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Mass Increase with Strong and Gravitational Potentials, and Mass Defect with Electromagnetic Potential

Hany Ali Hussein

Electronic & Communication, Shoubra College, University of Banha, Banha, Egypt
Email: hani.ali.hussein79@gmail.com

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Abstract

The proposal is "mass increases due to strong and gravitational potentials, while it decreases due to Electromagnetic potential". This proposal explains the big difference in mass between hadrons (protons, neutrons, & mesons) and their components (quarks), mass difference between nucleus and its individual components (protons and neutrons), massless of gamma photons, abnormal masses of mesons and bosons, and the excess in galaxy masses (dark matter). Also, this proposal shows the exact relation between mass and energy:

$$\text{Strong Potential} = -3.04mc^2$$

$$|\text{Electric Potential}| = -5.57\times10^{-3}mc^2$$

$$\text{Gravitational Potential} = -1.22\times10^{-7}mc^2$$

where m represents the excess in mass due to strong potential, or gravitational potential and represents the decrease in mass due to electromagnetic potential. Released energy here equals potential energy and doesn't equal decrease in mass using the formula $E = mc^2$. Released energy is transferred to heat, photons, kinetic energy… Finally, proposal will try to describe the relation between photon energy and mass of its components using the general equation of kinetic energy:

$$\text{Photon Energy} = 1/2\,mc^2$$

m is the sum of the individual masses of its components, while the total mass of photon is zero.

Keywords

Mass Defect, Dark Matter, Photon, Gamma Photon, Strong Potential, Gravitational Potential, Electromagnetic Potential, Quarks, Mesons, Bosons, Deuterium, Proton, Neutron

1. Introduction

As known in chemical or nuclear interactions, binding between components will cause total mass to be less than sum of individual masses, and release energy of this action is equal to mass defect as per the formula $E = mc^2$. But when quarks interact to form nucleon, why mass will increase? Same question for quarks when forming mesons.

Another question, in a beta decay Neutron will turn into proton, and boson will be emitted. Then, boson will turn into electron and antineutrino. But how does it come to get boson with mass higher than 80 GeV/c^2 [1]. So, how does it come to get boson from neutron decay? And in general, in nuclear interaction, how can we get products with masses higher than reactants masses?

Going to macroscopic level, why is the mass of Galaxy (for example Milky Way) higher than masses of its components (clouds, stars…)? What is behind its dark matter?

All these questions and more lead to a new theory.

Before going to the theory and methodology, it is better to show briefly the related works in this field. Initially Nikolay Umov introduced a relation between mass and energy ($E = kmc^2$, where k between 0.5 and 1). Later Einstein proposed the famous equation $E = mc^2$. His equation showed how mass can be converted into energy.

However, here we will show that mass and energy are two separate entities. Actually, the potential between two particles has two effects. First, there will be a released energy that equals the potential energy. Secondly, potential will affect the measured mass. Mass may increase or decrease based on type of potential. So, total measured mass will not equal the sum of masses of individual particles. The two effects together caused scientists to think that mass was converted to energy, especially that in some cases (such as producing photons), total measured mass will equal zero. But as we mentioned released energy equals potential energy and no mass converted. Mass is still existing, but its measured value will be affected by the internal potential energy.

2. Theory & Methodology

Let us say that mass increases due to strong and gravity potentials, while it decreases due to electromagnetic potential. Then let us apply this proposal on:

1) Binding between proton and neutron in deuterium atom, and internal binding between quarks of proton and between quarks of neutron. This will enable us to get a relation between electromagnetic potential and reduction in mass and a relation between strong potential and increase in mass.

2) Binding in Milky Way to get a relation between gravitational potential and increase in mass.

Then we will discuss why mesons and bosons have a short lifetime and why they have too much mass in comparison to its components. Also, we will try to discuss why photons are massless. Moreover, we will discuss how this is important to transfer energy and mass from an excited system to others and we will discuss conservation of energy and conservation of mass. We will use classical form of equations (non-quantum form).

2.1. Strong and Electromagnetic Potentials in Deuterium Atom

Here are, we will determine the coefficient (F_s) of mass increase due to strong potential and the coefficient (F_e) of mass decrease due to electric potential. Where:

$$\text{Strong Potential} = -F_s mc^2 \tag{1}$$

$$|\text{Electric Potential}| = -F_e mc^2 \tag{2}$$

This will be the core of the article. F_s and F_e values should fulfil:

1) The exact mass defect in deuterium atom due to interaction between proton and neutron.

2) The exact mass increase of proton due to interaction between its quarks.

3) The exact mass increase of neutron due to interaction between its quarks.

To achieve this, we should get total strong potential and total electric potential between quarks into proton, into neutron, and between quarks of proton and neutron. Then solving equations of the three systems (proton, neutron, and deuterium atom).

2.1.1. Total of Strong Potentials

We will set few assumptions here to simplify the idea and to get accurate values as much as we can. But at the end of this section, you will find that even if ignoring these assumptions, our proposal is still valid. Also, please note that nuclear force is the residual of strong force. So, strong interaction in this article refers to any of strong or nuclear force.

Deuterium nucleus includes one proton and one neutron. They are bound together due to strong interaction. Indeed, although neutron has a neutral electric charge, but the separation of charges causes electrical interaction with proton.

For simplicity, we will assume the following geometry where quarks have angle 120˚ between each other and have same average distance into Hadron. Soon, we will clarify why the nearest quark between proton and neutron is the up quark from both sides.

Also, we will ignore the tensor component and focus only on the central force. The central component has two parts: attractive part at long and intermediate ranges, and repulsive part at short range. We will assume that the central force is always attractive, and repulsion is due to another force that prohibits subatomic particles to overlap. The nature of repulsive force is out of our scope now. We will focus only on that the repulsive force is higher at short ranges (because it is inversely proportional to higher orders of distance) and this force balances with attractive force at a certain distance. Consequently, for the strong interaction between neutron and proton, we will use the following formula which is like to Yukawa potential equation [2].

$$\text{Strong Potential} = -Ae^{-Br}/r \tag{3}$$

Constants in this equation are determined based on the following conditions:

1) Strong force equals 137 times electric force at 0.9 fm between two protons.

2) Strong force equals electric force at distance 1.7 fm between two protons.

Depending on details of appendix A, equation of strong potential between proton and neutron will be:

$$\text{Strong Potential} = -2.12\times10^{-24}\mathrm{e}^{-6.86\times10^{15}r}/r\ \mathrm{N\cdot m} \tag{4}$$

$$\text{Strong Potential} = -1.32\times10^{-11}\mathrm{e}^{-6.86\times10^{15}r}/r\ \mathrm{MeV} \tag{5}$$

On the other hand, we can see this interaction between proton and neutron, as an interaction between quarks of both sides. So, we should get a modified formula to represent total strong potential as a sum of the strong potentials between each two quarks. Referring to appendix B, we will try to get a formula for each type of bonds, as follow:

$$\begin{aligned} S.P._{np} = -7.74\times10^{-13}\Big(&3\mathrm{e}^{-6.86\times10^{15}r_{u11u21}}/r_{u11u21} + (3+1.5)\mathrm{e}^{-6.86\times10^{15}r_{u11u22}}/r_{u11u22} \\ &+(1.5+1.5)\mathrm{e}^{-6.86\times10^{15}r_{u21d11}}/r_{u21d11} + (1+1.5)\mathrm{e}^{-6.86\times10^{15}r_{d11u22}}/r_{d11u22} \\ &+(1+1.5)\mathrm{e}^{-6.86\times10^{15}r_{d11d21}}/r_{d11d21}\Big)\ \mathrm{MeV} \end{aligned} \tag{6}$$

$$S.P._{n} = -7.74\times10^{-13}\times(2\times1.5+1)\mathrm{e}^{-6.86\times10^{15}r}/r\ \mathrm{MeV} \tag{7}$$

$$S.P._{p} = -7.74\times10^{-13}\times(2\times1.5+3)\mathrm{e}^{-6.86\times10^{15}r}/r\ \mathrm{MeV} \tag{8}$$

where $S.P._{np}$ is the strong potential between neutron and proton, $S.P._{n}$ is the strong potential in the neutron, and $S.P._{p}$ is the strong potential in the proton.

2.1.2. Total of Electric Potentials

Based on the proposal, mass reduces due to electric potential regardless the potential is positive or negative. It means that mass reduction depends on the absolute value of potential. Now, if a particle (quark or hadron) subjects to many different electric potentials, how can we get the absolute value? If the potentials occupy the same space, the total absolute value is equal to the absolute of sum of potentials. If the potentials occupy different spaces, the total absolute value is equal to sum of the absolute values of each potential.

Accordingly, and referring to **Figure 1**, the total absolute value of electric potential into proton (or neutron) is almost equal to the sum of the absolute values of potential between each two quarks, while the total absolute value of electric potential between proton and neutron is almost equal to the absolute of sum of potentials between quarks from both sides.

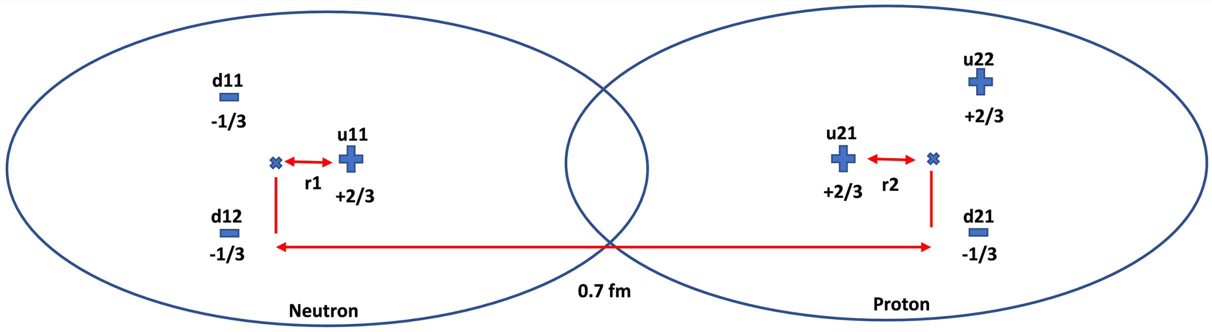

Figure 1. Position of quarks into proton and neutron. We assume all quarks on the same plain.

$$\left|E.P._n\right| = (2+2+1)/9 \times Kq^{(2)} / (2r_1 \sin 60)\ \mathrm{N\cdot m} \tag{9}$$

$$\left|E.P._n\right| = 4.62 \times 10^{-16} / r_1\ \mathrm{MeV} \tag{10}$$

$$\left|E.P._p\right| = (2+2+4)/9 \times Kq^{(2)} / (2r_2 \sin 60)\ \mathrm{N\cdot m} \tag{11}$$

$$\left|E.P._p\right| = 7.39 \times 10^{-16} / r_2\ \mathrm{MeV} \tag{12}$$

$$\begin{aligned}\left|E.P._{np}\right| = \Big|Kq^{(2)}\big(&-4/9/r_{u11u21} + (-4/9+2/9)/r_{u11u22} + (2/9+2/9)/r_{u21d11} \\ &+ (2/9-1/9)/r_{d11u22} + (2/9-1/9)/r_{d11d21}\big)\Big|\ \mathrm{N\cdot m}\end{aligned} \tag{13}$$

$$\begin{aligned}\left|E.P._{np}\right| = \Big|1.44\times10^{-15}\big(&-4/9/r_{u11u21} - 2/9/r_{u11u22} + 4/9/r_{u21d11} \\ &+ 1/9/r_{d11u22} + 1/9/r_{d11d21}\big)\Big|\ \mathrm{MeV}\end{aligned} \tag{14}$$

where $|E.P._n|$ is the absolute value of electric potential in neutron, $|E.P._p|$ is the absolute value of electric potential in proton, and $|E.P._{np}|$ is the absolute value of electric potential between neutron and proton.

2.1.3. Solving the Equations

Referring to Equations 1 and 2, we can get the total change in mass as follow:

$$m = -S.P./F_s/c^2 - |E.P.|/F_e/c^2 \tag{15}$$

where *S.P.* and *E.P.* are in N.m, and *m* in kg.

Or

$$m = -S.P./F_s - |E.P.|/F_e \tag{16}$$

where *S.P.* and *E.P.* are in MeV, and *m* in MeV/c².

For interaction between proton and neutron, m (reduction in mass) is equal to −2.2243 MeV/c², into proton m (increase in mass) is equal to 928.88 MeV/c² and into neutron m (increase in mass) is equal to 927.67 MeV/c². So:

$$-2.2243 = -S.P._{np}/F_s - \left|E.P._{np}\right|/F_e \tag{17}$$

$$927.67 = -S.P._n/F_s - \left|E.P._n\right|/F_e \tag{18}$$

$$928.88 = -S.P._p/F_s - \left|E.P._p\right|/F_e \tag{19}$$

These are three equations with four variables F_s, F_e, r_1 and r_2. If you check appendix B, there are two hidden variables (ratio of uu to dd and ratio of ud to dd). To reduce variables, we assumed these ratios are 3 and 1.5 respectively. Now, to solve these equations, we have to know r_1, or r_2. But this is not measurable yet. So, we will use computer application (program or Microsoft Excel) to set many random values for r_1 and r_2 to get values of F_s, F_e that fulfil these equations.

You can contact me by E-mail, to share with you this template of excel sheet. Appendix C will discuss how to use it.

At $r_1 = 8 \times 10^{-17}$, and $r_2 = 8.8 \times 10^{-17}$, and using ratio 3:1:1.5 for uu:dd:ud, the result was that:

$$F_e = 5.57 \times 10^{-3} \tag{20}$$

$$F_s = 3.04 \tag{21}$$

Now back to our assumptions, let us list here all of them and see to what extent they affect the results.

1) uu has a higher strong potential, then ud, then dd. Also, we assumed the ration of 3:1:1.5. However, if you ignored this ratio, even ignored that uu has the highest potential value, you will find that F_e is still too much lower than 1 (the coefficient in formula $E = mc^2$), and F_s is still higher than 1. For example, if you assumed that dd has a higher strong potential, F_e will be a little bit lower. It will be around 1.6×10^{-3}. If you assumed that ud has a higher strong potential, F_e will be a little bit higher. It will be around 3.5×10^{-2}. So, regardless of the exact values of F_e, it is still too much less than 1. Also, this concept will be important in transferring energy using photons as discussed in section "Transferring Energy & Mass".

2) The interaction between proton and neutron was treated as an interaction between each quark into proton with each quark into neutron (all combinations). If you consider only the interaction between the nearest quarks only (up from proton with up from neutron), you will get almost the same result. If you tried it, we would get F_e with a value around 1.8×10^{-2}, and F_s value around 19.

3) We assumed that the distances between quarks into hadron are equal and have a fixed value, while quarks may be in a very dynamic motion. You can treat this distance as the average distance.

4) For simplicity, we assumed all quarks of proton and neutron are in the same plain. If not in the same plain, the result will be almost the same.

Finally, the relation between mass and strong or electromagnetic potential can be written as below:

$$\text{Strong Potential} = -3.04mc^2 \tag{22}$$

$$\left|\text{Electric Potential}\right| = -5.57 \times 10^{-3} mc^2 \tag{23}$$

Actually, there is no need or physical meaning to keep the constant C in these equations. So, it can be rewritten as follow:

$$\text{Strong Potential} = -2.74 \times 10^{17} m \tag{24}$$

$$\left|\text{Electric Potential}\right| = -5.01 \times 10^{14} m \tag{25}$$

However, it is better to keep use of the previous expressions in equations 22 and 23, to be comparable with Einstein's equation $E = mc^2$.

If you check the electric and strong potential values between proton and neutron in deuterium atom are 0.3 MeV and −157.6 MeV, respectively. So, the total released energy is equal to 157.3 MeV. As shown, it is too much higher than released energy calculated based on mass defect (2.2 MeV). It is an important result for this hypothesis. It means that the real released energy of nuclear fusion/fission is higher than calculated released energy.

2.2. Gamma Rays

When electron and anti-electron approach each other, the absolute value of electric potential will increase gradually, and their total mass will decrease. This will continue till the distance:

$$r = -Kq^2 / \left(mF_e c^2 \right) \tag{26}$$

where m is the double of electron mass in kg.

Or

$$r = -Kq / \left(mF_e 10^6 \right) \tag{27}$$

where m is the double of electron mass in MeV/c^2

$$r = 2.59 \times 10^{-13} \text{ m} \tag{28}$$

At this distance, the total measured mass is zero. Now it is a photon with massless!!

But internally this system still has a not measurable mass of $2m_e$, and it has a kinetic energy as follow:

$$K.E. = 1/2 \left(2m_e \right) c^2 = m_e c^2 = 0.510999 \text{ MeV} \tag{29}$$

The effect of this mass and its kinetic energy will appear only when it collides with atomic particles. In this case the bond between e^- and e^+ will break and kinetic energy of each particle ($1/2 m_e c^2$) will be transferred to collided particles.

What about the strong potential? At 2.59×10^{-13}, the electric potential is the dominant and the strong potential is almost zero. If you remember, the effect of strong potential appears at distance around 1 fm. The attraction between e^- and e^+ will continue till a certain distance at which a balance will occur between the attractive electric force and a repulsive force (a stable state like what happens between proton and electron in hydrogen atom). This distance is not measured yet; however, it is lower than 2.59×10^{-13} and higher than parts of 1 fm. On the other hand, the equation of strong potential between e^+ and e^- can be simplified as follow:

$$\text{Strong Potential} = -3.75 \times 10^{-12} \, e^{-6.86 \times 10^{15} r} / r \text{ MeV} \tag{30}$$

In section "Mesons & Bosons", we will show how we got this equation.

Another important question, what is about the charge? When mass reduces to zero, charge decreases to zero as well. In the inner system, still there are two particles with their own mass and charge, but from outer perspective, mass and charge are zero. Please note that in case of deuterium atom, reduction in mass doesn't cause reduction in charge, because the reduction was in the excess mass of strong potential between its quarks, not in the original mass of proton quarks.

2.3. Transferring Energy and Mass

When considering a gamma Photon:

$$K.E. = m_e c^2 \text{ N}\cdot\text{m} \tag{31}$$

$$E.P. = -5.57\times10^{-3}\times 2m_e c^2 = -1.11\times10^{-2} m_e c^2 \text{ N}\cdot\text{m} \tag{32}$$

This photon will move from an excited body to surroundings, carrying energy and mass (not energy only!!). Transferred energy equals *K.E.* – *E.P.* As you see, *P.E.* is too much fewer than *K.E.* So, it will be ignored, and transferred energy is almost equal to *K.E.* It is clear now that the kinetic energy of photon components represents photon energy.

The same concept is applied to any photon. So, photons don't transfer energy only. It transfers mass as well.

K.E. equals half of total inner mass multiplied by square of light speed. So, you can simulate total inner mass here to the double of rest mass of photon.

2.4. Conservation of Energy and Conservation of Mass

Energy is conservative. But mass is not conservative for a single process. In a single process, mass may increase or decrease. For a series of processes that generate the exact initial state, mass is conservative.

When e^- and e^+ combine to produce gamma photon, mass reduces. Then when breaking the bond, mass returns to $2m_e$.

Regarding the processes of β^- (to generate proton, electron, and antineutrino from neutron) and β^+ (to generate neutron, positron, and neutrino from proton), both processes together can't be considered as a complete cycle to return to the exact initial state. You may think the initial state here is the neutron. However, the initial state is a neutron-rich nuclei (in which β^- process occurs).

Here, we can conclude that for any interaction, we should we have three separate equations; one for components of reactants and products, one for energy which is conservative, and final one for mass which is not mandatory to be conservative and it depends one masses of components and change in potential energies.

2.5. Mesons and Bosons

As mentioned previously, when two quarks are near enough to each other, the strong and electric potentials will affect the total mass:

$$m_t = m_q - S.P./F_s - |E.P.|/F_e \text{ MeV} \tag{33}$$

For up antiquark and down quark at distance less than 0.5 fm, the strong potential will be the dominant and the total mass will be higher than the sum of individual masses of quarks. There will be three states.

1) At 0.178 fm, the total mass is 139.57 MeV/c^2 (meson state: pion Π-) [3]. But this state is not stable. Its lifetime is 26 ns. So, quarks will go away to a more stable state.

2) At 0.187 fm, the total mass is 105.66 MeV/c^2 (muon state: μ) [4]. Its lifetime is 2.2 µs. Then quarks will go away more, and muon will decay.

3) At 0.232 fm, the total mass is 0.511 MeV/c^2 (electron state: e^-). It is a very stable state.

The same scenario can be applied to up quark and down antiquark. Pion Π^+ will be created. Then it will decay to muon, then positron.

Pion Π^0 is composite of up (quark and antiquark), and down (quark and antiquark). Then up antiquark and down quark together will form electron, and up quark and down antiquark will form positron. Then electron and positron will form gamma photon.

Note: based on this assumption, the strong potential between electron and positron is equal to the total of strong potentials between their components. For simplicity, we will ignore the separation between components of electron, and ignore the separation between components of positron. So, the strong Potential between e^- and e^+ is:

$$\begin{aligned} S.P. &= -5.36\times10^{-13}\times\left(1.5\times2+2+3\right)\mathrm{e}^{-6.86\times10^{15}r}\big/r \\ &= -3.75\times10^{-12}\,\mathrm{e}^{-6.86\times10^{15}r}\big/r\ \text{MeV} \end{aligned} \tag{34}$$

With the same concept, you can explain other types of mesons and Bosons (W^-, W^+, Z^0). You need only to know the exact value of amplitude (Constant A) of strong potential equation between components.

As you see, the explanation of muon decay to electron based on this hypothesis implies that electron is not an elementary particle. This is one of the main challenges. We will face the same challenge in the next section as well.

Another challenge, we claimed that at 0.232 fm, the bond between up antiquark and down quark will be very stable to from electron. What happens if the two particles go away to another state with a distance higher than 0.232 fm? In this case, the effect of electric potential will be higher than that of strong potential, and mass reduces to zero. It means a photon will be formed. But this photon is different, where its bond potential (around 700 MeV) will be too much higher than its kinetic energy (3.55 MeV). So, this photon will transfer mass, but it will not transfer energy. On the contrary, it will absorb high energy to break the bond. Maybe this explains why we haven't detected free quarks, yet.

2.6. Photon of Light

Here we will try to explain the massless of light photon as done in gamma photon. Based on this hypothesis, we can assume that the light photon is composite of pair of neutrino and antineutrino or more. It is not a new idea. De Broglie already introduced the idea of composite photon. Then Kronig, Jordan and others worked on developing the neutrino theory of light. This theory has some challenges. One of main challenges is that to produce a massless photon, neutrino should be massless.

Although our proposal will solve this problem as shown soon, however still there are other issues with this idea. Anyway, we will proceed and if we failed to explain massless of light photon, our proposal is still valid in explaining the relation between potential and mass change (increase or decrease) for hadrons, mesons, bosons, gamma photon and galaxies.

The smallest light photon is composed of one pair of neutrino and antineutrino. Although neutrino and antineutrino have a neutral charge, there is an electrical interaction between them due to separation of charges of its components. It means that neutrino is composed of smaller charged particles (something like quarks into neutron or proton). When neutrino approaches antineutrino (due to electrical or strong interaction), the electrical interaction will cause a gradual reduction in total mass of the system till reaching zero and photon is produced (in this case, the effect of strong interaction is too little in comparing with the effect of electrical interaction). This photon has the minimum kinetic energy and frequency among photons.

$$K.E. = 1/2\left(2m_{\nu}\right)c^2 = m_{\nu}c^2 = 0.1122\ \text{eV} \tag{35}$$

$$\nu = 0.1122/h = 2.7\times 10^{13}\ \text{Hz} \tag{36}$$

If the composite photon includes more pairs, it will have more energy. This may continue till covering the visible range (or more) of electromagnetic spectrum. It means that electromagnetic waves with frequencies lower than 2.7×10^{13} have a pure electromagnetic wave properties and they don't have photon properties, or there are new particles (not detected yet) with lower mass, and they are combined to produce such photons.

2.7. Gravitational Potential and Dark Matter

According to this hypothesis, dark matter of galaxies is due to the gravitational potential between their components (stars, hydrogen clouds…). Gravitational potential of galaxy can be determined as follow:

For spherical shape

$$G.P. = -3/5Gm^2/r\ \text{N}\cdot\text{m} \tag{37}$$

For disc shape

$$G.P. = -2/3Gm^2/r\ \text{N}\cdot\text{m} \tag{38}$$

Here we treated galaxies components as points, and the calculated potential is the sum of potential between them. This equation doesn't include the gravitational potential into each celestial body (between its atoms).

As per the proposal,

$$G.P. = -F_g mc^2 \tag{39}$$

To determine F_g, we will use available data of Milky Way. As you know Milky Way almost has a disc shape for luminous matter with a radius 5 × 10^{20} m, and mass 0.95 × 10^{11} $M_\odot$ [5]. It has a spherical shape for dark matter with mass 0.8 × 10^{12} $M_\odot$ and halo radius 9 × 10^{21} m. So, with a simple form, we can get Fg as follow:

$$-3/5Gm^2/r = -F_g m_d c^2 \tag{40}$$

where M is the total mass (luminous and dark), m_d is the mass of dark matter. As you see, this equation considers the interaction between all types of matter (dark and luminous). So,

$$F_g = 3/5G\left(m_l + m_d\right)^2 / \left(rm_d c^2\right) = 9.85\times10^{-8} \tag{41}$$

For accuracy, we should consider two different densities: density of matter within the radius 5 × 10^{20}, and density of matter between radius 5 × 10^{20} and radius 9 × 10^{21}. In this case:

$$\begin{aligned} G.P. &= -3/5G\left(m_l + \left(R_1/R_2\right)^3 m_d\right)^2 \Big/ R_1 - G\int_{R_1}^{R_2}\left(4\pi r^2\rho_2\right)\left(m_l + 4/3\pi r^3\rho_2\right)/r\,\mathrm{d}r \\ &= -1.75\times10^{-52}\ \mathrm{N\cdot m} \end{aligned} \tag{42}$$

$$F_g = -G.P./\left(m_d c^2\right) = 1.22\times10^{-7} \tag{43}$$

Note: we considered disc of Milky Way as a sphere with radius of 5 × 10^{20}. To get more accuracy, you should consider it as a disc, but calculation will be complex.

The previous equations can be used directly for Galaxies and young hydrogen clouds. Regarding planets and stars, we have to take into account the electric potential between atoms due to separation between electrons and nucleus. For more details, you can search for van der Waals force.

3. Results

In Section 3, we found that the relation between the potential and the change in mass was as follow:

$$\text{Strong Potential} = -3.04mc^2 \tag{44}$$

$$\left|\text{Electric Potential}\right| = -5.57\times10^{-3}mc^2 \tag{45}$$

$$\text{Gravitational Potential} = -1.22\times10^{-7}mc^2 \tag{46}$$

The accuracy of values of factors should be validated experimentally.

Using these basic equations, we can explain the change in mass of micro or macro systems such as baryon, nucleus, meson, boson, photon, and galaxy.

4. Conclusions

Now we have a clear description for the relation between potentials (strong, electric, and gravitational) and change in mass. The total mass of a system may be higher or lower than sum of masses of its components based on the type of potential between them. Total mass of a system may decrease till zero value (photon state). But mass doesn't convert into energy and the system components are still existing with their individual masses. Only the energy is changed from type to another type and the total mass of a system is affected by the potential between its components.

The reason, behind dark matter, is the gravitational potential between the galaxy components. The reason, behind the big difference in mass between hadrons/bosons and their components, is the strong potential between their components. The reason, behind the photon state (zero mass), is the electromagnetic potential between components.

The limitation in this hypothesis is that explaining the photon or boson state requires that photon, neutrino, and boson must be composite.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix A—Determining Amplitude and Exponential Constants of Strong Potential Equation

$$\text{Strong Potential} = -Ae^{-Br}/r \quad \text{(A1)}$$

Now, to get values of constants A and B, we have two constraints:

1) Strong force equals137 times of electric force at distance 0.9 fm between two protons.

2) Strong force equals electric force at distance 1.7 fm between two protons.

$$\text{Strong Force} = Ae^{-Br}/r^2 + ABe^{-Br}/r + C \quad \text{(A2)}$$

At infinity, Strong Force is equal to 0. So, C is equal to 0.

At 1.7 fm

$$Ae^{-B1.7\times10^{-15}}/\left(1.7\times10^{-15}\right)^2 + ABe^{-B1.7\times10^{-15}}/\left(1.7\times10^{-15}\right) = kq^2/\left(1.7\times10^{-15}\right)^2 \quad \text{(A3)}$$

So,

$$A = kq^2/\left(e^{-B1.7\times10^{-15}}\times\left(1+B\times1.7\times10^{-15}\right)\right) \quad \text{(A4)}$$

At $r = 0.9$ fm

$$37\times kq^2/\left(e^{-B\times0.9\times10^{-15}}\times\left(1+B\times0.9\times10^{-15}\right)\right) \quad \text{(A5)}$$

So,

$$\begin{aligned} &kq^2/\left(e^{-B\times1.7\times10^{-15}}\times\left(1+B\times1.7\times10^{-15}\right)\right) \\ &=137\times kq^2/\left(e^{-B\times0.9\times10^{-15}}\times\left(1+B\times0.9\times10^{-15}\right)\right) \end{aligned} \quad \text{(A6)}$$

$$e^{-B\times0.8\times10^{-15}}\times\left(1+B\times0.9\times10^{-15}\right) = 137\times\left(1+B\times1.7\times10^{-15}\right) \quad \text{(A7)}$$

By using different values on computer application:

$$B = 6.86\times10^{15} \quad \text{(A8)}$$

$$A = 2.12\times10^{-24} \quad \text{(A9)}$$

Note: As seen here, the strong force is inversely proportional to distance but as we know the strong force is proportional to distance!!!

Actually, when two subatomic particles are near enough, the strong force attracts them to each other till a certain distance. At this distance there is a balance between the attractive strong force and a repulsive force. Regardless the nature of this repulsive force, it is inversely proportional to higher orders of distance. So, at a distance slightly higher than balance distance, the net force will be proportional to distance (you can validate this by calculating the net force of two forces, one attractive force equals to $1/r^2$ and the other is repulsive and equals $1/r^3$. At distances less than 0.04, the net force is proportional to r). For higher distances, the repulsive force will rapidly decrease, and the net force is almost equal to the strong force which decreases exponentially with distance.

Appendix B—Determining Constants of Strong Potential Equations of Quarks

First let us say uu, dd, and ud refer to strong potential between two up quarks, strong potential between two down quarks, and strong potential between up and down quarks, respectively. We will assume that the ratio of uu:dd:ud is 3:1:1.5.

Referring to the strong potential between proton and neutron

$$\text{Strong Potential} = -1.32\times10^{-11}\,\mathrm{e}^{-6.86\times10^{15}r}/r\ \text{MeV} \quad \text{(B1)}$$

If we need to get a similar formula between quarks of both sides, as shown in Figure 1:

$$\begin{aligned} S.P._{np} = {} & -1.32\times10^{-11}/(2\times3+2\times1+5\times1.5)/\text{Separation\_Error}\Big(3\mathrm{e}^{-6.86\times10^{15}r_{u11u21}}/r_{u11u21} \\ & +(3+1.5)\mathrm{e}^{-6.86\times10^{15}r_{u11u22}}/r_{u11u22}+(1.5+1.5)\mathrm{e}^{-6.86\times10^{15}r_{u21d11}}/r_{u21d11} \\ & +(1+1.5)\mathrm{e}^{-6.86\times10^{15}r_{d11u22}}/r_{d11u22}+(1+1.5)\mathrm{e}^{-6.86\times10^{15}r_{d11d21}}/r_{d11d21}\Big)\ \text{MeV} \end{aligned} \quad \text{(B2)}$$

where:

$S.P._{np}$ is the strong potential between neutron and proton.

$$r_{u11u21} = 0.7\times10^{-15} - r_1 - r_2 \quad \text{(B3)}$$

$$r_{u11u22} = r_{u11d21} = \left(\left(0.7\times10^{-15} - r_1 - r_2 + r_2 + r_2\sin(30)\right)^2 + \left(r_2\sin(60)\right)^2\right)^{0.5} \quad \text{(B4)}$$

$$r_{u21d11} = r_{u21d12} = \left(\left(0.7\times10^{-15} - r_1 - r_2 + r_1 + r_1\sin(30)\right)^2 + \left(r_1\sin(60)\right)^2\right)^{0.5} \quad \text{(B5)}$$

$$r_{d11u22} = r_{d12d21} = 0.7\times10^{-15} + r_1\sin(30) + r_2\sin(30) \quad \text{(B6)}$$

$$\begin{aligned} & r_{d11d21} = r_{d12u22} \\ & = \left(\left(0.7\times10^{-15} + r_1\sin(30) + r_2\sin(30)\right)^2 + \left(r_1\sin(60) + r_2\sin(60)\right)^2\right)^{0.5} \end{aligned} \quad \text{(B7)}$$

When replacing one exponential expression between proton and neutron with exponential expressions between quarks of both sides, total will be higher due to separation. So, total result should be divided by a factor of error. This factor is higher than 1 and it should be determined based on keeping the two conditions of force:

1) Strong force equals 137 times of electric force at distance 0.9 fm between two protons.

2) Strong force equals electric force at distance 1.7 fm between two protons.

But this error can't be determined till knowing the exact distance between quarks into proton and neutron (r_1 and r_2). This will be discussed in Appendix C. For now, you can consider it equals to 1.1.

And in general, strong potential between two quarks is:

$$S.P._{uu} = -2.32\times10^{-12}\,\mathrm{e}^{-6.86\times10^{15}r}/r\ \text{MeV} \quad \text{(B8)}$$

$$S.P._{dd} = -7.74\times10^{-13}\,\mathrm{e}^{-6.86\times10^{15}r}/r\ \text{MeV} \quad \text{(B9)}$$

$$S.P._{ud} = -1.16\times10^{-12}\,\mathrm{e}^{-6.86\times10^{15}r}/r\ \text{MeV} \quad \text{(B10)}$$

where $S.P._{uu}$ is the strong potential between two up quarks, $S.P._{dd}$ is the strong potential between two down quarks, $S.P._{ud}$ is the strong potential between up and down quarks, and r is the distance between each two quarks.

Appendix C—Solving Equations of Mass and Strong and Electric Potentials Using Microsoft Excel

We have three equations, and we will use Microsoft Excel to set different values for r_1 and r_2 and get values for F_s and F_e.

$$m_1 = -S.P._1/F_s - |E.P._1|/F_e \quad \text{(C1)}$$

$$m_2 = -S.P._2/F_s - |E.P._2|/F_e \quad \text{(C2)}$$

$$m_3 = -S.P._3/F_s - |E.P._3|/F_e \quad \text{(C3)}$$

Linking equations C1 and C2

From C1

$$F_e = |E.P._1|/(-S.P._1/F_s - m_1) \quad \text{(C4)}$$

Into C2

$$m_2 = -S.P._2/F_s - |E.P._2|/|E.P._1|(-S.P._1/F_s - m_1) \quad \text{(C5)}$$

$$m_2F_s = -S.P._2 - |E.P._2|/|E.P._1|(-S.P._1 - m_1F_s) \quad \text{(C6)}$$

$$m_2F_s - F_sm_1|E.P._2|/|E.P._1| = -S.P._2 + |E.P._2|S.P._1/|E.P._1| \quad \text{(C7)}$$

$$F_s = (-S.P._2 + |E.P._2|S.P._1/|E.P._1|)/(m_2 - m_1|E.P._2|/|E.P._1|) \quad \text{(C8)}$$

When linking C1 and C3

$$F_e = |E.P._1|/(-S.P._1/F_s - m_1) \quad \text{(C9)}$$

$$F_s = (-S.P._3 + |E.P._3|S.P._1/|E.P._1|)/(m_3 - m_1|E.P._3|/|E.P._1|) \quad \text{(C10)}$$

When linking C2 and C3

$$F_e = |E.P._2|/(-S.P._2/F_s - m_2) \quad \text{(C11)}$$

$$F_s = (-S.P._3 + |E.P._3|S.P._2/|E.P._2|)/(m_3 - m_2|E.P._3|/|E.P._2|) \quad \text{(C12)}$$

1) Now each of F_s and F_e has three values that have to be the same. You can prepare an excel sheet (or computer program) to calculate the electric and strong potentials for proton, neutron and between them. Also, it can calculate F_s and F_e based on the previous six equations. Then you should try different values for r_1 and r_2. To get approximate values that provide identical values for F_s and identical values for F_e.

2) Till now, we didn't take into account the separation error. After getting a solution (where the three values of F_e are the same and the three values of F_e are the same at certain values for r_1 and r_2), you should prepare another excel sheet to calculate the accurate value of error. The conditions are that force ratio (strong force / electric force) should be 137 at distance 0.9 fm and it should be 1 or less at 1.7 fm. Separation error will be 1.59.

3) Once you got the right separation error, you should repeat the first step to get more accurate values for r_1 and r_2.

If you are interested, I can share, with you by E-mail, the full excel templates for all these calculations and equations.

Note: After determining the exact separation error, equation (B8), (B9), (B10), (6), (7), and (8) should be modified as follow:

$$S.P._{uu} = -1.61\times10^{-12}\,\mathrm{e}^{-6.86\times10^{15}r}/r\ \text{MeV} \tag{C13}$$

$$S.P._{dd} = -5.36\times10^{-13}\,\mathrm{e}^{-6.86\times10^{15}r}/r\ \text{MeV} \tag{C14}$$

$$S.P._{ud} = -8.04\times10^{-13}\,\mathrm{e}^{-6.86\times10^{15}r}/r\ \text{MeV} \tag{C15}$$

$$\begin{aligned} S.P._{np} = -5.36\times10^{-13}\Big(&3\mathrm{e}^{-6.86\times10^{15}r_{u11u21}}/r_{u11u21} + (3+1.5)\mathrm{e}^{-6.86\times10^{15}r_{u11u22}}/r_{u11u22} \\ &+ (1.5+1.5)\mathrm{e}^{-6.86\times10^{15}r_{u21d11}}/r_{u21d11} + (1+1.5)\mathrm{e}^{-6.86\times10^{15}r_{d11u22}}/r_{d11u22} \\ &+ (1+1.5)\mathrm{e}^{-6.86\times10^{15}r_{d11d21}}/r_{d11d21}\Big)\ \text{MeV} \end{aligned} \tag{C16}$$

$$S.P._{n} = -5.36\times10^{-13}\times(2\times1.5+1)\mathrm{e}^{-6.86\times10^{15}r}/r\ \text{MeV} \tag{C17}$$

$$S.P._{p} = -5.36\times10^{-13}\times(2\times1.5+3)\mathrm{e}^{-6.86\times10^{15}r}/r\ \text{MeV} \tag{C18}$$