Alternative solution of Galaxy Rotation Curves, expansion of universe and Hubble expansion

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Abstract. The galaxy dynamics does not strictly follow Newtonian law of gravity. But the galaxies have a set pattern of geometry and rotation curve. Introduction of expansion coefficient in einstein field equation and the universe expansion as observed by Hubble remains the unresolved mystery. This gives rise the concept of dark energy. I feel that force of gravity of our universe or matterverse alone cannot construct whole universe. So, there must be another force of gravity, equally strong in nature, is acting as antigravity to our universe. Hence, I have proposed a possible solution by introducing concept of antimatterverse acting as antigravity to our matterverse and working as binary Universe like binary star system. This proposed solution also gives insight of the origin of dark energy, creation of antimatter and fate of antimatter during big bang and observed dynamics of galaxies

Keywords. Galaxy rotation curve, Hubble expansion, Gravity, Cosmological constant, Hubble constant

1. Introduction

Background: The Galaxies in the universe have many different shapes and sizes ranging from dwarf galaxies with as few as 10^7 stars, to giants with 10^{12} stars. The Hubble in his book "The Realm of the Nebulae" has classified as Hubble Sequence. As per Hubble, galaxies are elliptical, normal spiral, barred spirals and irregular galaxies. Our galaxy Milkey way is also a normal spiral galaxy (E Hubble, Proc Natl Acad Sci, 1929). Among these, nearly 20% of galaxies are elliptical and possess comparatively little gas and dust, contain older stars and are not actively forming stars anymore. Nearly 60% galaxies are spiral and are actively forming stars and comprise a large fraction of all the galaxies in the local universe. Irregular galaxies, which have very little dust, are neither disk-like nor elliptical and are part of early universe.

All spiral galaxies have a set pattern of radial velocity, mass distribution and formation of bulge etc. Their rotation curves are flat after certain distance of 6-10 Mega parsec (Mpca) as shown in fig. 2. Hubble has also observed that all galaxies are moving away from each other with the velocity of their recession being directly proportional to their distance called Hubble expansion velocity H as shown in fig.1(Neta A. Bahcall , PNAS, 2015- Robert P. Kirshner, PNAS , 2004).

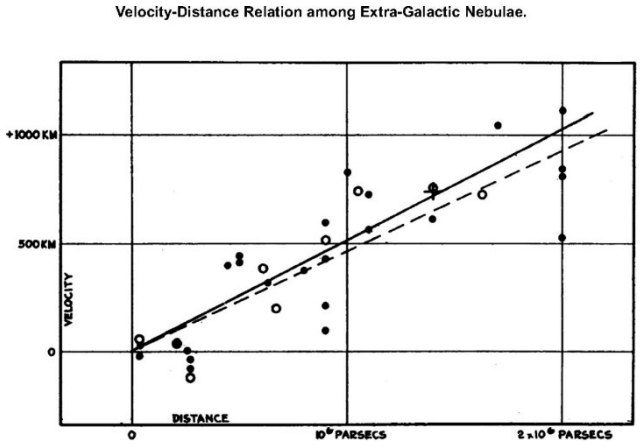


*Fig. 1. Velocity–distance relation among extragalactic nebulae (2). "Radial velocities, corrected for solar motion, are plotted against distances estimated from involved stars and mean luminosities of nebulae in a cluster. The black discs and full line represent the solution for solar motion using the nebulae individually; the circles and broken line represent the solution combining the nebulae into groups; the cross represents the mean velocity corresponding to the mean distance of 22 nebulae whose distances could not be estimated individually" (*Robert P. Kirshner, PNAS ,2004*).*

All these patterns of observations do not follow the Newtonian gravity law and Kepler's law. This is also called as missing gravity problem by hypothetical particle called baryons. Einstein has given the solution of this problem by introducing *expansion coeff.* $= \Lambda$ in his famous Einstein Field equation (EFE). He has given a

concept of dark energy (DE) to resolve this issue. However, the origin of expansion coefficient 'L' and DE is still muted (C. Trachternach et.al. A&A, 2009,). Keplers' laws. Newtonian laws of gravity do not follow well as observed by Benoît Famaey (Springer Nature, 2012), It is mentioned in the paper "In short, what astronomical observations are telling us is that the dynamics of galactic and extragalactic systems, as well as the expansion of the Universe itself, do not correspond to the observed mass-energy as they should if our understanding of gravity is complete. Thus, this indicates either (i) the presence of unseen (and yet unknown) mass-energy, or (ii) a failure of our theory of gravity, or (iii) both.

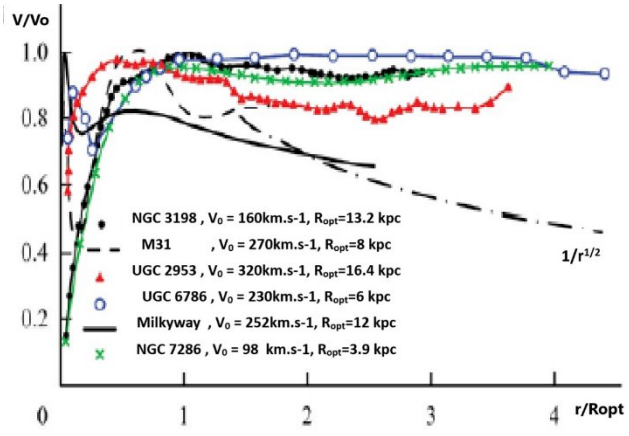


Fig. 2 Rotation curves of a sample of nearby galaxies (en.wikipedia.org/wiki/Cosmological constant).

In 1983, Milgrom has developed Miligromian dynamics called MOND to address the issue of velocity profile of galaxies as given in fig 2. He proposes that gravity g_N in an isolated spherically symmetric system is asymptotically related to the Newtonian gravity g_N of the baryons alone according to (Indranil Banik et.al., Monthly Notices of the Royal Astronomical Society, 2023)

$g = g_N$ if $g_N >> a_0$

$= (g_N . a_0)^{0.5}$ if $g_N << a_0$

Where a_0 is critical acceleration ($\sim 10^{-10}$ ms^{-2}) introduced by Milgrom Mond as a fundamental acceleration scale, below which the Newtonian gravity deviates substantially. However, it was observed by McGaugh and Lelli (2016) that 'radial acceleration relation' (RAR) of the baryonic mass of a galaxy (the sum of masses of its stars M* and gas M_g: Mbar = M* + M_g) correlates with the amplitude of the flat rotation velocity V_f. This baryonic Tully-Fisher relation (C. Trachternach et.al. A&A, 2009,) is a simple scaling relation ($M_{bar} \propto V_f^4$) with no apparent dependence on other properties like galaxy size or surface brightness. The RAR also extends to elliptical galaxies and even to weak gravitational lensing down to $g_N \sim 10^{-5}$ a_0 (Indranil Banik et.al.,Symmetry, 1-87 (2022)). However, the origin of the such effect is not certain so far but probably due to presence of dark matter(DM).

2. Measurements of mass and rotation curves of galaxies and DM

The mass distribution of galaxies is determined luminated mass of stars by Infrared photometry at 2.2 μm along the Galactic plane and mass-to-luminosity (M/L) ratio. These illuminating stars constitute 90% of mass of galaxy (Coble et al., 2025). In addition to these luminous components, most galaxies nest a central massive object or a black hole, and a massive core in the a dynamically relaxed system. The mass in stars in a typical galaxy makes up about 1–2% of the cluster mass, the hot gas makes up about 5–15%, and dark matter makes up the rest (up to 85%). In other words, the mass of the gas between galaxies is about 6 times more than the mass of the stars in the galaxies and the mass of the dark matter is in turn about 8 times more than that of the gas. Galaxy clusters range in mass from a little more than 10^{10} solar masses M ⊙, and typical sizes are from 3–30 million light-years. However, with best efforts, the dark matter is not detected physically and only indirect evidences are indicating the presence of dark matter as mentioned in para 5.

3. **Rotation Curves**: The rotation curve of galaxy can be seen by observing spectral line intensity in l21 cm HI and l 2.6 mm CO emission line on longitude (Bosma A. 1981a, 1981b,AJ) radial velocity (LV) diagram. Radial velocity of galaxy is by measuring the Doppler width of spectral lines of a collection of objects; the more radial velocities one measures, the more accurately one knows their dispersion. A *central velocity dispersion* refers to the σ of the interior regions of an extended object, such as a galaxy or cluster. This "velocity dispersion" is related to the gravitational potential and thus the mass of galaxy.

The observed velocity dispersion along the line sight, σ_0, will be related to the typical velocity v by $\sigma_0 \propto v$ (because v is a three-dimensional space velocity).

$S\sigma_0^2 \propto M / R_0$.

$\therefore M \propto \sigma_0^2 R_0$.

Equating this with $M \propto I_0 R_0^2$

from above,
$\therefore R_0 I_0 \sigma_0^{-2}$ = constant . ----------(1)
In fact, $R_0 I_0^{0.8} \sigma^{-1.3}$ = constant. The power of coefficients of eq-1 does not follows simple integers because of probaply presence of dark matter and multiple galaxy effect. Where I_0 be the central surface brightness R_0 being scale size of galaxy. We observe (fig 2) that most of galaxies rotation curve gets saturated to a rotational velocity of 200-250 km/sec at around 12-15 kpc from nucleus (Dimitar Valev, ,Physics International, 2014). The saturation velocity distance and mass of galaxy seems to be correlated one (Fig 2) using same simple Keplerian mathematics and considering the source of proposed antigravity, it is possible to explain above phenomenon.

Table 1 *typical masses and saturation rotation velocity of galaxies.*

Name of galaxy	Mass M at R200	Saturation velocity V_0 kms^{-1} at R_{opt} kcp
Milkey way	$1.17X10^{12}$ M ⊙	252 at 12kpc
M31	$1.27X10^{12}$ M ⊙	270 at 8 kpc
NGC 3198	$6X10^{10}$ M ⊙	169 at 13.2 kpc
NGC 4594	$4.02X10^{11}$ M ⊙	200 at 10kpc

4. Hubble's Law and an Expanding Universe:

The expansion of the universe is a separate phenomenon that affects the overall distances between galaxies and it looks that galaxies are not gravitationally bound. Hubble's Law describes the expansion of the universe on very large scales. It states that galaxies are moving away from each other, with their recession velocity proportional to their distance. Fig 3 is derived from the Einstein field equation (EFE) and its subsequent derivation proposed by Friedmann-Lemaître-Robertson-Walker (FLRW) metric (Yoshiaki Sofue, PASJ,2015).

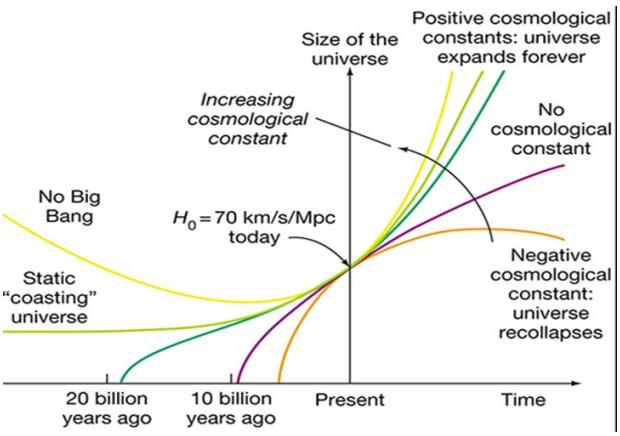


Fig 3. Variation of Hubble constant with time of evolution of universe as per FLRW theory (Eigen Chris ,Lectures on Relativity by Eigen Chris on YouTube, 110f).

5. Dark matter and Dark energy :

It was observed that collision of galaxy Bullet Cluster (1E 0657-56) is one of the strongest pieces of evidence for the existence of dark matter (Figure 4). It consists of two colliding galaxy clusters, and its study provides a unique way to separate dark matter from normal, baryonic matter. Most of the normal matter (hot gas) interacted and slowed down, but the dark matter passed through nearly unaffected. So dark matter only produce

Fig. 4 Credit: X-ray: NASA/CXC/CfA/M.Markevitch et al.; Optical: NASA/STScI; agellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et

gravitional effect but does not interect with normal(as seen in fig 4) baryonic matter. It was observed that light from background galaxies passing through the cluster was bent due to gravitational lensing but X ray gereration do not?. This effect revealed two distinct mass concentrations that did not align with the X-ray

gases.These mass concentrations coincided with the locations of the galaxies, suggesting the presence of dark matter halos. This DM halo affects rotational curve of galaxy . But we do not find any evidence of dark matter in our solar system and nearby solar systems . If dark matter were present in significant amounts locally, we would expect to see its gravitational effects on planetary orbits, spacecraft trajectories, or even variations in asteroid motions and light bending due to effect of gravity by DM. But so far, these observations align perfectly with what we expect from normal (baryonic) matter and Newtonian/relativistic gravity except that there is no formation of planet in Oort cloud of our solar system.

6. Rotation Curve of Galaxy

Various models have been proposed to explain missing gravity problem the rotation curve and Hubble expansion. This includes MOND theory, Dark energy (DE) theory and Lambda cold dark matter ΛCDM. I have attempted to suggest alternative solution of missing gravity problem/ antigravity and Hubble expansion by introducing cosmological wave theory (Author of this paper). It is observed that inner rotation curve of any spiral galaxy and solar systems follows Keplerian law very well. But outer beyond >~0.3 kpc, we observed that there is another gravity is working which is as
antigravity to galaxy, which causes such phenomenon of velocity saturation and Hubble expansion. Here,

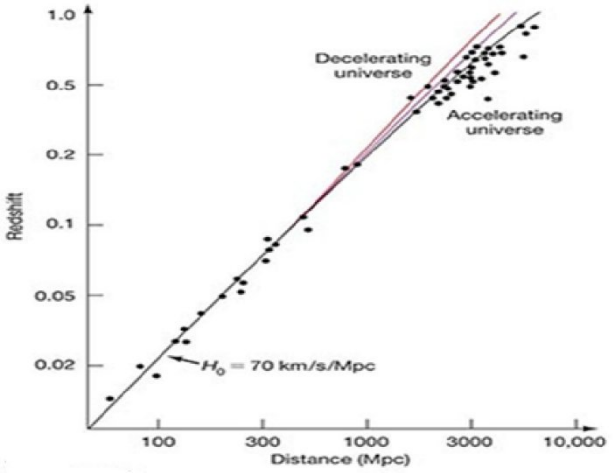


Fig. 5: *Variation in Hubble constant with distance.*

we believe that this expansion is not due to gravitational forces in the traditional sense but rather to the stretching of space itself due to attractive gravitational force imposed by antimatterverse as binary stars do. The expansion of interspace between galaxies also changes with time as shown in Fig 3 and 5.

7. Expansion of intergalactic space and Dark energy

The problem of expansion of galaxy interspace and saturation of rotation curve has been the recent topic for many cosmologists and they have proposed many theories to explain the phenomenon and given the concept of dark energy (DE). However, this problem has many solutions and they do not match with others. Here I proposed that the solution of above problems can be resolved by Kepler's law and introduction of antigravity (which is attractive in nature only and applied from outside of matterworld) and formation of binary universe system.

As Hubble constant relates with Einstein expansion coefficient and gravitation acceleration

If we see the origin of EFE is based on Poisson equation

$\tilde{N}^2 j = 4pGr - Lc^2$ ----------(2)

Where $\nabla^2 \mathbf{j}$: is the Laplacian of the gravitational potential j, G is gravitational constant, Einstein *expansion coeff.* $= \Lambda$, r is density and is function of radius r, c is speed of light.

The solution gives

$j(r) = -\frac{GM}{r} - \frac{1}{6}\Lambda c^2 r^2$ ---------- (3)

The gravitational force F_G is m*d(j(r)) and the above equation will become

$F_G = -m\frac{GM}{r^2} + manti\frac{1}{3}\Lambda c^2 r$ ----------(4)

Where $-m\frac{GM}{r^2}$ is standard Newtonian gravity g_N and $g_R = manti\frac{1}{3}\Lambda c^2 r$ is repulsive force. Where m is is mass of galaxy and m_{anti} mass of antimatterverse . The repulsive force is also given as mg_r and is equal to $manti\frac{1}{3}\Lambda c^2 r$. Here, we see that net gravitational force F_G is sum of g_N and g_R

Evaluating the above expression and introducing a constant k to compensate attractive force and due to g_N generated by N galaxies and unknown proper reference of centre of matterverse or called as geocentric, we have

$L = \frac{3.k.g_R}{r.c^2}$ ----------(5)

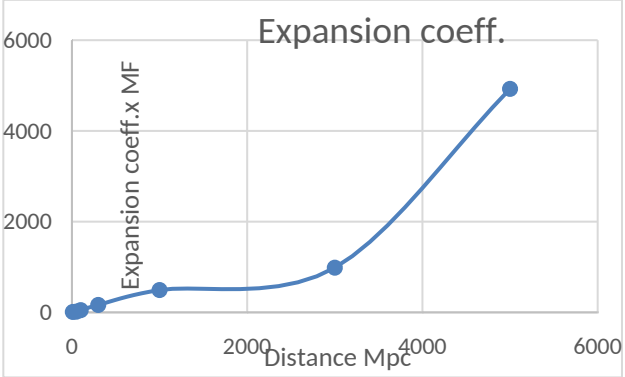
So, we can plot a graph between *expansion coeff.* $= \Lambda$ verses r using equation (5) for k value of $1X10^{-3}$, we get following values as given in the table below

Table *2: Distance from antimatterverse and Hubble expansion by equation 5*

Distance from our reference from antimatterverse	Value of L, expansion coefficient $/m^2$ $X10^{-55}$	H = Hubble constant km/sec/Mpca

10 Mpc	4900	1186
50 Mpc	980	530
100 Mpc	490	375
300 Mpc	160	216
1000 Mpc	49	118
3000 Mpc	16	68
5000 Mpc	9.8	53

The fig 5,6 depicts the similar curve as proposed by FLRW theory for different type of universe (open, close, flat) as per theory (Fig 3).
Now if we assume that antimatterverse to exists as per figure below. Manti is mass of Antimatterverse And ra is the distance of object in matterverse in FLRW matric (ref Relativity 110b, chris) with R= ra sinh(□) from antimatterverse centre of mass. Where □ is angle subtended by Manti on object galaxy and is ~ equal to arctan (14.5/47)=~ 18 deg . Then for a rotating galaxy at a distance of 94 (r=47 Mpca) Mpca will experience antigravitational pull to generate ~200 km/sec rotational speed will have mass Manti is given by following formula of Newtonian gravity



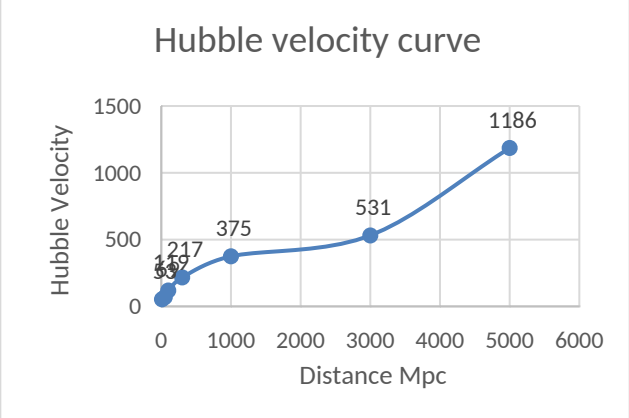


Fig. 5,6 :*Hubble velocity(*km/sec/Mpca) *curve and expansion coefficient(MF=10^{-55}) as derived by wave theory*

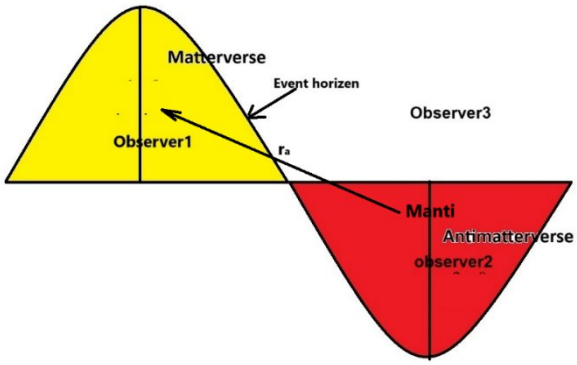


Fig 7: *Origin of antigravity*

$$M_{anti} = \frac{r_a . v^2}{G} \qquad \text{----------(6)}$$

The calculations using equation (6) shows that a mass of antimatterverse ~10^{56} kg ± 5% . (The error may be due to nonavailability of proper reference of distance or geocentric in binary system.), which is nearly equal to the mass of universe (matterverse) (Dimitar Valev, ,Physics International, 2014). This is causing all this phenomenon of expansion of universe and saturation of rotation speed to ~200 km/sec and generating an antigravitational acceleration of ~10^{-10} ms^{-2} and equivalent to Milgrom Mond's fundamental acceleration scale a_0. This also probably make binary universe system like binary stars in order to introduce stability of system (Fig. 7).
It is worth mentioning here that sun exerts gravitational acceleration of ~ $6X10^{-3}$ ms^{-2} on earth and~ $6.5X10^{-5}$ ms^{-2} on Saturn. So, the value of antigravitational acceleration of ~10^{-10} ms^{-2} is much lower than sun gravitational pull of earth and Saturn like planets moving around sun.
Similar effects can be seen on galaxies and other solar system also.
And if we calculate the gravitational pull by sun on Oort cloud , it is of the order of ~10^{-10} ms^{-2}. This again is equivalent to antigravity pull. This may be the reason that no planet is formed in Oort cloud region
Similarly, galaxy mass will generate a gravitational acceleration g_{anti} by Newtonian gravity model in milky way or andromeda galaxy (M31)and other distant objects as per table below

Table 3 *Mass and acceleration of Milkey way and Andromeda Galaxy(M31)*

Name of Galaxy	Mass at 8 kpc Kg	Mass at 12 kpc Kg	g_N at kpa ms^{-2}	g_N at 12 kpc ms^{-2}	g_R ms^{-2}
Milkey way	$2X10^{41}$	$3x10^{41}$	$2.17X\ 10^{-10}$	$1.5X\ 10^{-10}$	$4.53X\ 10^{-9}$
M31	$1.6X10^{40}$	$2.2X\ 10^{40}$	$1.7X\ 10^{-11}$	$1.07X\ 10^{-11}$	$4.53X\ 10^{-9}$

We can see that M31 has less g_N at 8 kpc and 12 kpc, so saturation achieved faster as $g_R > g_N$, ($\sim 10^{-10}$ ms^{-2}) whereas milky way achieved slower due to high g_N. Similar trends can be observed fig. 2 in NGC3198, UGC6786 ,NGC7286,UGC6786 etc . This gives the idea that galaxy rotation curve saturates the velocity where $g_R=g_N$. implies that antigravity also shapes the galaxy .

It is worth mentioning here that if matterverse and antimatterverse does not exists together as binary system and have not created antigravity for both, then single universe would have collapsed within a very short time as its own and would have resulted into a singularly point again as prior to big bang. And we would have not existed as we see all today.

8. Conclusion

In this paper, we have presented the issues related to galaxy rotation curve and Hubble expansion of universe. We have proposed that the solution of above issues can be handled by old Newtonian gravity law and Keplerian inverse square distance law of gravitational field with proper consideration of matterverse and antimatterverse.

It is also presented that entire matterverse (our universe) and antimatterverse follows Kepler's inverse square gravity field well.

In this paper, we assumed that there is another mass exists in the form of antimatterverse created simultaneously with big bang ,whose edge ends at nearly 47 billion light year and forming a binary universe system. Based on the rotational curve of milky way and M31 galaxy and using Newtonian gravity law, FLRW matric and geodesic curves, we estimated the mass of antimatterverse is nearly 10^{56} Kg. This mass nearly matches mass estimates of our universe. I feel that single attractive force of gravity alone cannot construct whole universe So, there must be another equally force of gravity which is acting as antigravity to our universe and

therefore, antimatterverse will be constructor of matterverse of our own universe like binary star system. Hence, I have proposed a possible solution by introducing concept of antimatterverse and a source of gravity, acting as antigravity to our matterverse. This solution also gives insight of the origin of dark energy, creation of antimatter and fate of antimatter during big bang and observed size and shape of galaxies. So, all the galaxies and celestial bodies are under influence of two type of gravitation forces a) own mass of galaxy b) gravitational force in the form of antigravity by antimatterverse. This force causes flatten of galaxy curve, influences the size and shape of galaxies, distribution of dark matter etc. This same antigravity is also responsible for Hubble expansion and $expansion\ coeff. = \Lambda$ in EFE. I have presented relation of antigravity and expansion coefficient and estimated Λ and Hubble velocity H, which follows well for all type of universe as predicted by FLRW theory.

9. Acknowledgements

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10. Disclaimer (artificial intelligence)

I hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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