$

We propose below that particles are attracted to their antimatter particles and since the antimatter density at the bottom of the virtual box is higher than at its top (as part of the pion tetrahedron density), particles will have more frequent exchange reactions with pion tetrahedron condensate at the bottom and will move downwards.

However, far from the galaxy center with the MOND acceleration limit, a << a_0, the pion tetrahedron condensate is extremely diluted and we propose to scale up the virtual box height with the term $\frac{r}{\lambda}$ > 1 to allow more collisions to occur in the diluted virtual box. In the MOND limit, the antimatter density difference between the upper and lower virtual integration box surfaces is extremely low. Particles that will move downwards will increase the chiral entropy of the pion tetrahedron condensate since they will have more collisions that will increase the frequency of flipping the chirality of the pion tetrahedron condensate. The differential equation for the non-uniform condensate pressure (equation 5 above) with the scaling term $\frac{r}{\lambda}$ is -

$$\frac{1}{p}\frac{dp}{dr} = -\frac{G m_{\pi} M}{k_B T\, r^2}\left(\frac{r}{\lambda}\right) \qquad (8)$$

The gravitational acceleration (equation 7 above) in the MOND limit is-

$$g_{MOND} = -\frac{k_B T}{m_\pi}\frac{1}{p}\frac{dp}{dr} = \frac{GM}{\lambda r} \qquad (9)$$

Hence, the acceleration far from the galaxy center, at r >> λ where $g \ll a_0$, is $\frac{GM}{\lambda r}$ and not the Newtonian acceleration $\frac{GM}{r^2}$ with $\lambda = \sqrt{\frac{MG}{a_0}}$ -

$$g_{MOND} = \frac{GM}{\lambda r} = \frac{\sqrt{GMa_0}}{r} \qquad (10)$$

The MOND gravitational acceleration at the galaxy edge is extremely small but will be larger than the Newtonian gravitation acceleration if r >> λ. For the milky-way mass, $\lambda = 51.5$ parsecs and the galaxy radius is about 16 parsecs so the MOND limit is not reached.

4. Pion Tetrahedron Condensate Kinetics

In previous papers we proposed that hadron quarks perform quark exchange reactions with the pion tetrahedrons[9-10,17-20]. The pion tetrahedrons collide with each other like in the ideal gas model as shown in figure 2 below. The gluons exchanges may flip the quark flavor from d to u and vice versa.

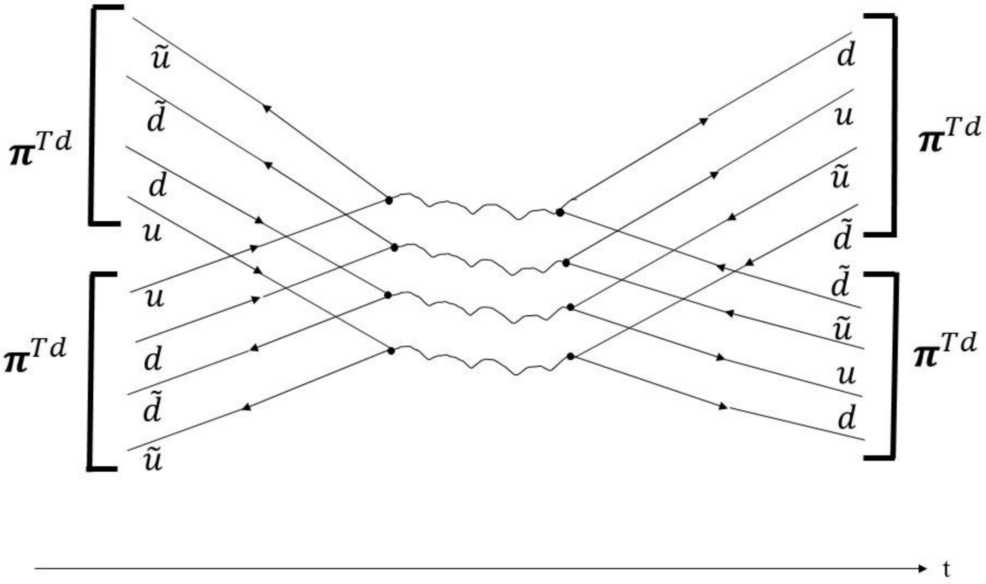

Figure 2 illustrates scattering of two pion tetrahedrons.

Baryonic particles, a neutron or a proton for example, may interact with the pion tetrahedron condensate via tunneling. For example, a hot d and u quarks of an accelerated neutron (dud) or accelerated proton (uud) can be exchanged with a cold d and u quarks of a pion tetrahedron via gluons as shown in equations 11a and 11b and the Feynman diagram below. The two antiquarks of the pion tetrahedrons $\tilde{d}$ *and* $\tilde{u}$ are the active reagents that trigger the exchange reactions as shown in the Feynman diagrams below -

$$dud + u\tilde{d}d\tilde{u} \rightarrow ddu + u\tilde{d}d\tilde{u} \tag{11a}$$

$$uud + u\tilde{d}d\tilde{u} \rightarrow udu + u\tilde{d}d\tilde{u} \tag{11b}$$

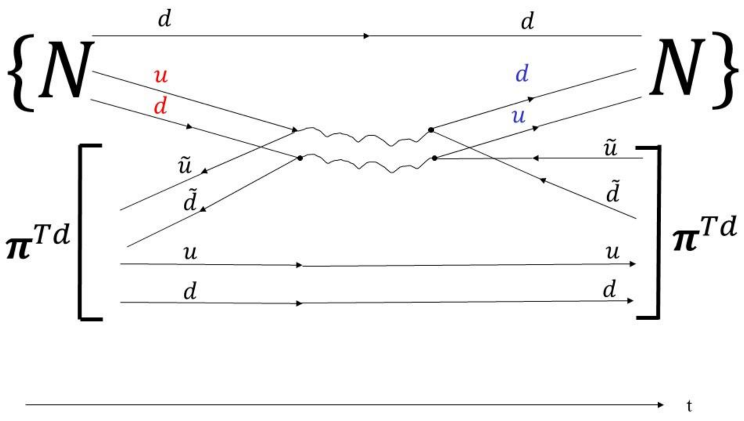

Figure 3 illustrates quarks exchange reaction of a neutron and a pion tetrahedron where the antiquarks $\tilde{d}$ *and* $\widetilde{u}$ are the reagents that drive the exchange reactions via gluons.

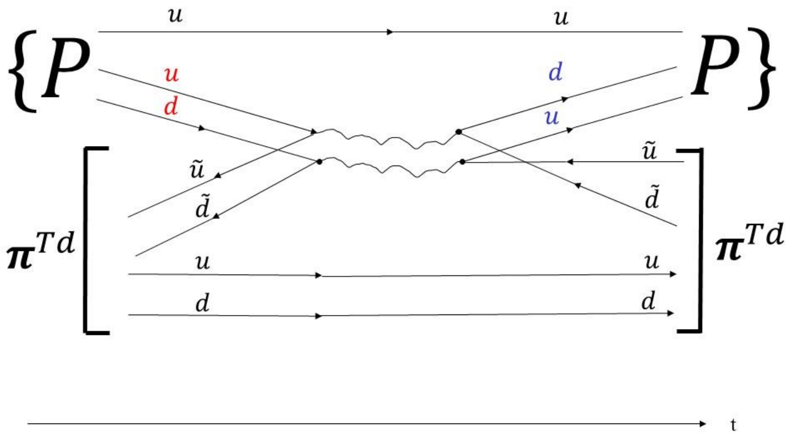

Figure 4 illustrates quarks exchange reaction of a proton and a pion tetrahedron where the antiquarks $\tilde{d}$ *and* $\widetilde{u}$ are the reagents that drive the exchange reactions via gluons.

Feynman diagrams are used to describe high energy scattering events where momentum and energy is transferred in high energy particle colliders. However, we propose here that the quark exchange reactions described above with the pion tetrahedron condensate occur at low energies via tunneling and contribute to the binding energy of the protons and neutrons that are surrounded by a cloud of pion tetrahedrons. In a previous paper we used a double well potential model to describe the binding between a neutron and a proton in a deuterium nucleus[10] and here we propose that the double well potential model may be also used for protons and neutrons surrounded by pion tetrahedron cloud. Accordingly, equation 11a and 11b may be seen as dynamic equilibrium equations for tunneling reactions in a double well symmetric potentials and the barrier heights may be proportional to the condensation energy gap **Δ**.

$$dud + u\tilde{d}d\widetilde{u} \rightleftarrows ddu + u\tilde{d}d\widetilde{u} \qquad (12a)$$

$$uud + u\tilde{d}d\widetilde{u} \rightleftarrows udu + u\tilde{d}d\widetilde{u} \qquad (12b)$$

5. Source of Gravity

We hypothesize that the source of gravity is the microscopic attraction of antimatter to matter, e.g. the underlying attraction of antiquarks and quarks mediated by the vacuum condensate pion tetrahedrons. The protons and neutrons' quarks attract the vacuum pion tetrahedrons antiquarks and create clouds of pion tetrahedrons around them with a density drop similar to the atmospheric density drop. The protons and neutrons perform high frequency quark and antiquark exchange reactions with the pion tetrahedrons described by equation 12a and 12b via tunneling through the gap barrier **Δ**. The protons and neutrons quarks are attracted to the antimatter densities of neighboring particles' clouds as shown in the figure 5 below. The source for gravity is than the attraction between quarks and antiquarks and the pion tetrahedron atmospheric like pressure drop around a massive body.

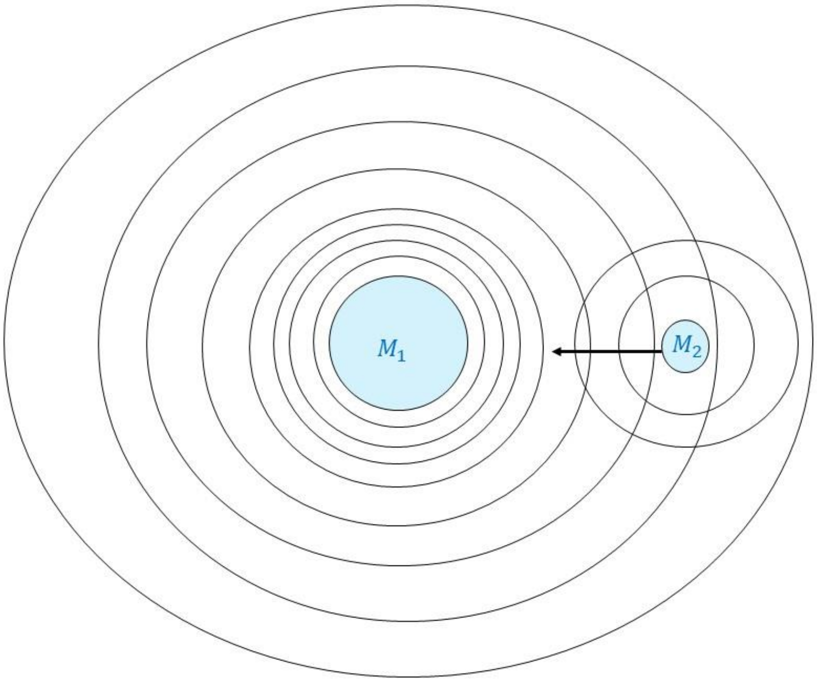

Figure 5 illustrates the pion tetrahedron densities around two masses, M1 >> M2. Since M1 attracts higher density of pion tetrahedrons, M2 will be attracted to it and will fall inwards in the direction of increasing pion tetrahedron density.

We propose to calculate the non-uniform pion tetrahedron condensate pressure based on an ideal gas kinetics where the pion tetrahedrons gravitate and collide with each other in the field of a massive body. Then, based on the pion tetrahedron condensate pressure, a formula for the gravitational acceleration is proposed (see equations 7 and 9). The pion tetrahedron density far from galaxy clusters may be extremely reduced in the KBC giant voids and may reach the MOND acceleration limit.

We assumed an ideal gas equation for the pion tetrahedrons in equation 4, however, the pion tetrahedron condensate is not an ideal gas. We assume that it can perform quark exchange reactions with matter particles and hence is reactive and it probably be better described for example by Sinha et al invisible superfluid fermion and antifermions Aether[21]. We proposed that the pion tetrahedrons are comprised of two light valence quarks and antiquarks, hence, antiquarks fill space in huge quantities and they have a central role in physics.

Migdal studied π condensation in nuclear matter and suggested that neutral and charged pions condense to superfluid in neutron stars[22]. Sinha et al invisible superfluid Aether[21] pervades the entire universe and may account for the missing matter. Sinha et al assumed that the density of visible matter in the universe is about 2* $10^{-31}\ \frac{gram}{cm^3}$ where the density of the invisible superfluid Aether is much higher and is on the order of $10^{-29}\ \frac{gram}{cm^3}$. The pion tetrahedron condensate may be the invisible superfluid Aether that may account for the missing matter with no need to add new dark matter particles and its density may be related to Einstein's equation cosmological constant Λ. However, Sinha's superfluid Aether model did not specify explicitly if its density may be non-uniform, $\Lambda(\vec{x})$, and did not specify the attraction mechanism between pairs that triggers the condensation and creates the energy gap.

6. Electron Tetrahedron Model and the "QCD Glue"

According to the Standard Model (SM), the electron is an elementary, point-like, spin-half fermion. The SM Electric Dipole Moment (EDM) is related to CP violation and is expected to be extremely small below experimental sensitivity[23], $d < \ 10^{-34}\ \ e\ cm,$ based on Czarnecki and Krause three-loop calculation of the EDM of the u and d quarks.[24] If the electron has an internal structure, beyond the SM, its EDM will be larger. We propose an electron tetrahedron model, where the electron is comprised of tetraquarks, $d\tilde{u}\tilde{d}d$ and $d\tilde{u}\tilde{u}u$. We assume that the $d\tilde{u}$ quarks determine the charge and the $\tilde{d}d$ or $\tilde{u}u$ quarks determine the electron spin. The positron two spin state tetraquarks may be $u\tilde{d}\tilde{d}d$ and $u\tilde{d}\tilde{u}u$. Dirac electron is represented by a four component Spinor wavefunction, $\widehat{\Psi}\ (\vec{x})$, that included the electron spin and the two chiral symmetry Weyl spinors[25], however, it is not clear how four quarks can be combined to give a spin-half electron. The tetrahedral group symmetry may allow such four spins combination, however, the proposed electron tetrahedron model gives the following interesting results:

(a) High-frequency quark exchange reactions may transform electron tetrahedrons to pion tetrahedrons and vice versa by tunneling through the vacuum condensation gap as shown in figure 6 with the exchange of only a single quark flavor.

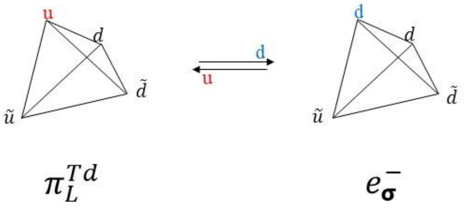

Figure 6 illustrates an electron and a pion tetrahedron models where a single quark flavor is changed (u and d).

(b) An electron and the pion tetrahedrons condensate may form a delocalized electron cloud with a determined spin state **σ**, or -**σ**, described by equations 13a and 13b and illustrated in figure 7.

$$d\widetilde{u}\, d\tilde{d}(e_\sigma^-) + d\widetilde{u}\, u\tilde{d}\,(\pi^{Td}) \rightleftarrows d\widetilde{u}\, u\tilde{d}\,(\pi^{Td}) + d\widetilde{u}\, d\tilde{d}\,(e_\sigma^-) \qquad (13a)$$

$$d\widetilde{u}\, u\tilde{u}(e_{-\sigma}^-) + d\widetilde{u}\, u\tilde{d}\,(\pi^{Td}) \rightleftarrows d\widetilde{u}\, u\tilde{d}\,(\pi^{Td}) + d\widetilde{u}\, u\tilde{u}\,(e_{-\sigma}^-) \qquad (13b)$$

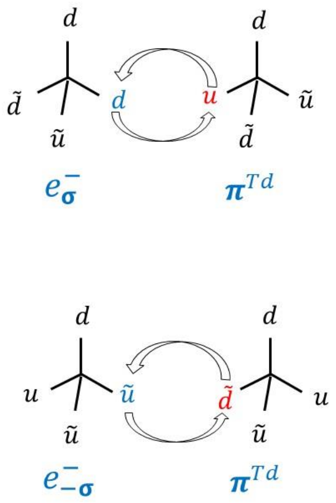

Figure 7 illustrates the quark exchange reaction between electrons and pion tetrahedrons with the two spin states **σ** or **-σ** that form delocalize electron clouds.

(c) Two electrons with opposite spin states may form a **pion tetrahedron QCD bond** where the pion tetrahedron, $u\tilde{u}d\tilde{d}$, acts as a "QCD glue".

$$d\widetilde{u}\, d\tilde{d}(e^-_\sigma) + d\widetilde{u}\, u\tilde{u}\,(e^-_{-\sigma}) \rightleftarrows d\tilde{u}\, u\tilde{u}d\tilde{d}\, d\widetilde{u} \tag{14}$$

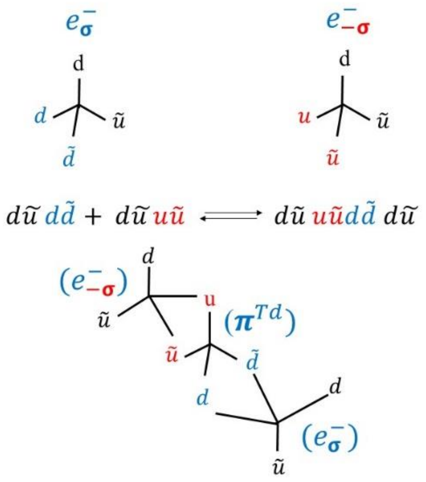

Figure 8 illustrates the pion tetrahedron bond between two electrons with opposite spins mediated by a pion tetrahedron "QCD glue".

(d) electrons and positrons annihilation may create two pion tetrahedrons that join the vacuum pion tetrahedron condensate.

$$d\widetilde{u}\,d\tilde{d}(e^{-}_{\sigma}) \;+\; u\widetilde{d}\,u\tilde{u}(e^{+}_{-\sigma}) \quad \rightleftarrows \quad 2\;\, d\tilde{u}u\tilde{d} \tag{15}$$

However, if the electron and positron have the same spin state, the result are more energetic $d\widetilde{d}\,d\tilde{d}$ or a $u\widetilde{u}\,u\tilde{u}$ tetraquark combinations that will decay fast to two $\boldsymbol{\gamma}$ rays that propagate in the underlying pion tetrahedron condensate.

$$d\widetilde{u}\,d\tilde{d}(e^{-}_{\sigma}) \;+\; u\widetilde{d}\,d\tilde{d}(e^{+}_{\sigma}) \quad \rightleftarrows \; d\tilde{u}u\tilde{d} \;+\; d\widetilde{d}\,d\tilde{d} \tag{16a}$$

$$d\widetilde{u}\,u\tilde{u}(e^{-}_{-\sigma}) + \; u\widetilde{d}\,u\tilde{u}\;(e^{+}_{-\sigma}) \;\rightleftarrows d\tilde{u}u\tilde{d} \;+\; u\widetilde{u}\,u\tilde{u} \tag{16b}$$

(e) The protons and neutrons two spin states may also be determined by the $\tilde{d}d$ or $\tilde{u}u$ quarks. Protons and neutrons may be pentaquarks and may also form a **pion tetrahedron bond** in the deuterium nuclei for example[10] as shown in equation 17 and illustrated below in figure 9 –

$$uud\tilde{d}d(P_{\sigma}) + udd\tilde{u}u(N_{-\sigma}) \rightarrow \; udd(N_{-\sigma})u\tilde{d}d\widetilde{u}\,uud(P_{\sigma}) \tag{17}$$

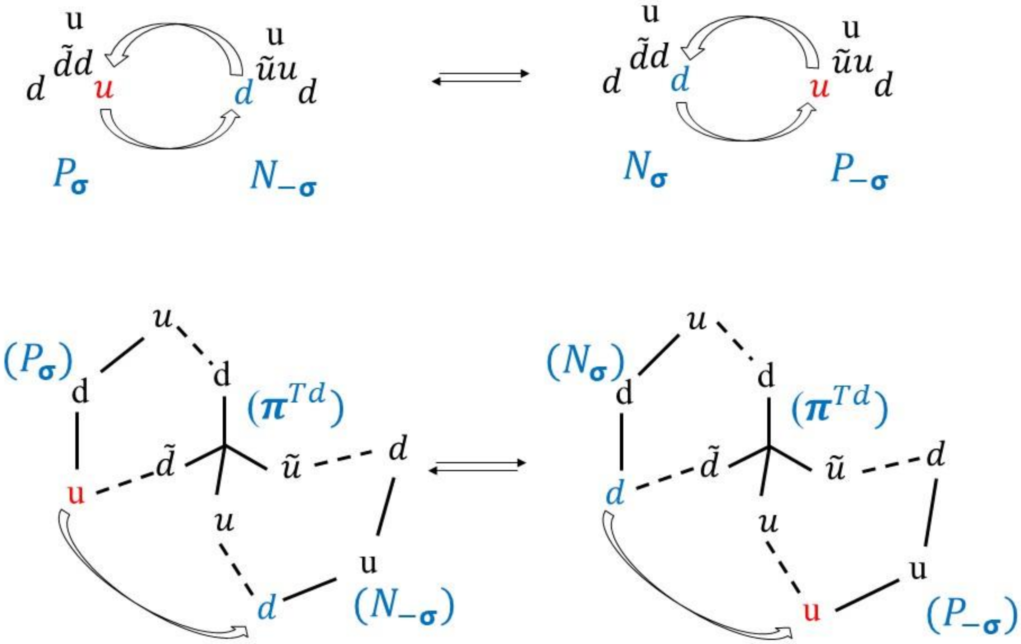

Figure 9 illustrates a proton and a neutron as pentaquarks with two spin states determined by the $\tilde{d}d$ or $\tilde{u}u$ quarks performing quark exchange that transform a proton to a neutron and vice versa on the top and where the $\tilde{d}d$ and $\tilde{u}u$ quarks may form a pion tetrahedron “QCD glue” tetraquark $\tilde{d}d\tilde{u}u$ as shown in the bottom that may represent a deuterium nuclei.

Nature seems to duplicate its tricks. The difference between a proton and a neutron is a single quark flavor exchange, a d flavor quark in a neutron is replaced by a u flavor quark in a proton. Similarly in the proposed electron tetrahedron model, the difference between an electron and a pion tetrahedron is a single quark flavor exchange. A d flavor quark in the electron tetrahedron model is replaced by a u flavor quark in the pion tetrahedron as illustrated in figure 10 below.

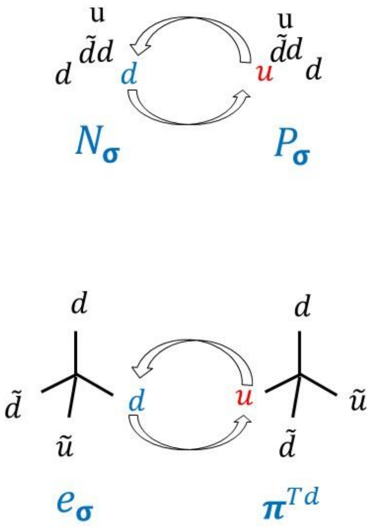

Figure 10 illustrates on the top a proton and a neutron exchanging d and u quarks and similarly at the bottom an electron tetrahedron and a pion tetrahedron exchanging the d and u quarks.

7. Summary

1. **Non-uniform pion tetrahedron Aether -** the $u\tilde{d}d\widetilde{u}$ pion tetrahedrons fill space and form a non-uniform condensate with an atmospheric density like drop. The $u\tilde{d}d\widetilde{u}$ pion tetrahedron mass may be calculated by measuring the β decay rate variability[9]. In the limit of infinite number of coupled pion tetrahedrons, the pion tetrahedron vacuum polarization integral vanishes and the vacuum pion tetrahedrons are stable[10].
2. **Source of gravity** – the attraction between particles and antiparticles may be the source of gravity. The pion tetrahedrons density in space vary according to the gravitational field and the gravitational force is transferred by interactions with the pion tetrahedron condensate. Far from the galaxies' centers in the KBC voids for example, the condensate

density is extremely small and the MOND limit may be obtained with no need for dark matter.

3. **Electron tetrahedron model** – the electron may be a tetraquark tetrahedron, two quarks determine the charge and two quarks determine the spin state. High frequency quark exchange reactions transform the electron tetrahedrons to the vacuum pion tetrahedrons and vice versa and form delocalized electron clouds with fixed spin state.
4. **Pion tetrahedron QCD glue** – electron pairs and proton-neutron pairs with opposite spins determined by the $u\tilde{u}\ and\ d\tilde{d}$ quarks form a pion tetrahedron bond, where the $u\tilde{d}d\tilde{u}$ pion tetrahedron act as a QCD glue.

The essence of quantum mechanics that makes it so different from classical mechanics may be the antimatter discovered by Dirac[25] which may also be part of the invisible non-uniform pion tetrahedron Aether. The central roles of antimatter and the non-uniform pion tetrahedron Aether were not anticipated by general relativity and quantum mechanics and are not fully understood still.

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