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The Dark Matter and Dark Energy in One Simple Explanation

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Abstract

Dark Matter and Dark Energy compose most of the universe. Yet, there is no understanding of their nature despite decades of intensive research. Here, we propose a new force that explains, without any further assumptions, the Dark Matter and Dark Energy and their related observations. This force is similar to Gravity, but it is coupled to the angular momentum tensor instead of the stress-energy tensor. This force appears to be negligible at small distances and increases with distance until it dominates over the gravity force , which is shown to happen in the outer regions of galaxies or large-scale universe structures. hence, a force of the large-scale structures. The coupling constant calculated from the observed galactic parameters of this force appears to be so small that it cannot be detected in any laboratory, which may explain why Dark matter has not been found despite extensive research. Dark Matter and Energy are shown to be just two different integrative parts of this single force. This paper includes the theoretical framework and empirical calculations proving the above-mentioned arguments.

Keywords: dark energy; dark matter; angular momentum; flat rotation curves; tully-fisher relation; gravity

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1. Introduction

The rotating stars around the galaxy were found to be in deviation from classical gravity calculations [20], which is also known as the galaxies' flat rotation curves. The velocity of a star revolving around the galaxy's center becomes constant as we get more distant from the galaxy's center, instead of decreasing according to Newton's law of gravity. Many theories are trying to explain these flat curves. The two most popular theories are the *Dark Matter* [21], which suggests very weakly interacting particles. This matter should be found mainly in the galaxies' halos; this extra mass should explain this deviation and many other unexplained phenomena. The problem with this theory is that no such particles have been found until now, despite continuous intensive searches for decades. The other theory is Modified Newtonian Dynamics (MOND) [18], which argues that at far distances from the galaxy's center, where the acceleration is very low, Newtonian dynamics becomes invalid, and we should use non-Newtonian dynamics. In other words, the second law must be changed to explain these deviations. This theory also has problems, as many observations are against it [22].

Another independent, unexplained phenomenon is the expansion of the universe, which Current physics can't explain either. There is a mysterious energy source called *Dark Energy* that drives this expansion. Many models are suggested to explain this kind of energy [23], like Einstein's cosmological constant, quintessence field [24], and others, but none of them have much success.

Dark Matter and Dark Energy make up most of the universe [23].

Here, we suggest a new field. We called the *Blue Field*, which is coupled to the angular momentum tensor of the matter, making a measurable force between them. The coupling constant of this force is so tiny, as will be shown, that its effects can be measured only at large distances.

This new field can explain the two phenomena, the Dark Matter (the "missing mass") and the Dark Energy, as one single entity. In other words, unify them in one field.

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The coupling constant of this field is found to be so small that no laboratory on Earth can measure it. This explains why it has not been spotted yet. Its effect is observable only at large scales, e.g., the halos of galaxies.

we will start with a classical description of the suggested Blue Force and how it explains flat rotation curves of spiral galaxies, the Tully-fisher relation [16], estimating its coupling constant from available cosmological data, reproduces MOND predictions using only regular Newtonian dynamics, calculating the missing mass of the galaxies, clusters, Explaining the Bullet Cluster phenomenon by introducing a new type of light rays' bending that depends on the orbital angular momentum the photons carry. The Dark Energy formulation will also be derived, and it will be shown how it is constant across space-time. Other cosmological observations will also be discussed.

2. The Proposed Model at the Classical Level

The space-time is invariant under translation symmetry, and the conserved current of this symmetry is the 4d stress-energy tensor $T_{\mu\nu}$, which is the source of the familiar gravity field. The space-time is also invariant under the Lorentz group, and the conserved current of this symmetry is the 4d angular momentum tensor density $M_{\alpha\beta\gamma}$. What is the equivalent force or field charged under this symmetry, and has the angular momentum tensor as its source? As we know, none. Here, we propose another gravity-like field force that is charged under the Lorentz symmetry and coupled to the angular momentum tensor, which should complete the picture of the invariance of space-time under the Poincaré group (Lorentz group+translation). We call this new field the "*Blue field*"

In this context, the suggested potential produced between two point rotating objects is as follows:

$$E(r) = -g\frac{L_{1\mu\nu}L_2^{\mu\nu}}{r}, \tag{1}$$

$\mu/\nu = 0, 1, 2, 3$. L_1, L_2 are constant angular momentum tensor of each particle. The produced force is:

$$\vec{F}(r) = -\frac{dE(r)}{dr} = -g\frac{L_{1\mu\nu}L_2^{\mu\nu}}{r^2}\hat{r}, \tag{2}$$

r is the distance between the two particles' centers of mass. g is the coupling constant of the force. This formulation is very similar to the Coulomb law. The angular momentum here is analogous to the electric charge. In a continuum medium, it becomes:

$$\begin{aligned}\vec{F}(r) &= -\sum_{ij} g\frac{L_{i\mu\nu}L_j^{\mu\nu}}{r^2}\hat{r} = \\ &= -\int\int g\frac{dL_{1\mu\nu}dL_2^{\mu\nu}}{r^2}\hat{r} = \\ &= -\int\int g\frac{\rho_{L_1}\rho_{L_2}}{r^2}dV_1dV_2\hat{r}\,,\end{aligned} \tag{3}$$

and the potential energy:

$$\begin{aligned}E(r) &= -\sum_{ij} g\frac{L_{i\mu\nu}L_j^{\mu\nu}}{r} = \\ &= -\int\int g\frac{dL_{1\mu\nu}dL_2^{\mu\nu}}{r} = \\ &= -\int\int g\frac{\rho_{L_1}\rho_{L_2}}{r}dV_1dV_2\,,\end{aligned} \tag{4}$$

$\rho_{L_{1/2}}$ is the angular momentum spatial density.

The carrying particle of this field has spin 2 as a gravity field (Graviton), thus always an attractive force [5].

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The angular momentum tensor in four dimensions:

$$M^{\mu\nu} = x^{\mu} \wedge p^{\nu} = x^{\mu} p^{\nu} - x^{\nu} p^{\mu} \,, \tag{5}$$

where $\mu/\nu = 0, 1, 2, 3$, p^{μ} is the four-momentum and x^{ν} is the four position.[2,3]This tensor is additive; the total angular momentum of a system is the sum of the angular momentum tensors for each constituent of the system:

$$L_{\text{tot}} = \sum_n L_n = \sum_n \mathbf{X}_n \wedge \mathbf{P}_n \,, \tag{6}$$

Next, there are six independent quantities altogether. Each of them forms a conserved quantity. The three components

$$L^{ij} = x^i p^j - x^j p^i = x^i \wedge p^i \,, \tag{7}$$

$i = 1, 2, 3$ are the familiar classical 3-space orbital angular momentum $\{L_x, L_y, L_z\} = \vec{L}$, and the left three:

$$L^{0i} = x^0 p^i - x^i p^0 = c\left(tp^i - x^i \frac{E}{c^2}\right) = -cn^i \,, \tag{8}$$

are the dynamic mass moments multiplied by c. The three dynamic mass moments are defined as [3]

$$n_x = \frac{Ex}{c^2} - p_x t \,, \tag{9}$$

$$n_y = \frac{Ey}{c^2} - p_y t \,, \tag{10}$$

$$n_z = \frac{Ez}{c^2} - p_z t \,, \tag{11}$$

They are conserved quantities and equivalent to the conservation of the center of mass (C.O.M):

$$\vec{R}_{\text{C.O.M}} = \frac{\sum m_i \vec{r}_i}{\sum m_i} \,, \tag{12}$$

Choosing t=0 frame and a particle almost at rest $v \approx 0$ (or $\sum p \approx 0$ in the center-of-mass coordinates in the case of an ensemble [6]), i.e. $E \approx mc^2$. Substituting in the dynamic mass moment gives:

$$n_x = \frac{Ex}{c^2} - p_x t \approx mx - p_x \cdot 0 = mx \,, \tag{13}$$

$$n_y = \frac{Ey}{c^2} - p_y t \approx my - p_y \cdot 0 = my \,, \tag{14}$$

$$n_z = \frac{Ez}{c^2} - p_z t \approx mz - p_z \cdot 0 = mz \tag{15}$$

Or in short:

$$\vec{n} = m\vec{r} \,, \tag{16}$$

Where $\vec{n} = \{n_x, n_y, n_z\}, \vec{r} = \{x, y, z\}$, m is the particle's mass, and $\vec{r}$ is the distance from the center of mass. Next, defining:

$$\vec{N} := c\vec{n} = mc\vec{r} \,, \tag{17}$$

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Therefore, $\vec{N}$ can be considered as "spatial angular momentum" in which the particle is "moving " at the speed of light (particle has $(+c)$ speed and anti-particle has $(-c)$ speed, i.e., moving backward in time). like the electromagnetic tensor $F_{\mu\nu}$ expansion [25]

$$F_{\mu\nu}F^{\mu\nu} = 2(\vec{B}\cdot\vec{B} - \frac{\vec{E}\cdot\vec{E}}{c^2})\,, \tag{18}$$

where $\vec{N}$ is equivalent to $\vec{E}/c$ and $\vec{L}$ is equivalent to $\vec{B}$, we obtain:

$$L_{\mu\nu}L^{\mu\nu} = 2(\vec{L}\cdot\vec{L} - \vec{N}\cdot\vec{N})\,, \tag{19}$$

The same is in the case of two different angular momenta :

$$L_{1\mu\nu}L_2^{\mu\nu} = 2(\vec{L}_1\cdot\vec{L}_2 - \vec{N}_1\cdot\vec{N}_2)\,, \tag{20}$$

Hence, the force becomes:

$$\begin{aligned} \vec{F} &= -\mathbf{g}\frac{L_{1\mu\nu}L_2^{\mu\nu}}{r^2}\hat{r} = \\ &= -2\mathbf{g}\frac{\vec{L}_1\cdot\vec{L}_2 - \vec{N}_1\cdot\vec{N}_2}{r^2}\hat{r} = \\ &= -g\frac{\vec{L}_1\cdot\vec{L}_2 - \vec{N}_1\cdot\vec{N}_2}{r^2}\hat{r}\,, \end{aligned} \tag{21}$$

with the definition: $2\mathbf{g} := g$.

This force can be split into two interesting parts using the following fact:

$$|\vec{N}| = mcr \gg |\vec{L}| = mvr\,, \tag{22}$$

Because $v \ll c$, Eq.21 becomes:

$$\vec{F}(r) \sim g\frac{\vec{N}_1\cdot\vec{N}_2}{r^2}\hat{r} := \vec{F}^N_{(r)}\,, \tag{23}$$

It is defined as the force between the dynamic mass moments of two particles. This force will be shown to be a constant and isotropic across space-time and will play the role of Dark Energy in sect. 2.2. The second part is a non-constant local force :

$$\vec{F}^L_{(r)} = -g\frac{\vec{L}_1\cdot\vec{L}_2}{r^2}\hat{r}\,, \tag{24}$$

Which will play the role of Dark Matter, as will be shown later on in sect. 2.1.

2.1. The Force Between Two Spatial Angular Momenta and the Emergence of Dark Matter

The total angular momentum is:

$$\vec{\mathbf{J}} = \vec{\mathbf{L}} + \vec{\mathbf{S}}\,, \tag{25}$$

Where $\vec{L}$ is the orbital angular momentum, and $\vec{S}$ is the self-rotation angular momentum or the spin (in classical terms, because we deal with stars, not elementary particles).

The force between two spatial angular momenta is:

$$\vec{F}^L_{(r)} = -g\frac{\vec{J}_1\cdot\vec{J}_2}{|r_2 - r_1|^2}\hat{r}\,, \tag{26}$$

$$\tag{27}$$

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Throughout this paper, the angular momenta are assumed co-linear $\vec{J}_1 || \vec{J}_2 \Rightarrow \vec{J}_1 \cdot \vec{J}_2 = |\vec{J}_1||\vec{J}_2| > 0$, so we will use J, S, L and $\vec{J}, \vec{S}, \vec{L}$ reciprocally unless otherwise stated. This assumption is reasonable and natural because all the rotating masses mostly rotate in the same plane as the ecliptic plane in the solar system or the disc of a galaxy.

2.1.1. The Force Between the Sun and the Earth

Choosing the Sun to be located at $\vec{r}_1$ and the Earth to be located at $\vec{r}_2$ and choosing the reference point to be $\vec{r}_1$, i.e. $\vec{r}_1 = 0$, and $\vec{r}_2 = r$. $\Rightarrow \vec{r}_2 - \vec{r}_1 = \vec{r}_2 := r$. thus,

$$\vec{R}_{C.O.M} = \frac{m_1 \vec{r}_1 + m_2 \vec{r}_2}{m_1 + m_2} = \frac{m_2 \vec{r}_2}{m_1 + m_2}\,, \tag{28}$$

The sun's mass $(m_1 := M)$ is bigger than the Earth's mass (m_2) : $M \gg m_2$. thus,

$$\vec{R}_{C.O.M} = \frac{m_2 \vec{r}_2}{M + m_2} = 0\,, \tag{29}$$

$\vec{R}_{C.O.M}$ is the center of mass. Therefore, approximately, the Earth is at a distance r from the C.O.M., which is located in the sun's center:

$$|r_1 - R_{C.O.M}| = 0\,, \tag{30}$$
$$|r_2 - R_{C.O.M}| = r\,, \tag{31}$$

Then, the Sun's angular momentum is:

$$\begin{aligned} J_1 &= L_1 + S_1 = \\ &= m_1 v_1 |r_1 - R_{C.O.M}| + I_1 \omega_1 \approx I_1 \omega_1\,, \end{aligned} \tag{32}$$

I_1 is the moment of inertia of the sun ω_1 is the angular velocity of the sun around itself. The first term is zero because of Eq.(30)

The Earth's angular momentum is:

$$\begin{aligned} J_2 &= L_2 + S_2 = \\ &= m_2 v_2 |r_2 - R_{C.O.M}| + I_2 \omega_2 \approx m_2 v_2 r_2\,, \end{aligned} \tag{33}$$

I_2 is the moment of inertia of the Earth, ω_2 and is the angular velocity of the Earth around itself. Because the Earth has a big orbital angular momentum and a tiny bulk, the latter is negligible. By substituting in Eq.(26) we obtain:

$$\vec{F}^{L}_{(r)} = -g \frac{I_1 \omega_1 m_2 v_2 r}{r^2} \hat{r} = -g \frac{I_1 \omega_1 m_2 v_2 r}{r^2} \hat{r}\,, \tag{34}$$

The force decays as $1/r$! Unlike gravity, which decays as $1/r^2$.

The force from the dynamic mass moment equation $\vec{F}^{N}_{(r)}$ (23) is zero because:

$$L_1 = L_{\text{sun}} := m_1 c |r_1 - R_{C.O.M}| = 0\,, \tag{35}$$

i.e,

$$\vec{F}^{N}_{(r)} = 0\,, \tag{36}$$

Therefore, doesn't contribute.

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$$\vec{F}_{\text{total}} = \vec{F}^{L}_{(r)} + \vec{F}^{N}_{(r)} = \\ = g\frac{I_1\omega_1 m_2 v_2}{r}\hat{r} + 0 = g\frac{I_1\omega_1 m_2 v_2}{r}\hat{r}\,, \tag{37}$$

2.1.2. The Force Between a Galaxy and a Star and the Flat Rotation Curves

1. Choose the Galaxy's center to be located at $\vec{r}_1$ and the star to be located at $\vec{r}_2$ and choose the reference point to be at $\vec{r}_1 = 0$, and choose $\vec{r}_2 = r \Rightarrow \vec{r}_2 - \vec{r}_1 = r$ Thus:

$$\vec{R}_{C.O.M} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2} = \frac{m_2\vec{r}_2}{m_1 + m_2}\,, \tag{38}$$

The galaxy's mass $m_1 := M$ is bigger than the star's mass m_2: $M \gg m_2$. gives,

$$\vec{R}_{C.O.M} = \frac{m_2\vec{r}_2}{M + m_2} = 0\,, \tag{39}$$

Therefore, the star is at a distance r from the C.O.M. and the Galaxy at $r = 0$ from it, i.e.,

$$|r_1 - R_{C.O.M}| = 0\,, \tag{40}$$
$$|r_2 - R_{C.O.M}| = r\,, \tag{41}$$

The Galaxy's angular momentum:

$$J_1 = L_1 + S_1 = \\ = m_1 v_1 |r_1 - R_{C.O.M}| + S_1 \approx S_1\,, \tag{42}$$

Where S_1 is the galaxy's spin around itself, and L_1 is the orbital angular momentum around the center of mass (binary system with the star). The first term is zero due to Eq.(41) because the galaxy is massive compared to the star.
The force,$\vec{F}^{N}_{(r)}$, from the dynamic mass moment Eq.(23) is zero because:

$$L_1 = L_{\text{Galaxy}} := m_1 c |r_1 - R_{C.O.M}| = 0\,, \tag{43}$$

i.e. :

$$\vec{F}^{N}_{(r)} = 0\,, \tag{44}$$

The star's angular momentum:

$$J_2 = L_2 + S_2 = \\ m_2 v_2 |r_2 - R_{C.O.M}| + I_2\omega_2 \approx m_2 v_2 r_2\,, \tag{45}$$

Where I_2 is the moment of inertia of the star, ω_2 is the angular velocity of the star around itself (spin). Because the star has a big orbital angular momentum and a tiny bulk, the latter is negligible. L_2 is the orbital angular momentum of a rotating star around the galaxy at a distance r from the galaxy's center with orbital velocity $v(r)$:

$$|L_2| = mrv(r)\,, \tag{46}$$

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Calculating the S_1 for a Galaxy with a disk shape (two-dimensional as spiral galaxies): assuming a general mass density distribution $\rho_{(r)} = a_m r^m$ in a unit area A, the mass $M(r)$ is :

$$dM(r) = \rho(r)dA = a_m r^m (2\pi r)dr\,, \tag{47}$$

m is any integer number. Calculating the mass enclosed at radius r:

$$\begin{aligned} M(r) := \int_0^r dM = \\ &= \int_0^r \rho(r')dA = \int_0^r a_m r'^m 2\pi r' dr' = \\ &= 2\pi \frac{a_m}{m+2} r^{m+2}\,, \end{aligned} \tag{48}$$

assuming a general velocity distribution of the mass density:

$$v(r) = b_n r^n\,, \tag{49}$$

n is any integer number. Thus, the total spin S_1 becomes:

$$\begin{aligned} S_1(r) &= \int_0^r dMv(r')r' \\ &= b_n a_m 2\pi \frac{r^{(m+n+3)}}{(m+n+3)} \\ &= b_n a_m 2\pi \frac{m+2}{(m+n+3)} \frac{r^n}{1} \frac{r^{(m+2)}}{(m+2)} \\ &= \frac{(m+2)}{(m+n+3)} [\frac{b_n r^n}{1}][\frac{a_m 2\pi r^{(m+2)}}{(m+2)}] r \\ &= a_{n,m} M(r) r v(r)\,, \end{aligned} \tag{50}$$

Therefore,

$$S_1(r) = a_{n,m} M(r) r v(r)\,, \tag{51}$$

Where $a_{n,m}$ depends on the shape, mass, and velocity distribution of a given Galaxy.
The force $\vec{F}^L_{(r)}$ becomes:

$$\vec{F}^L_{(r)} = -g \frac{S_1(r)[mv(r)r]}{r^2} \hat{r}\,, \tag{52}$$

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2. Flat rotation curves The stable orbits of a rotating star around the center of the Galaxy, including the Gravity and the Blue Field forces, are given by :

$$
\begin{aligned}
&\underbrace{\frac{GM(r)m}{r^2}}_{\text{Gravity Force}} + \underbrace{g\frac{S_1(r)[mv(r)r]}{r^2}}_{\text{Blue Force}} = \underbrace{\frac{mv(r)^2}{r}}_{\text{Centrifugal force}} \\
&GM(r) + gv(r)rS_1(r) = rv^2_{(r)} \\
&rv^2_{(r)} - (grS_1(r))v(r) - GM(r) = 0 \\
&v(r) = \frac{grS_1(r) \pm \sqrt{g^2r^2S_1^2(r) + 4rGM(r)}}{2r} \\
&v(r) = \frac{gS_1(r) \pm \sqrt{g^2S_1^2(r) + \frac{4GM(r)}{r}}}{2},
\end{aligned}
\tag{53}
$$

with the limits,

$$
v(r) \sim \begin{cases} \sqrt{\dfrac{GM(r)}{r}} & r \to 0 \\ gS_1(r) & r \to \infty \end{cases}, \tag{54}
$$

The radius at which the two forces become equal, we denote by R_e:

- $r < R_e$ The Gravity Force dominates. So we ignored the Blue Force.
- $r > R_e$ The Blue Force dominates. So we ignore the Gravity Force.
- $r = R_e$ Transition zone. The two forces are equal.

Calculating R_e by equating the two forces:

$$
\begin{aligned}
\frac{GM_{(R_e)}m}{R_e^2} &= g\frac{S_{1(R_e)}(mv_{(R_e)}R_e)}{R_e^2} \\
R_e &= \frac{GM_{(R_e)}}{gv_{(R_e)}S_{1(R_e)}},
\end{aligned}
\tag{55}
$$

From the Gravity Force, we know:

$$
v_{(R_e)} = \sqrt{\frac{GM_{(R_e)}}{R_e}}, \tag{56}
$$

Substituting in Eq. (55) gives:

$$
v_{(R_e)} = gS_{1(R_e)}, \tag{57}
$$

Hence, the orbital velocity of the stars around the center of the Galaxy can be approximated:

$$
v(r) \sim \begin{cases} \sqrt{\dfrac{GM(r)}{r}} & 0 < r < R_e \\ gS_1(R_e) \equiv \sqrt{\dfrac{GM_{(R_e)}}{R_e}} = c. & R_e < r < \infty \end{cases} \tag{58}
$$

where c is constant. Therefore, the velocity is a constant over very far distances from the galaxy's center (even very far beyond the Halo), which follows the recent big research that found so [14]. This contradicts the popular Dark Matter theory, which predicts a velocity drop after the halo of

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the galaxy ends (most of the Dark Matter lies there according to Dark Matter theory) , which wasn't found in this research [14].
A spiral galaxy built approximately from a disk $0 < r < R$ (approximated by 2d mass density- we ignore the bulge, which is smaller than the planar late-type spiral galaxies, by Hubble's classification of galaxies, and include it in the disk) and a Halo $r > R$, is which is very sparse relative to the disk, so can be set to zero. Thus, the mass of the galaxy $M(r)$ versus distance r from the center can be modeled as (in section (4) we will explain why this approximation is true):

$$M(r) = \begin{cases} \rho_0 \pi r^2 \sim r^2 & \text{Disk } : 0 < r < R \\ 0 & \text{sparse Halo} : R < r < \infty \, , \end{cases} \tag{59}$$

Calculating the rotational velocity expected from the Gravity Force only (assuming the Blue Field doesn't exist) around the center of the Galaxy according to Newton's law:

$$v(r) = \sqrt{\frac{GM(r)}{r}} \, , \tag{60}$$

gives:

$$v(r) \sim \begin{cases} \sqrt{r} & \text{Disk} : 0 < r < R \\ \frac{1}{\sqrt{r}} & \text{sparse Halo} : R < r < \infty \end{cases} \, , \tag{61}$$

Adding the Blue Force using Eq.(58) and assuming the radius of the disk (R) is

$$R = R_e \, , \tag{62}$$

R_e is according to Eq. (55) we also assume that most of the mass of the galaxy is enclosed in $r < R_e$ (all the mass concentrated in the center of the galaxy) which is not the same as R_G which is defined as the radius of where there are still visible stars bounded to the galaxy, it can be far away from its center and the total mass density there approaches zero i.e. $R_e \ll R_G$ but $M(R_e) \approx M(R_G)$ the total mass of the galaxy. We call R_e the *effective galaxy radius*.
Beyond the disk or effective galaxy's radius R_e, the Gravity Force is weak, and the Blue Force begins to dominate. Therefore:

$$v(r) \sim \begin{cases} \sqrt{r} & 0 < r < R_e : \text{ Disk(Gravity dominates)} \\ \text{c} & R_e < r < \infty : \text{ Halo(Blue Field dominates)} \end{cases} \tag{63}$$

Where c :=constant, equals:

$$c = gS_1(R_e) = gS_1(r > R_e) = gS_1(\infty) \, , \tag{64}$$

The Halo $r > R_e$ is very sparse. Therefore, doesn't contribute to the total angular momentum of the galaxy $S_1(R)$, which will remain constant as no more mass (angular momentum) is added. then

$$M_{(R_e)} \approx M(R_G) := M \Longleftrightarrow S(R_e) \approx S(R_G) := S \, , \tag{65}$$

M is the total mass of the galaxy, and S is the total angular momentum of the galaxy. Therefore, the velocity remains constant, i.e., $v_{(r > R_e)} = gS_1(r > R_e) = gS_1(R_e) = v_{(R_e)}$. Hence, a *flat rotation curve*!

The asymptotic velocity (at a radius very distant from the center of the Galaxy) is:

$$v_{(\infty)} := gS_1(\infty) \underbrace{\approx}_{\text{sparse Halo}} v(R_e) = gS_1(R_e) =$$
$$= \sqrt{\frac{GM_{(R_e)}}{R_e}}\,, \tag{66}$$

Or in short,

$$v_{(\infty)} \approx v(R_e)\,, \tag{67}$$

The sparse halo indicates again that beyond R_e, there is negligible mass and angular momentum. Thus, $v(R_e)$ doesn't change.

3. Extracting the coupling constant g
Calculating the total angular momentum of the Galaxy according to Eq.(50)

$$\begin{aligned} S_1(\infty) &= \int_0^{R_e} dMv(r')r' + \int_{R_e}^{\infty} dMv(r')r' = \\ &= a_{n,m}M_{(R_e)}R_e v_{(R_e)} + 0 = \\ &= a_{n,m}M_{(R_e)}R_e v_{(R_e)}\,, \end{aligned} \tag{68}$$

for $r > R_e$ the contribution is negligible and is set to zero. Plugging R_G (the Galaxy's radius) $\approx \alpha_G R_e$, where α_G depends on each spiral galaxy type. According to Eq.(62), M_G (the Galaxy's mass) $\approx M_{(R_e)}$ and Eqs.(65) (66) $v_{(\infty)} \approx v_{(R_e)}$ gives:

$$\begin{aligned} S_1(\infty) &\approx \alpha_G a_{n,m} M_{(R_e)} R_e v_{(R_e)} \\ &\approx a_{n,m} M R v_{(\infty)}\,, \end{aligned} \tag{69}$$

using Eq. (58)

$$v_{(\infty)} = gS_1(\infty)\,, \tag{70}$$

gives:

$$\frac{v_{(\infty)}}{g} \approx \alpha_G a_{n,m} M R v_{(\infty)}\,, \tag{71}$$

canceling v_∞ from the two sides:

$$1 \approx g\alpha_G a_{n,m} M R\,, \tag{72}$$

then,

$$g^{-1} \approx \alpha_G a_{n,m} M R\,, \tag{73}$$

where $a_{n,m}$ depends on the shape, mass, and velocity distribution of the given Galaxy, M is the total mass of the galaxy, and R is the disk's radius.

4. The Tully-Fisher relation and Modified Newtonian dynamics (MOND)
Tully–Fisher relation (TFR) is an empirical relation between the asymptotic rotation velocity v_∞ of the galaxy's outer stars and the galaxy's mass (M): $v_\infty^4 \sim M$ [16] This relation can be derived from Eqs. (60),(57) as follows :

From Gravity Force:

$$\frac{GM(r)m}{r^2} = \frac{mv(r)^2}{r} \Rightarrow v(r)^2 = \frac{GM(r)}{r}, \tag{74}$$

The spiral Galaxies have a discoid shape and a mass density of the disk according to Enisato profile [17] :

$$\rho(r) \sim \rho_0 e^{-Ar^\alpha}, \tag{75}$$

The parameter α controls the degree of curvature of the profile. For spiral galaxies $\alpha = 1$ [19]. ρ_0 is the mass density at the center of the galaxy.
A is the scale length of the galaxy, and the radius of a spiral galaxy (R_G), which can be defined, for example, where the mass density $\rho(r)$ (visible mass) becomes n times lower than ρ_0 :

$$\rho_0/n = \rho_0 e^{-AR_G} \Rightarrow R_G = \ln n/A, \tag{76}$$

So the total mass of the galaxy (in 2d disc shape), using integration by parts, is:

$$\begin{aligned} M(r) &= \int_0^r \rho(r')(2\pi r')dr' \\ &= \int_0^r e^{-Ar'}(2\pi r')dr' = \\ &= 2\pi\rho_0 \frac{1 - Are^{-Ar} - e^{-Ar}}{A^2}, \end{aligned} \tag{77}$$

For $r \ll \frac{1}{A} = \frac{R_G}{\ln n}$, the exponents approximated by $\exp(x) = 1 + x$ we obtain,

$$\begin{aligned} M(r) &\sim 2\pi\rho_0 \frac{1 - Ar(1 - Ar) - (1 - Ar)}{A^2} = \\ &= 2\pi\rho_0 r^2 \end{aligned} \tag{78}$$

thus,

$$M(r) \sim 2\rho_0 \pi r^2 \Rightarrow r \sim \sqrt{\frac{M(r)}{2\pi\rho_0}}, \tag{79}$$

substitute in Eq. (74) gives:

$$\begin{aligned} v^2(r) &\sim \frac{GM(r)}{r} = \frac{GM(r)}{\sqrt{\frac{M(r)}{2\pi\rho_0}}} = \\ &= G\sqrt{2\rho_0 \pi M(r)}, \end{aligned} \tag{80}$$

hence,

$$v(r)^4 \sim 2\rho_0 \pi G^2 M(r), \tag{81}$$

choosing r to be the radius R_e we obtain,

$$v^4_{(R_e)} \sim 2\rho_0 \pi G^2 M_{(R_e)}, \tag{82}$$

But M(the Galaxy's mass) $\approx M_{(R_e)}$ according to Eq.(65) and using Eq.(66) $v_{(\infty)} \approx v_{(R_e)}$ gives:

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$$v^4_{(\infty)} \sim 2\rho_0 \pi G^2 M \sim M\,, \tag{83}$$

which is TFR!
Furthermore, the Modified Newtonian dynamics (MOND) is an alternative theory for Dark Matter that explains the TFR [18], which predicts the empirical relation:

$$v^4_{(\infty)} = a_0 G M\,, \tag{84}$$

where $a_0 \approx 1.2 \times 10^{-10} m/s^2$ [18] is a tiny constant acceleration, below which the classical gravity stops working, and the realm of non-Newtonian dynamics dominates. Equating to the relation in Eq. (82) gives:

$$a_0 = 2\rho_0 \pi G\,, \tag{85}$$

Substituting the values in this equation gives an average mass density $\rho_0 \approx 1kg/m^2$.
by Eq.(79) , ρ_0 also satisfies

$$M_{(R_e)} \approx \rho_0 2\pi R_e^2\,, \tag{86}$$

Substituting in Eq. (85) gives:

$$\begin{aligned} a_0 &= \frac{GM_{(R_e)}}{R_e^2} \\ \Rightarrow m a_0 &= \frac{GM_{(R_e)} m}{R_e^2} = F_{\text{Gravity}} = F_{\text{Blue Force}}\,, \end{aligned} \tag{87}$$

This is the gravitational acceleration at the radius R_e where the Gravity Force becomes equal to the Blue Force that was calculated before. Beyond this radius or below this acceleration, the Blue Force dominates and gives a deviation from the gravitational acceleration as expected. Thus, the Blue Force recapitulates the MOND predictions without the need for MOND itself. The $r > R_e$ regime is equivalent to the MOND regime in MOND theory, where the Newtonian dynamics isn't valid anymore according to MOND, but here it is just because of another Newtonian force, the Blue Force.
ρ_0 must be a constant among the spiral galaxies, so these arguments can hold. It is the average mass density in the central regions. It could be constant because of similar dynamics in the Galaxies' center, e.g., supermassive black hole effects.

2.2. The Force Between Two Dynamic Mass Moments and the Emergence of Dark Energy

The potential energy between two dynamic mass moments of two objects, according to the approximation in Eq. (22) is:

$$\begin{aligned} E(r) &= g\frac{\vec{N}_1 \cdot \vec{N}_2}{r} \\ &= g\frac{[m_1 c|r_1 - \vec{R}_{C.O.M}|][m_2 c|r_2 - \vec{R}_{C.O.M}|]}{|r_2 - r_1|}\,, \end{aligned} \tag{88}$$

and the force between them:

$$\vec{F} = g\frac{\vec{N}_1 \cdot \vec{N}_2}{r^2}\hat{r}$$
$$= g\frac{[m_1 c|r_1 - \vec{R}_{C.O.M}|][m_2 c|r_2 - \vec{R}_{C.O.M}|]}{|r_2 - r_1|^2}|r_2 \hat{-} r_1|\,, \tag{89}$$

The center of mass of two particles located at $\vec{r}_1, \vec{r}_2$ and the distance in between is r. Choosing the reference point to be $\vec{r}_1$. Thus $\vec{r}_1 = 0, \vec{r}_2 = r, \Rightarrow \vec{r}_2 - \vec{r}_1 = \vec{r}$.

$$\vec{R}_{C.O.M} = \frac{m_2\vec{r}_2}{m_1 + m_2}\,, \tag{90}$$

The two masses are identical $m_1 = m_2$. Thus:

$$\vec{R}_{C.O.M} = \frac{r}{2}\,, \tag{91}$$

Substituting in Eq.(88) gives

$$\vec{F} = g\frac{m^2c^2}{4}\hat{r}\,, \tag{92}$$

Plugging the Planck density $m = M_p$, we obtain,

$$\vec{F} = g\frac{M_p^2c^2}{4}\hat{r}\,, \tag{93}$$

The force is independent of r! It is a *constant* in space-time.

This force doesn't have any special direction. It is a uniform force that cancels out in the bulk except for the boundary and acts upon it. It's like the pressure of a gas pushing the edges of a container, but with a negative force, as this force is always attractive. Therefore, it behaves like vacuum energy! The relation between energy density and pressure is given by:

$$\text{Energy density} = \frac{E}{V} := P = |\frac{\vec{F}}{A}| \propto gm^2\,, \tag{94}$$

Where P is the pressure, and A is a unit of area. This is a Lorentz invariant constant energy density in space-time that can play the role of a *vacuum-like energy*.

3. Calculations and Predictions of the Model

Here we do some calculations and show how the suggested model fits the cosmological observations.

3.1. Estimating the Coupling Constant g

Taking the average of Eq.(73):

$$\langle g^{-1}\rangle = \langle \alpha_G a_{n,m} MR\rangle\,, \tag{95}$$

Using the well-known covariance formula:

$$\langle XY\rangle - \langle X\rangle\langle Y\rangle = cov(X,Y)\,, \tag{96}$$

Gives:

$$\begin{aligned}\langle g^{-1}\rangle =&\langle \alpha_G a_{n,m} MR\rangle \\ =&\langle \alpha_G a_{n,m}\rangle\langle MR\rangle + cov(\alpha_G a_{n,m}, MR)\,,\end{aligned} \tag{97}$$

Defining:

$$\begin{aligned}cov(\alpha_G a_{n,m}, MR) &= \text{constant} := \beta \\ \langle \alpha_G a_{n,m}\rangle &= \text{constant} := \alpha\,,\end{aligned} \tag{98}$$

Gives:

$$\langle g^{-1}\rangle = \alpha\langle MR\rangle + \beta\,, \tag{99}$$

Using the variance formula:

$$Var(\alpha X + \beta) = \alpha^2 Var(X)\,, \tag{100}$$

Gives:

$$Var(g^{-1}) = Var(\alpha MR + \beta) = \alpha^2 Var(MR)\,, \tag{101}$$

Thus, the g^{-1} can be calculated by $\langle MR\rangle$ up to multiplicative and additive constants.

Calculating the $\langle MR\rangle$ from Table A gives:

$$\langle MR\rangle = 27.24\,, \tag{102}$$

$$\sqrt{Var} := S_d(MR) = 38.85\,, \tag{103}$$

Hence,

$$\langle g^{-1}\rangle \propto \langle MR\rangle = 27.24\,, \tag{104}$$

$$s_d(g^{-1}) = 38.85\,, \tag{105}$$

using the scale factor for g^{-1} from Table A which is 10^{61}, we obtain,

$$\langle g^{-1}\rangle \propto \langle MR\rangle = 27.24 \times 10^{61}\,, \tag{106}$$

Thus:

$$\langle g\rangle \sim 3.6 \times 10^{-63}\,, \tag{107}$$

Which is estimated to be the coupling constant for the suggested Blue Force.

It is impossible to measure this tiny value in any lab on Earth. This explains why the "Dark Matter" is so elusive and has not been detected yet in any particle accelerator!

Next, the values of g^{-1} are closely situated around the mean and only one standard deviation from it. i.e., they are minimally dispersed as shown in Figure (1). This strongly supports the existence of this new force.

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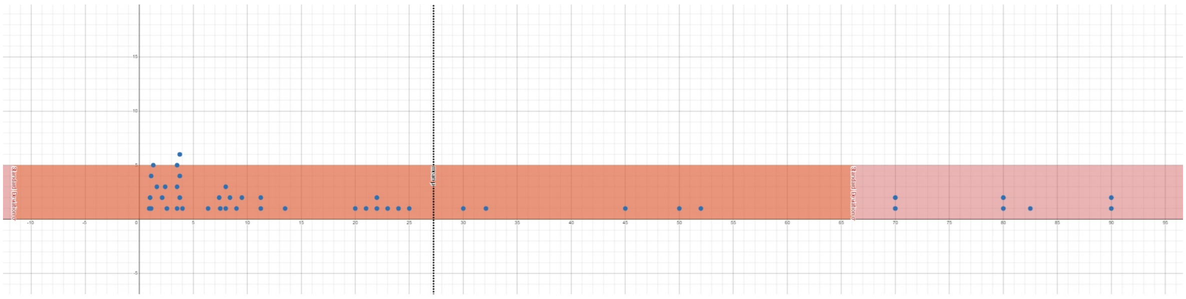

Figure 1. g^{-1} values around the mean

3.2. The Effects on Our Solar System

using Eq.(108), the Blue Force between the sun and Earth is:

$$\vec{F} = g\frac{I_1\omega_1 m_2 v_2}{r}\hat{r} \tag{108}$$

Where $I_1 w_1 = M_1 R_1^2 \omega_1$ is the total spin (self-rotation) of the Sun, I_1 is the moment of inertia of the Sun: $I_1 = 2/5 M_1 R_1^2 \sim M_1 R_1^2$, where M_1 is the Sun's mass, R_1 is its radius, and ω_1 its self-rotation angular velocity. m_2 is the Earth's mass, ω_2 is the orbital angular velocity of the Earth's rotation around the sun. $v_2 = \omega_2 r_2$, where v_2 is the revolving velocity of the Earth around the Sun. $r = |r_2 - r_1|$ is the distance between the Sun (r_1) and the Earth (r_2). renaming quantities for more clarity: $M_1 := M_{\text{sun}}$, $R_1 := R_{\text{sun}}$, $\omega_1 := \omega_{\text{sun}}$, $m_2 := m_{\text{earth}}$, $\omega_2 := \omega_{\text{earth}}$,$v_2 := v_{\text{earth}}$. Rearranging terms of Eq. (108) gives:

$$\begin{aligned}\vec{F} &= g\frac{(m_{\text{earth}} r^2 \omega_{\text{earth}})(M_{\text{sun}} R_{\text{sun}}^2 \omega_{\text{sun}})}{r^2}\hat{r} = \\ &= gG^{-1}(r^2 \omega_{\text{earth}} R_{\text{sun}}^2 \omega_{\text{sun}}) \underbrace{\frac{(GM_{\text{sun}} m_{\text{earth}})}{r^2}}_{\text{regular Gravity Force}=\vec{F}_g} \hat{r}\,,\end{aligned} \tag{109}$$

Inserting the well-known values:

G= Gravity constant.
$R_{\text{sun}} = 7 \times 10^8 m$.
$r = 1.5 \times 10^{11} m$.
$\omega_{\text{sun}} \approx 2\pi/24$ hours.
$\omega_{\text{earth}} = 2\pi/24$ hours.
$g \approx 3 \times 10^{-63}$ by Eq. (107).
then,

$$\begin{aligned}\vec{F} &= gG^{-1}(r^2 \omega_{\text{earth}} R_{\text{sun}}^2 \omega_{\text{sun}}) \\ &= 2.4 \times 10^{-23} \vec{F}_g\,,\end{aligned} \tag{110}$$

Hence, the force is negligible in our solar system!. This explains why there is no "Dark Matter" in our solar system!

Inserting parameters of other planets in the solar system gives similar results.

Next, replacing the Sun with the Milky Way Galaxy parameters and substituting $v_G = R_{\text{Milky Way}} \omega_{\text{Milky Way}} \approx 220 km/s$, which is also known as the galactic year, the time the Sun takes to revolve around the center of the galaxy. It is also considered the asymptotic rotational velocity as the sum exists in the outer regions of the Milky Way. We obtain:

$$r = \frac{g^{-1}G}{v_{\text{earth}} R^2_{\text{Milky way}} \omega_{\text{Milky way}}} = \frac{g^{-1}G}{v_{\text{earth}} R_{\text{Milky way}} v_G} \gtrsim 10^{21} m \,, \tag{111}$$

Miraculously, the Blue force equates the gravity at radii located in the Milky Galaxy edges, i.e., the Halo region! (The Milky Way Disk's radius $R \approx 10^{21} m$) This explains why the "hypothetical Dark Matter" lies mainly there, as this force becomes as strong as gravity and starts to dominate.

3.3. The Dark Matter in Different Structures of the Universe

3.3.1. Cluster's Dark Matter

The potential energy of the Blue Field between two galaxies in a cluster of galaxies is:

$$E^L_{(r)} = -g \frac{\vec{J}_1 \cdot \vec{J}_2}{|r_2 - r_1|} = -g \frac{|\vec{J}_1||\vec{J}_1|}{|r_2 - r_1|} \cos\theta \,, \tag{112}$$

$r_{1/2}$ is the position of the two galaxies. The Blue force is:

$$F^L_{(r)} = -g \frac{\vec{J}_1 \cdot \vec{J}_2}{|r_2 - r_1|^2} |r_2 \hat{-} r_1| \,, \tag{113}$$

$J_{1/2} = L_{1/2} + S_{1/2}$ is the total angular momentum. $L_1 = (M_1 v_1 |r_1 - r_{C.O.M}|), L_2 = (M_2 v_2 |r_2 - r_{C.O.M}|)$ is the orbital angular momentum of each galaxy around its center of mass, and $S_1 = M_1 V_1 R_1, S_2 = M_2 V_2 R_2$ is the spin of each of the two galaxies around itself. assuming the two galaxies are identical $M_1 = M_2 := M, R_1 = R_2 := R$ (radius of the galaxy). $v_1 = v_2 := v$ (orbital velocity),$V_1 = V_2 := V$ (self-rotational velocity) and choosing $|r_2 - r_1| := r$. thus, $r_{C.O.M} = \frac{r}{2}$. Substituting and arranging terms in Eq.(112) gives:

$$E^L_{(r)} = -g(\frac{V^2R^2 + 4v^2r^2}{4G}) \underbrace{\frac{GM^2}{r}}_{\text{grav. pot.} = E^G_{(r)}} \cos\theta = -g(\frac{V^2R^2 + 4v^2r^2}{4G}) E^G_{(r)} \cos\theta \,, \tag{114}$$

Where (grav. pot.) Stands for gravitational potential energy. Taking the average:

$$\langle E^L_{(r)} \rangle = -g(\frac{V^2R^2 + 4v^2r^2}{4G}) \langle E^G_{(r)} \rangle \langle \cos\theta \rangle = -g(\frac{V^2R^2 + 4v^2r^2}{4\pi G}) \langle E^G_{(r)} \rangle \,, \tag{115}$$

where $\langle |\cos\theta| \rangle = 1/\pi$ (for a uniform random distribution $[0, 2\pi]$).

Gives:

$$\langle E^L_{(r)} \rangle = -g(\frac{V^2R^2 + 4v^2r^2}{4\pi G}) \langle E^G_{(r)} \rangle \,, \tag{116}$$

This Blue potential energy quickly overcomes gravitational potential energy at large distances as the "coupling constant " grows quadratically $\sim r^2$ relative to gravity. using values: R is the radius of an average galaxy, for the Milky Way $R \approx 10^{21} m$. The average speed of a galaxy's rotation around itself of the Milky Way is about $V \approx 200 km/sec = 2 \times 10^5 m/sec$ (galactic year). The galaxy's orbital velocity in the cluster is about $v \approx 1000km/sec = 10^6 m/sec$ (galaxy's orbital velocity [26]). The cluster's total radius is about $r_{\text{cluster}} = 10^{23} m$ (cluster's total radius [26]). The average distance between galaxies is about $r = 10^{22} m$ [15] and $g \sim 3 \times 10^{-63}$ from previous sections. G is the gravitational constant. Substituting these values in Eq. (114) gives ($V^2 R^2$ is negligible relative to $4v^2 r^2$):

$$\langle E^L_{(r)} \rangle \approx 400 \langle E^G_{(r)} \rangle \,, \tag{117}$$

Now, calculating the supposed "effective mass" that contributes to this potential energy, substituting back in $E^G_{(r)}$:

$$400 \langle E^G_{(r)} \rangle \approx \frac{G(20M)^2}{r} := \frac{G(M_{\text{eff}})^2}{r} \,, \tag{118}$$

thus,

$$M_{\text{eff}} \approx 20M \,, \tag{119}$$

Therefore, the effective (measured) mass of the cluster is bigger than its actual mass (times 20); this extra mass is considered as the "Dark Matter"! This follows, in a rough estimation, the observation that most of the cluster's mass, about 90%, is "Dark Matter" [4].

Notice that even when two masses are moving in a straight line relative to each other, they still have angular momentum $L = m\vec{v} \times \vec{r} \neq 0$ .r_0 is the distance to their center of mass. The angular momentum for a linearly moving particle is:

$$\begin{aligned} L = m\vec{v}_{1/2} \times \vec{r} = m|\vec{v}_{1/2}||\vec{r}_0| \cos\theta = \\ = m v_{1/2} \frac{r}{\cos\theta} \cos\theta = m v_{1/2} r_0 \,, \end{aligned} \tag{120}$$

Therefore, although the net angular momentum of the cluster may be zero as it doesn't rotate in total, the galaxies within still have angular momentum relative to each other, according to the above argument (angular momentum density isn't zero). Thus, the orbital-orbital interaction of galaxies within the cluster is non-zero if the galaxies move in straight relative to each other, and the above calculation still holds in both cases.

3.3.2. The Universe's Dark Matter

The density of galaxies in the entire universe is similar to the cluster of galaxies [14]. Hence, Eq.(114) also holds for the entire universe and gives the same result:

$$M_{\text{eff}} \approx 20M \,, \tag{121}$$

Therefore, the effective (measured) mass of the universe is bigger than its actual mass. This extra mass is considered the "Dark Matter"! This is in accordance, in a rough estimation, with the observation that most of the universe's mass, about 90%, is "Dark Matter" [27].

3.3.3. Galaxy's Dark Matter

The same calculation in the cluster section 3.3.1 can be applied to an elliptical galaxy or spiral galaxy, which can be considered as a "cluster of stars", the attraction between the angular momenta of its randomly moving stars imitates the existence of the "Dark Matter" within it, as follows:

The potential energy of the Blue Field between two stars within the galaxy is:

$$E^L_{(r)} = -g \frac{\vec{J}_1 \cdot \vec{J}_2}{|r_2 - r_1|} = -g \frac{|\vec{J}_1||\vec{J}_1|}{|r_2 - r_1|} \cos\theta \,, \tag{122}$$

$r_{1/2}$ is the position of the stars. And the Blue Force is:

$$F^{L}_{(r)} = g\frac{\vec{J}_1 \cdot \vec{J}_2}{|r_2 - r_1|^2}|r_2 \hat{-} r_1|\,, \tag{123}$$

$J = L + S$ is the total angular momentum. substituting $L_1 = (M_1 v_1 |r_1 - r_{C.O.M}|), L_2 = (M_2 v_2 |r_2 - r_{C.O.M}|)$ is the orbital angular momentum of each star around its center of mass, and $S_1 = M_1 V_1 R_1, S_2 = M_2 V_2 R_2$ is the spin of each of the two stars. assuming the two stars are identical $M_1 = M_2 := M, R_1 = R_2 := R$ (radius of the star)$v_1 = v_2 := v$, (orbital velocity),$V_1 = V_2 := V$ (self-rotational velocity), and choosing $|r_2 - r_1| := r$, then $r_{C.O.M} = \frac{r}{2}$. Substituting and arranging terms in Eq.(122) gives:

$$E^{L}_{(r)} = -g(\frac{V^2R^2 + 4v^2r^2}{4G})\underbrace{\frac{GM^2}{r}}_{\text{grav. pot. } = E^{G}_{(r)}}\cos\theta =$$

$$= -g(\frac{V^2R^2 + 4v^2r^2}{4G})E^{G}_{(r)}\cos\theta\,, \tag{124}$$

Where (grav. pot.) Stands for gravitational potential. Taking the average:

$$\langle E^{L}_{(r)}\rangle = -g(\frac{V^2R^2 + 4v^2r^2}{4G})\langle E^{G}_{(r)}\rangle\langle\cos\theta\rangle\,, \tag{125}$$

Where $\langle|\cos\theta|\rangle = 1/\pi$, for a uniform random distribution $[0, 2\pi]$ of an elliptical galaxy. $\langle|\cos\theta|\rangle = 1$, for spiral galaxies, all the stars rotate in the same plane (the galaxy's disk), which gives:

$$\langle E^{L}_{(r)}\rangle = -g(\frac{V^2R^2 + 4v^2r^2}{4G})\langle E^{G}_{(r)}\rangle\,, \tag{126}$$

The spin of the stars is negligible to the orbital angular momentum around the galaxy, so we ignore the first term, which gives:

$$\langle E^{L}_{(r)}\rangle = -g(\frac{v^2r^2}{G})\langle E^{G}_{(r)}\rangle\,, \tag{127}$$

This Blue potential energy quickly overcomes gravitational potential energy at large distances as the "coupling constant" grows quadratically $\sim r^2$ relative to gravity. plugging values: The average speed of a star's rotation around the galaxy's center of mass is about $v \approx 200km/sec = 2 \times 10^5 m/sec$ (galactic year) for the Milky Way, and the average distance between stars within the galaxy is about $r = 5\text{ly} = 5 \times 10^{16} m$ (National Radio astronomy observatory [28]) for the Milky Way. $g \sim 3 \times 10^{-63}$ From previous sections. G is the gravitational constant. Substituting in Eq (127) gives,

$$\langle E^{L}_{(r)}\rangle \approx 10^{-9}\langle E^{G}_{(r)}\rangle\,, \tag{128}$$

Which is negligible within the galaxy itself. But if we take r to be in the edges (the halo) of the galaxy, i.e., $r \geq 10^{21} m$ (the radius of the Milky Way) and substitute back for $E^{G}_{(r)}$:

$$\langle E^{L}_{(r)}\rangle \gtrsim 0.4\langle E^{G}_{(r)}\rangle\,, \tag{129}$$

Thus, *this extra gravity potential is sensible only at the edges (Halo) of galaxies and negligible in the center of galaxies! This explains why the hypothetical Dark Matter lies only in the halo!* This extra potential in the halo also makes the flat rotation curve that we dealt with in the previous section.

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3.3.4. Solar System's Dark Matter

The potential energy of the Blue Field between two planets in the solar system is:

$$E^L_{(r)} = -g\frac{\vec{J}_1 \cdot \vec{J}_2}{|r_2 - r_1|} = -g\frac{|\vec{J}_1||\vec{J}_1|}{|r_2 - r_1|}\cos\theta\,, \tag{130}$$

$r_{1/2}$ is the position of the planets. The Blue Force is:

$$F^L_{(r)} = -g\frac{\vec{J}_1 \cdot \vec{J}_2}{|r_2 - r_1|^2}|r_2 \hat{-} r_1|\,, \tag{131}$$

Substituting $L_1 = (M_1 v_1 |r_1 - r_{C.O.M}|), L_2 = (M_2 v_2 |r_2 - r_{C.O.M}|)$ is the orbital angular momentum of each planet around its center of mass $S_1 = M_1 V_1 R_1, S_2 = M_2 V_2 R_2$ is the spin of each of the two planets.

Assuming the two planets are identical $M_1 = M_2 := M, R_1 = R_2 := R$ (radius of the planet)$v_1 = v_2 := v$, (orbital velocity),$V_1 = V_2 := V$ (self-rotational velocity), and choosing $|r_2 - r_1| := r$, $r_{C.O.M} = \frac{r}{2}$. Arranging terms in Eq.(130) :

$$\begin{aligned} E^L_{(r)} &= -g(\frac{V^2R^2 + 4v^2r^2}{4G}) \underbrace{\frac{GM^2}{r}}_{\text{grav. pot. } = E^G_{(r)}} \cos\theta = \\ &= -g(\frac{V^2R^2 + 4v^2r^2}{4G})E^G_{(r)}\cos\theta\,, \end{aligned} \tag{132}$$

Where $|\cos\theta| = 1$ because all the planets rotate in the same plane.

The spin of the planets is negligible compared to their orbital angular momentum around the sun. We ignore the first term, giving:

$$E^L_{(r)} = -g(\frac{v^2r^2}{G})E^G_{(r)}\,, \tag{133}$$

plugging values for Earth and Mars: The average speed of the Earth's rotation around the galaxy's center of mass is about $v \approx 30km/sec = 3 \times 10^4 m/sec$ for Earth and Mars. The average distance between Earth and Mars is $\approx 5 \times 10^{10} m$. $g \sim 3 \times 10^{-63}$ From previous sections. G is the gravitational constant.

Substituting in equation (133) we obtain

$$\langle E^L_{(r)} \rangle \approx 10^{-38} \langle E^G_{(r)} \rangle\,, \tag{134}$$

Which is very negligible and can't be measured. Even if we take r to be at the edges of the solar system, i.e., the distance from Earth to Pluto $r \approx 5 \times 10^{12} m$, and take v to be the highest speed between the two planets, which is the Earth, substitute back for $E^G_{(r)}$ gives:

$$\langle E^L_{(r)} \rangle \approx 10^{-30} \langle E^G_{(r)} \rangle\,, \tag{135}$$

Taking r to be at the edges of the solar system, i.e., an object in the Oort cloud, which is about $r = 2\text{ly} \approx 10^{15} m$, and taking v as the speed of Earth gives:

$$\langle E^L_{(r)} \rangle \approx 10^{-21} \langle E^G_{(r)} \rangle\,, \tag{136}$$

Thus, the Blue Field is negligible in the solar system. This is in accordance with the observed fact that *there is no Dark Matter in our solar system*!

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3.4. The Bullet Cluster

The Bullet Cluster [1] consists of two colliding clusters of galaxies in which the Dark Matter in the halo of these two clusters isn't interrupted by this collision, and it is used to defy any alternative theory of Dark Matter as not inert particles. This phenomenon can be explained by *light lensing* exerted by this new force as follows: The light rays are also affected by this new force, as they also contain orbital angular momentum, The force between light and a galaxy/cluster (M) is:

$$\vec{F} = g\frac{\vec{L}_{\text{light}} \cdot \vec{L}_{\text{Bullet Cluster}}}{r^2}\hat{r} = g\frac{\vec{L}_{\text{light}}\,\vec{L}_{\text{Bullet Cluster}}|\cos\theta|}{r^2}\hat{r}\,, \tag{137}$$

Where θ is the angle between the two angular momenta. We took its absolute value as this force is always attractive. Substituting for the angular momentum of the light:

$$|\vec{L}_{light}| = pr = (\hbar k)r = m_{light}cr\,, \tag{138}$$

Where $m_{light} := \frac{\hbar w}{c^2}$ is the "mass" of light in classical terms. Where k =wave number of the light. r =Radius to the center of the cluster. The angular momentum of the cluster $\vec{L}_{\text{Bullet Cluster}}$ is the angular momentum of its constituents (M_i) after the impaction:

$$\vec{L}_{\text{Bullet Cluster}} \approx \sum_i M_i v_i \times r_i = \sum_i M_i|v_i||r_i|\sin\theta_i\,, \tag{139}$$

Gives:

$$\begin{aligned}\vec{F} &= \frac{g(m_{light}cr)(\sum_i M_i v_i r_i|\sin\theta_i|)}{r^2}|\cos\theta|\hat{r} = \\ &= \sum_i \overbrace{\frac{gcv_i r_i|\cos\theta||\sin\theta_i|r}{G}}^{\text{coupling constant}:=k(r,\theta)} \cdot \overbrace{(\frac{GM_i m_{light}}{r^2})}^{\text{Gravity Force}:=\vec{F}_g} \\ &:= k(r,\theta)\vec{F}_g\,,\end{aligned} \tag{140}$$

Thus, the coupling constant is anisotropic and depends on the angle! This coupling constant increases with distance from the cluster center, exceeding the gravity strength at larger distances. This bending of light is so weak that we see it only in very huge cosmological structures like clusters that also have huge angular momentum (of the impaction).

Here, we introduced only a classical treatment of the bending of the light as if it had a mass. Gravity bends the light beam by changing the curvature of space-time. A similar treatment should be done, which was discussed in another paper.

4. Discussion

The suggested Blue Field can explain various observations of the supposed Dark Matter and Dark Energy in one simple formulation. This force is coupled to the angular momentum tensor of particles (the conserved charges of the force) and has been shown to increase with distance till overcoming gravity at large distances. Thus dominating the universe at large scales. It also interacts with light and bends its route, which can explain the light lensing around the Bullet Cluster without the need for the hypothetical "Dark Matter".

The current model manages to produce the famous Tully-Fisher relation (TFR) explained by MOND [16]. The estimated coupling constant of this field by rough estimation from cosmological observation such as galaxies' masses and radii is found to be incredibly tiny that no effects can be measured in our solar system, including any particle detector on earth, that fits the fact that no "dark" matter has been detected in our solar system or any deviation from newton's law of gravity. This force becomes measurable only at the galaxy scale, especially at the Halo region, where the force, as has been shown, increases enough to affect the orbits of stars. This force causes the star to orbit the galaxy's center at a constant speed, making the flat rotation curves observed in the outskirts of galaxies and explaining the fact that "Dark Matter" is mainly found in the galaxy's halo. The same argument applies to other galaxy types, such as elliptical galaxies. At the cluster scale and bigger scales, the missing mass or "Dark Matter" is nothing more than the interaction between the galaxies via the Blue Force. It also helped the formation of the first galaxies, as they have non-zero angular momentum density. At these large scales, gravity is too weak to cause matter to clump together, which makes the presence of this force crucially important. The other part of the angular momentum tensor is the dynamic mass moment (besides the spatial angular momentum). This part gives a constant force across space-time. This constant force canceled out in the bulk of space-time except for the boundaries, thus making a negative pressure imitating the vacuum energy and contributing to the universe's expansion, becoming a possible origin of the mysterious "Dark Energy" hypothesized to drive this expansion. The smallness of the coupling constant of the Blue Force explains why the value of this Dark Energy is so tiny. Thus, in light of this new field, Dark Energy and matter are no longer "dark" and are just the two sides of the same coin, so we gave them a color, the Blue Field.

We used very rough cosmological data to estimate the coupling constant to show the principles, how the suggested model works, and how it can explain the mentioned observations. More accurate values and calculations are needed to get more accurate observations and predictions. Furthermore, in the Bullet Cluster description, we describe it in very general lines and qualitative descriptions. A more rigorous mathematical formulation could be done to make more specific predictions. Lastly, the fact that no pure dark galaxies, dark clusters, or dark stars that contain only Dark Matter have ever been seen, although it is the most abundant material in the universe. According to the Dark Matter theory, the Dark Matter" always tracks the regular matter and supports the current model, as there is no actual extra mass, just a missing twin of Einstein gravity. All of the calculations in this paper are approximated calculations because we used rough observed data. More accurate data could be used to get more accurate results, but the proof of concept has been shown.

5. Conclusion

The longstanding mysterious cosmological observations, including the missing mass ("Dark Matter") incarnated by flat rotation curves of galaxies, the Bullet Cluster, Tully-Fisher relation, and Dark Energy with its very tiny value (close to zero) can be explained in a simple model by suggesting one new field, the Blue Field. The coupling constants of this new field are so tiny that it becomes dominant only at large distances. Thus explaining the existence of "Dark Matter" mainly in galaxies' Halos and the absence of Dark Matter in our solar system. The potential energy of this field can be the "missing energy" of the universe. Because of the smallness of its coupling constant but increasing with distance makes this force the architect of the big scales of the universe from the galactic scale and bigger, where the gravity is too weak to play a role and make this field a good candidate even a needed one to understand the universe formation at a big scale especially with the observation of missing energy and mass on the big scale.

Appendix A

Table A1. Spiral galaxies and g^{-1}. Source: freestarcharts.com.

No.	Name	M ($10^{11} M_{\odot} = 10^{41}$ kg)	R (10^{20} m $\approx$ 10,000 ly)	g^{-1} (10^{61})
1	IC 342	1	7.5	7.5
2	ISOHDFS 27	13	4	52
3	Messier 58	10.7	3	32.1
4	Messier 61	0.7	5	3.5
5	Messier 77	5	10	50

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No.	Name	M ($10^{11} M_\odot = 10^{41}$ kg)	R (10^{20} m $\approx$ 10,000 ly)	$g^{-1}(10^{61})$
6	Messier 81	2.5	4.5	11.25
7	Messier 83	0.4	2.75	1.1
8	Messier 88	4	5.25	21
9	Messier 90	10	8.25	82.5
10	Messier 91	4	5	20
11	Messier 94	0.4	2.5	1
12	Messier 95	0.4	2.3	0.92
13	Messier 96	1	4	4
14	Messier 98	10	8	8
15	Messier 99	1.5	4.25	6.37
16	Messier 100	4	6.25	25
17	Messier 101	10	9	90
18	Messier 104	1	3.75	3.75
19	Messier 106	1	9	9
20	Messier 108	4	5.5	22
21	Messier 109	10	9	90
22	Maffei 2	1	3.5	3.5
23	NGC 891	5	6	30
24	NGC 1097	10	7	70
25	NGC 2403	0.5	3.25	1.625
26	NGC 4565	10	7	70
27	NGC 4631	4	6	24
28	NGC 5005	4	5.5	22
29	NGC 6946	1	3.75	3.75
30	NGC 7331	10	8	80
31	NGC 2775	1	3.5	3.5
32	NGC 3626	0.4	2.75	1.1
33	NGC 4244	0.4	3.25	1.3
34	NGC 4559	2.5	4.5	11.25
35	IC 2497 and Hanny's Voorwerp	4	5.75	23
36	Messier 51	1	3.75	3.75
37	Messier 66	2	4.75	9.5
38	Milky Way	9	5	45
39	Andromeda	8	10	80
40	Messier 65	2	4.2	8.4
41	M64 Black Eye	1.6	1.6	2.56
42	Messier 74	3	4.5	13.5
43	Messier 98	2	4	8
44	Messier 81	0.5	4.25	2.12
45	Sculptor Galaxy	50	4.25	212
46	Messier 96	0.8	3	2.4
47	Sunflower Galaxy	1.6	4.63	7.4

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