Investigation of Coulomb-like Gravitational Interaction

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Abstract: Gravitational relationship between two types of mass is investigated. It is proposed that the source of a dynamic scalar field that permeates all of space and defines the dynamics of the cosmos is the repelling self-gravitational nature of dark matter (DM) particles and the attractive gravitational nature between DM and baryons respectively. The model defines DM as a new form of matter and attributes self-antigravity to both baryons and DM and defines DM-Baryon gravitational interaction as like particles repel while unlike particles attract; a coulomb interaction. DM particles are proposed to permeate all of space, and arguably define space-time itself when describing Relativity Theory, and interact with baryons only gravitationally. To resolve the controversy of the apparent self-attraction of baryonic matter, metal-like force is proposed to produce Newtonian dynamics within cores of galaxies. In this metal-like attraction, same type mass (baryons) are gravitationally attracted to each other when a sea of other type DM "particles" are attracted to them and glue them together analogous to a metal bond. When baryonic objects defy their own repulsive nature and come close enough to each other, other dominant forces take place such as electromagnetic force. Normal matter is then created and further coalesces to form galactic structures. In light of this attraction-repulsion gravitational force, intergalactic self-repulsive DM particles are proposed to result in accelerating expansion of the universe. The model introduces new physics and explains the large scale structure of the universe. It also explains many cosmological anomalies and mysteries and removes gravitational singularity of black holes. An attempt to explain the model under the umbrella of Relativity Theory is presented.

1. Introduction

Newtonian dynamics fail to explain gravitational potentials of galaxies and galaxy clusters by only considering their baryonic mass [1]. Proposed solutions either invoke dominant quantities of non-luminous dark matter (DM) [2] or modification to Newton's law [3]. Also, the problem of flattening of galaxy rotation curves inspired researchers to investigate modification of gravitational theories by introducing weakly or non-interacting matter fields [4, 5, 6, 7].

Previous works suggested that visible baryonic matter and hypothesized DM are spatially coincident in most of the universe [8, 9]. These works favored the DM hypothesis over modification of Newton gravity, but their conclusions were necessarily based on non-trivial assumptions such as symmetry, the location of the center of mass of the system, and/or hydrostatic equilibrium.

The nature of DM particles is a mystery. Particle physics models suggest that DM is either axions, which is characterized as hypothetical new particles associated with quantum chromodynamics, or WIMPs, hypothetical new particles with weak interactions and TeV-scale masses, natural by-products of theories of supersymmetry or extra dimensions; neither of which have been detected.

It is always assumed that anti-gravitational particles are nonexistent as their existence largely runs against observation. Few attempts were made to use antigravity to explain natural phenomena such as dark energy (DE) where virtual anti-gravitational particle-antiparticle pair appear and self-annihilate to explain DE. An anti-gravitational relationship may be assumed to exist if it is totally obscured observationally.

When astronomers present galactic DM as non-baryonic to resolve its non-luminous nature problem they simply consider the same classical relationship between DM and baryonic matter as well

as self-relationship since they both seemingly possess “positive” mass and both “observationally” attract. The most common approach to model the universe is to present the gravitational DM-baryonic attraction force the same as that of the observed baryonic-baryonic attraction. Astronomers also assume that DM self-interaction is attractive as inferred from observation. While this approach seems very plausible it presents many cosmological challenges, most importantly the perplexing origin of DE. Moreover, it seems very attractive to link DE and DM as having the same origin.

If DM had self-anti-gravitational nature and DE shared the same origin, it would be an easy task to explain DE as simply the result of DM particles’ gravitational self-repulsive nature in the intergalactic region. This assumption doesn’t represent a challenge in galactic regions if DM-baryonic gravitational interaction is attractive as widely accepted. This is because heavy baryonic objects will attract relatively light DM particles and form halos. Furthermore, introducing a self-repulsive attribute of DM particles adds yet another scattering factor to DM particles trapped in a gravitational potential as in a galactic DM halo. In such a scenario, DM galactic halos provide the means for holding galaxies intact as observationally seen. This approach is discussed in this model.

Also, presenting self-anti-gravitational attributes to DM particles necessitates similar anti-gravitational attributes to baryons opposite to observations. This new physics pushes towards a new look at the dynamics of baryons.

By presenting gravitational properties of normal mass and DM as above and presenting DM as having opposite sign to that of the mass of normal matter we are attributing a “self-negative” mass to both of them. The observational fact that the normal mass seems to have a self-attractive gravitational properties has always led our thinking to drop a Coulomb-like gravitational option.

2. Basis of the Model

It seems likely that two gravitationally different types of particles existed at the dawn of the universe. With the successful Big Bang theory, those two types of particles must have contributed significantly to the evolution of the universe.

By accepting the concept of a negative gravitational interaction and if we treat DM particles and baryonic particles as opposite mass components, the following different scenarios may describe the gravitational nature between them,

1. Self-repulsive DM, self-repulsive baryons, and attractive DM-baryon.
2. Self-repulsive DM, self-attractive baryons, and attractive DM-baryon or equivalently, self-repulsive baryons, self-attractive DM, and attractive DM-baryon.
3. All attractive.
4. Self-attractive DM, self-attractive baryons, and repulsive DM-baryon.
5. All repulsive.

Postulate: Inertial mass is always positive.

Here, it is regarded that active and passive gravitational masses are equal as Newtonian dynamics require. Also, inertial mass is postulated to be always positive in sign with the equivalence principle of Einstein interpreted as that inertial mass is a physical quantity that resists motion against the line of action of any force regardless of its type, i.e., electrical force. Therefore, negative active-gravitational-mass possesses an inertial mass that resists the action of the negative gravitational force and therefore positive in sign. In other words, inertial mass is always positive regardless of the type of force.

Of the five above scenarios, choice “3” is widely accepted. While possibility 5 is excluded because it doesn’t provide any attractive force contrary to observation, possibility “4” may resolve a good number of cosmological problems. For example, flat galactic rotational curves can be explained by introducing external force emanating from negatively gravitating DM source acting on super large cosmological areas with rotational velocity explained in terms of tidal forces, see [10]. Furthermore, intergalactic space contains DM particles that are widely assumed to follow possibility number “3” above. With this choice, a number of cosmological anomalies remain unsolved, such as flat galactic rotation curves, dwarf satellite galaxy problem, cuspy halo problem and others. Also, DE remains a mystery.

Choice “2” looks odd and basically does not fall under any known category that reserves conservation laws.

Choice “1” could be a possible solution to many cosmological anomalies. It is stemmed from Newtonian assumption where a negative mass is similar to charge; like masses attract and unlike repel. It however presents a challenge to cosmological observation and currently accepted gravitational laws, since baryons seem to show self-attractive behavior. In this paper, suggestion “1” is further investigated.

Although no particles are known to have negative mass, some physicists, such as Hermann Bondi [11] described some of the anticipated properties such particles may have. He interpreted the equivalence principle of Einstein as inertial and active masses are equivalent in all cases and consequently all three concepts of mass, active, passive and inertial are equivalent and he explored gravitational interactions between masses of arbitrary sign. He concluded that for two positive masses, nothing changes and we have a pull on each other causing an attraction. Two negative masses would

produce a pull on one another, but would repel because of their negative inertial masses. For different signs we get a push that repels the positive mass but attracts the negative mass. His analysis of the interaction of a negative mass obviously follows the equivalence of the three types of masses. The conclusion is then, in general relativity (GR), a negative mass repels all masses, a positive attracts all. If we have a system with one mass of each type, the system will uniformly accelerate. It is reported in literature that physicist Gold asked Bondi: What happens if one attaches a negative and positive mass pair to the rim of a wheel? He adds; this is incompatible with GR, for the device gets more massive. Obviously, the confusion comes from the equivalence principle of GR. The principle works well with interacting positive masses and complies with observation. Since negative mass is not readily available in nature, the principle may not be verified experimentally with negative mass. It is very unlikely that GR ruling of non-existence or co-existence of negative mass to be true. In this paper, the principle of equivalence is revisited. Inertial mass is to be considered as always positive and acceleration is always in the direction of the net force on the active mass. This leaves the five different gravitational interactions above free to determine the net force on a system.

If we consider DM as opposite in sign to baryons, their analysis seems to contradict cosmological observations of hypothesized DM since DM is actually attracted to baryons and not just follow keep-a-distance-mechanism as Bondi's analysis seems to imply. On the other hand, with the assumption that DM having the same type of mass as widely believed (suggestion 3 above), many cosmological anomalies are not resolved and a DM particle should not be as elusive as it is, avoiding detection.

While Bondi's analysis may be true from the equivalence principle for positive masses (active and passive) as observed by experiment, it may not be true for negative-active and passive masses or negative-positive ones. The equivalence principle is postulated by Einstein and verified for the observationally available only positive mass. In this model, baryons and DM masses are gravitationally

self-repulsive with positive inertial mass (when it meets its own type) and they are gravitationally attractive when they meet with each other with still positive inertial mass. Therefore the inertial mass doesn't change the sign of the net gravitational force in a gravitational interaction.

A recent paper investigated whether virtual gravitational dipoles could be a solution to the DE problem [12]. While the dipoles are described there by repulsive matter and antimatter particles, here repulsive gravitational force of same-type DM particles that permeate intergalactic space produces similar result. The analogy is similar as far as how gravitational dipoles of virtual repulsive matter-antimatter particles contribute to vacuum energy or DM gravitational self-repulsive nature as suggested in this paper.

Recent work indicates that rotation curves due to DM halos at intermediate radii in spiral galaxies are remarkably similar [13] which suggest a universal DM mass profile. Furthermore it was reported that the universality of galactic surface densities within one dark halo scale-length holds for both DM and luminous matter. This can be interpreted as a close correlation between the enclosed surface densities of luminous and DM in galaxies [14]. This relationship seems to be a priori under the model proposed here.

3. Metal-like Attraction Mechanism

Following possibility "1" above, this model proposes a long range gravitational interaction with baryon-baryon repulsive gravitational interaction suppressed by a metal-like attraction mechanism. At close range, other forces, e.g., electromagnetic force, are responsible for bonding baryonic material.

Consider two gravitationally interacting baryonic objects; the interaction will be repulsive as suggested. Only due to the existence of attractive force between a sea of opposite-mass particles (DM particles), the baryonic-baryonic interaction will be seen as attractive. This approach seems plausible if

it can explain Newtonian dynamics.

It is suggested here that the metal-like mechanism is the acting galactic gravitational system. The sea of opposite particles is the DM particles that glue baryonic material together. The model presents DM density in the galactic core region as constant on average, therefore resulting in constant force, which solves the core-cusp problem arisen from numerical *N*-body simulations of DM halos based on the collisionless cold DM (CDM) model [15].

To illustrate the metal-like mechanism, figure 1 shows a general system of two repulsive baryonic objects glued together by a sea of DM particles.

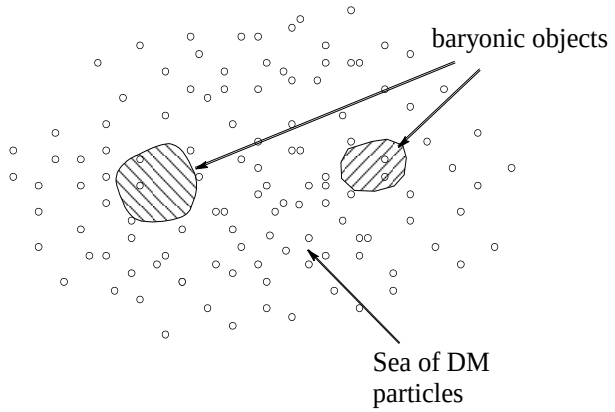

Fig.1. A general system of two self-repulsive baryonic objects glued together by sea of DM particles

4. Feasibility of Metal-like Force

The proposed metal-like force should be directional due to the weak gravitational interaction and the relative long range. This could be seen for an isolated two baryonic objects as the cloud of particles of opposite type would have highest probability density between the two objects as figure 2 illustrates. This should in general be the case whether DM particles are hot, warm or cold.

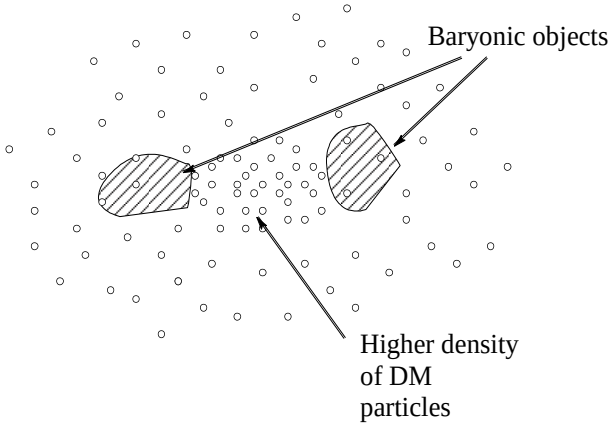

Fig.2. Higher density of DM particles between two core objects

The net centered DM mass between the two baryonic objects can be viewed as an overlapping of the DM halos of the two baryonic objects as figure 3 shows.

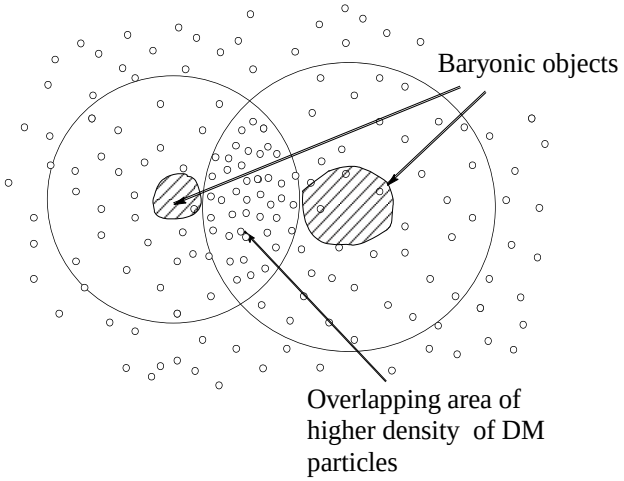

Fig.3. Higher density of DM particles in the overlapping area of two DM halos

It is important also to notice that for an isolated two baryonic objects, due to the coulomb force of inverse square of the distance, the DM mass that ultimately needs to allocate itself in between the baryonic objects to completely obscure the repulsive baryonic-baryonic force and yet produce apparent attractive force as suggested in a metal-like force is less than the total mass of the two baryonic objects. The close relationship between the DM halo particles and the baryonic galactic content that gave rise to MOND theory can be readily explained by the intimate DM-baryonic attractive relationship as well as the DM self-repulsive nature as presented here.

For cosmological large structures such as galaxies, figure 4 illustrates baryonic core with a baryonic edge star of a hypothetical spherically symmetrical galaxy. The DM halo particles are included in the volume between the edge star and the baryonic core.

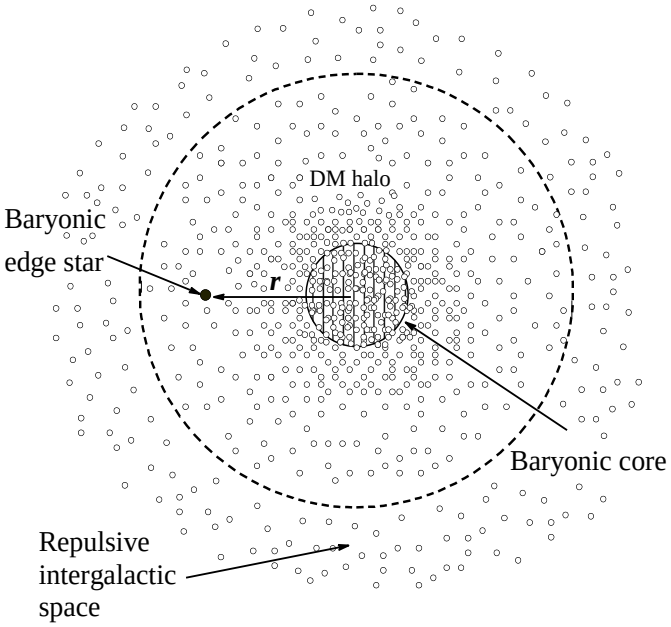

Fig.4. Galactic system showing intergalactic space, an edge star, the core and the enclosed DM halo

Three gravitationally bound systems can be clearly distinguished employing the DM-baryonic gravitational relationship. First, Newtonian behavior exists within the baryonic galactic inner cores with a constant metal-like force. Second, a metal-like varying gravitational force exists away from galactic cores due to varying DM halo density. Lastly, a centered DM halo exists in a cluster of galaxies as illustrated in figure 5.

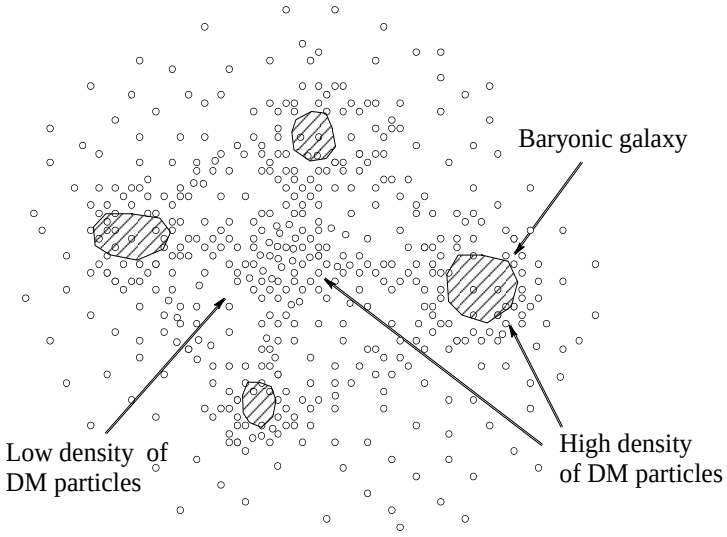

Fig.5. DM particle distribution in a cluster of galaxies

5. Metal-like Force Mathematical Form

In a metallic bond, the force that describes ionic interaction can be described as Coulombic and proportional to r^{-2}. Likewise, the gravitational force that describes the proposed metal-like force can be described as proportional to r^{-2} as we see it in Newtonian force. The apparent Newtonian force then describes the true "free" gravitational force if multiplied by a scaling factor. Therefore the true gravitational force can be described by the following equation,

$$F_T = G' \frac{m_1 m_2}{r^2} \qquad (1)$$

Where G' is a scaled gravitational constant, F_T is the true gravitational "free" force and m_1 and m_2 are the baryonic masses.

6. Stability of Cosmic Structures

In the metal-like model, any stable cosmic structure should be gravitationally bound with DM particles as the acting bonding agent. In the inner galactic core, the metal-like force results in Newtonian dynamics while in the galactic MONDian region the metal-like force predicts different dynamics. The metal-like model also predicts that the Newtonian force between two baryonic objects

within the inner core is larger than the "true" DM-baryonic attraction force or pure baryonic-baryonic repulsive force by a factor of eight due to the inverse square of the distance law. This is obvious when analyzing the force between two baryonic objects of equal mass with DM gluing agent of "hypothetical" same mass situated in the center.

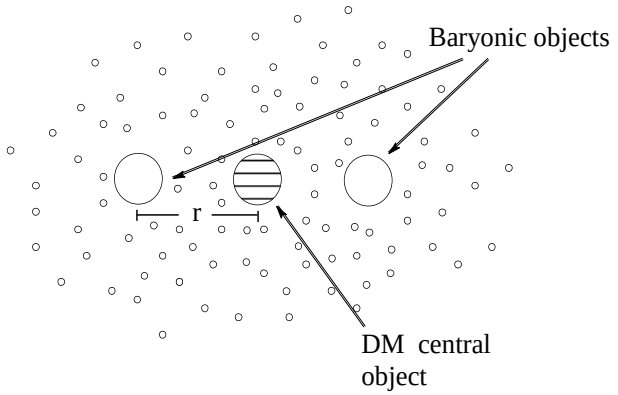

Fig.6. Metal-like force illustrating a centered DM attracting system

As well known, DM makes up roughly 80 percent of the mass in the universe. For a gravitationally stable cosmological structure the DM mass should proportionally be at least equal to one-eighth of that of the baryonic mass within its core on average. This is because, for same mass of central DM as that of the two baryonic objects as illustrated in figure 6 above, the apparent baryon-baryon attractive force is $2Gm^2/r^2$ while baryon-baryon repulsive force is $Gm^2/(2r)^2$. Therefore, for nucleation of any cosmological structure, the DM halo should make available a centered DM of at least one-eighth of that of the baryonic mass on average to counterbalance the baryon-baryon repulsive force and remain gravitationally intact, i.e., if the local force "Newtonian force" was the minimal for baryonic nucleation, any increase from the one-eighth magnitude would show a force larger than Newtonian and subsequently an added dynamical mass. There should also be an upper limit for the amount of the centered DM that would keep the cosmological structure intact. The proposed metal-like force necessitates apparent force to true force of a maximum ratio of 8:1. It is observationally determined that mass to light ratio of galaxies range between 2 and 10.

Satellite dwarf galaxies might be considered as objects bound to the host galaxy by metal-like force when their DM halos overlap, with the host galaxy's DM halo extends to engulf the dwarf galaxy. Tidal force from the host galaxy will reduce the dynamical mass of the satellite dwarf galaxy.

It is important to note here that it is puzzling that some dwarf galaxies are observed to contain a ratio of DM to baryons of 99:1, and still their structure holds since according to the metal-like force model the repelling nature of DM should shatter the dwarf galaxy apart.

7. Is DM the Continuum of Space-time itself?

The Coulomb-like gravitational interaction introduced in this model seems to contradict GR. It is of prime importance then to discuss GR when introducing such a universal gravitational model. Here the intention is to only discuss the viability of the model under the principles of GR and Special Relativity (SR) by introducing two propositions that validate the relativity theory under the model's umbrella.

The equivalence principle of GR, where a positive mass attracts positive or negative masses, and a negative mass repels positive or negative masses, such a system of equal number of positive and negative masses is self-accelerating. Therefore GR inherently assumes the lonely existence of positive mass even though Einstein's field equations don't necessitate the non-existence of negative mass mathematically. The model therefore is "seemingly" in a colliding course with GR. It is disputed though whether to consider the gravitational attraction should refer to force or to the oppositely oriented acceleration of a negative mass.

To comply with Relativity Theory, the model introduces two propositions,

1- Space-time is a DM-continuum structured solely by the proposed Coulomb gravitational interaction.

2- True gravitational force produces curvature of space-time.

8. The Equivalence Principle

The Einstein equivalence principle postulates that inertial mass must equal passive gravitational mass; while the law of conservation of momentum requires that active and passive gravitational mass be identical. It is admitted that projecting mass to space-time is very scary. Nevertheless, if so let it be self-repulsive then. With the above two propositions, GR is essentially unchanged since the actual gravitational force between a test baryonic particle, which constitutes the active mass, and the "apparently" gravitating baryonic object, which constitutes the passive mass, is mediated by the attracting DM space between them that actually produces a net positive field. The equivalence principle then sees no difference between the gravitational mass (represented by the gravitational positive force and proportional to the active mass) and the accelerating inertial mass since DM-space itself causes the gravitational acceleration. Simply the model leads to positive curvature of DM-space-time around baryons and negative curvature in the intergalactic region. Furthermore, proposition 1 introduces what could be the long sought space element that is direly needed to further develop quantum gravity and unified field theory. Another consequence to self-repulsive DM-space-time could be vacuum energy.

So, to clear the confusion, we are attributing self-repulsive mass to both DM and normal mass. This way, GR doesn't seem to contradict this model simply because the model produces net baryon-baryon attraction and baryon negative curvature of space-time is suppressed by a stronger positive curvature of DM-space-time due to the stronger baryon-DM attraction. As known, mathematically, GR can incorporate negative curvature of space-time by including a negative mass or a stress-energy tensor larger in magnitude than the mass density in Einstein's equations. GR then suffices to describe

curvature of space-time as positive by hypothesizing the existence of a “mysterious” DM that adds to the positive universal mass and yet more mysterious DE material that adds a negative pressure. The proposed Coulomb-like gravitational nature of DM and baryons does not necessitate a new overhaul of GR and doesn’t negate it. Figure 7 illustrates the equivalence principle under the DM-space-time model and the basic transition between classical to relativistic dynamics.

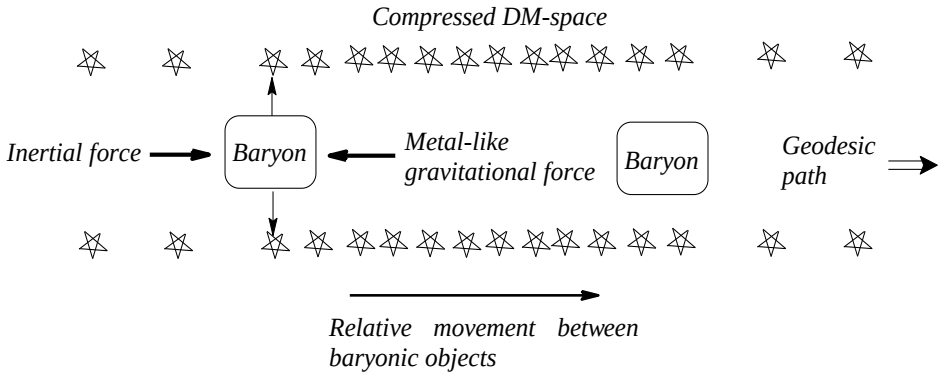

Fig. 7. The equivalence principle equates inertial force and gravitational force

In the figure above, accelerating a baryonic object against another of inertial state compresses DM-space elements between them and increases the metal-like gravitational force. The gravitational force will increase proportional to the applied inertial force until they equate. The accelerating object then moves at a constant speed.

9. The DM-Ether and SR

As had always been the case prior to the prevailing SR, an absolute reference frame was needed that any moving object should rely on for inertia.

Einstein based the derivation of Lorentz invariance (the essential core of SR) on just the two basic principles of relativity and light-speed invariance in vacuum.

Today, Lorentz Ether theory (LET) is often treated as some sort of Lorentzian interpretation of SR. The introduction of length contraction and time dilation for all phenomena in a "preferred" frame of reference, which plays the role of Lorentz's immobile ether, leads to the complete Lorentz transformation. Because of the same mathematical formalism it is not possible to distinguish between LET and SR by experiment. However, in LET the existence of undetectable ether is assumed and the validity of the relativity principle seems to be only coincidental, which is one reason why SR is commonly preferred over LET. Another important reason for preferring SR is that Einstein's concept of space-time was also fundamental for the development of GR.

One of the pillars of SR is the constancy of the speed of light in any inertial reference frame. Michelson's experiment perfectly ruled out the existence of a universal absolute reference frame, through which light thought to propagate at a constant speed, may be mechanically analogous to acoustic propagation of sound in a medium. But if this mechanical reference frame is only local to a baryonic two-object system moving relative to each other as discussed above, the ether concept may be resurrected. Specifically, the model may provide the mechanical means to produce a constant speed of light. The model produces unique DM-super highway for each two baryonic objects moving relative to each other that represents a local "absolute frame of reference" as will be discussed.

The concept of attributing mass to space doesn't seem to conflict with SR. Introducing a medium for the propagation of light is highly feared mainly due to the proved experimental and theoretical unverified medium-concept. Surely, Michelson's experiment ruled out the existence of an ether medium because it never produced drag. Nevertheless, not-introducing such a medium is highly criticized due to its large would-be positive contribution to other fields of physics, such as quantum physics, had the medium existed. The ether concept then might be reconsidered if the model produces no drag. In other words, as repeated Michelson's experiment verified; the Earth was always "stationary" relative to the

ether. For example, under DM-baryon model presented here, if the intervening DM elements of space along the line of motion of one moving baryonic object relative to another is completely delocalized from the rest of DM-space and quickly brought to rest along the line of action between the two objects, the DM-particles along the line of action then can be considered the “local” absolute space (ether) that can carry light along its path and defined only by objects moving at a constant speed or stationary relative to each other. The quick delocalization (complete separation) of the in-line DM elements from the rest of space is actually greatly aided by the fact that DM-space elements are self-repulsive. A good term is to call the “local” DM-Ether as “DM-super-highway”, analogous to superconductors where zero-electrical-resistance is produced. The interaction between the DM-super highway and the rest of DM-space produces zero-drag, aided by the balanced repulsive interaction from the rest of DM-space. So, a piece of DM-super highway is a detached piece of DM-space zooming in space at no cost to environment. Another good example is electromagnetic elevation with zero-loss of energy.

Classically, attributing “self-negative” mass to space is a viable option while attributing positive mass to it requires introducing another physical quantity to completely describe universal dynamics. Such physical quantity was introduced by Einstein himself when he introduced his cosmological constant to his equations of motion. It is hard to picture space possessing positive mass and yet produce flat curvature as coupling it for example with unknown source of a scalar field greatly complicates the picture. Picturing a mass-space that produces geodesic world-lines of universal flat nature as described by GR is a questionable approach, but it serves the purpose of classic-to-relativistic transition. It is a good approach to attribute the flatness of space as a combined action of self-negative gravitational nature of intergalactic space and gravitational attraction as described by the metal-like model.

Under the metal-like model then, the dynamics of a baryonic particle moving in DM-space-time may perfectly describe SR if it provides an explanation to the constancy of the speed of light in any

inertial reference frame. The special medium that identifies the “ether” as described in the DM-space above will not produce drag simply because, as SR requires, DM itself constitutes space as normal mass follows geodesics made by DM particles in its own continuum with a DM-super highway intermediating the space in between. Besides, self-repulsive nature of DM particles of space ensures their non-collapsing nature and normal mass itself ensures non-exploding nature of space through the metal-like model.

10. Constancy of the Speed of Light

To explain the constancy of the speed of light under the proposed metal-like force we need to link the speed of light with the equivalence principle. Figure 7 above shows two interacting baryonic objects. With the absence of external force the relative motion between them is constant. As explained earlier, an external “inertial” force applied on one of the baryonic objects accelerates it relative to the other one. This action compresses space in the line of motion between them. The larger the applied inertial force is the larger the packing of space between them. This leads to a larger net gravitational force between the intermediating DM-space and the accelerated baryonic object proportional to the applied inertial force. With the absence of external inertial force, the momentum acquired by the baryonic object maintains its relative motion along the DM-super highway as required by Newton’s first law. In other words, with self-repulsive DM-space elements, the compression of space-elements along the line of motion of a baryonic object will come to a maximum possible value when gravitational attraction of metal-like force is equalized with a maximum self-repulsive force of space-elements along the DM-super highway, leading to maximum applied inertial force and a maximum relative speed between baryonic objects of that of the speed of light. Therefore, speed of light is solely a property of DM-space as expected. To further illustrate the picture, if a light source is hypothetically moving at the speed of light in the direction of the pulse path, it sees a stationary pulse along the path but a detector in their path that is stationary relative to the absolute ether “DM-super highway” will see

the light pulse moving at c. If the light source is moving at lower than c speed (c_l) relative to the detector that is stationary relative to the "DM-super-highway", it will see a light pulse moving away with speed c′ and the detector will register the pulse's speed as c where classically c = c′ + c_l. Accordingly, any detector in any inertial reference frame in space will always register a speed of light equal to c. Figure 8 illustrates the constancy of the speed of light that leads to the Relativity Theory.

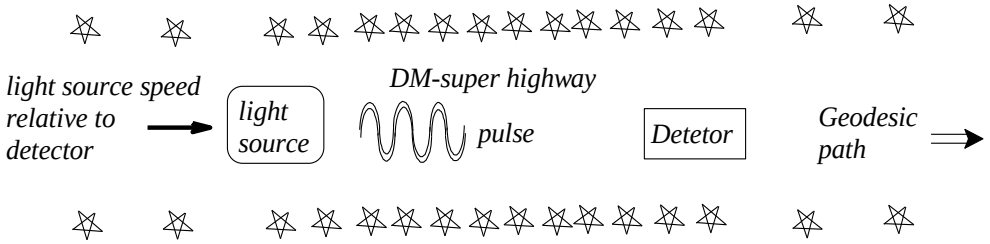

Fig. 8. The constancy of the speed of light under the "DM-super highway model"

In figure 8 above, if we fix the detector's reference frame as that of the DM-super highway, the light-pulse speed relative to the source will always be adjusted such that the detector will always register a speed of light c. This adjustment varies inversely with the linear mass density of the "DM-super highway" which in turn (density) is proportional to the speed of the source itself relative to the stationary DM-super highway.

Obviously, as Lorentz transformation requires, the relative velocity of the two baryonic objects changes the mechanical properties of the DM-super highway to produce a change of source-to-medium light velocity, consequently a constant speed of light. This is clear from figure 8 above since the packing of DM elements between the two baryonic objects is proportional to the metal-like gravitational force between them.

The metal-like model then provides a unique DM-super highway between any light-source and a detector in any direction in space to produce a speed of light of c.

11. Curved Geodesics under DM-space-time Model

While Einstein's SR stemmed from the constancy of the speed of light as a postulate, it seems that Einstein's equivalence principle is an inherent property of SR through the mechanical property of the DM-super highway discussed here. Einstein's GR as a generalization of his SR is already explained by the equivalence principle in the metal-like-gravity model. Therefore, DM-space model should readily explain GR as discussed below.

To explain curvature of DM-space time let's consider a massive baryonic object that gravitationally attract DM-particles. DM-space-particles should be spaced apart more in the radial direction, away from the center of the baryonic object as discussed before. This effectively curves DM-space around the baryonic object and therefore DM-super highways as well. Figure 9 illustrates the curvature concept of space geodesics around a massive object under the metal-like model.

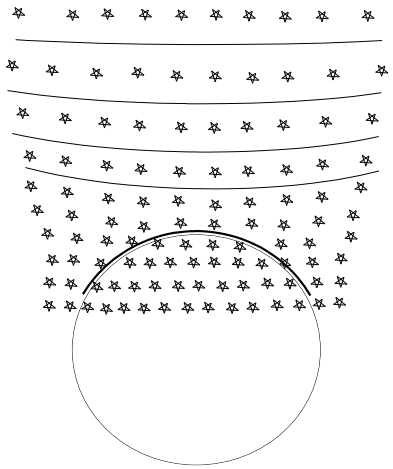

Fig.9. Massive baryonic object curves DM-space, where approaching baryonic object follows curved geodesics

12. Can Antigravity Device Work?

It seems that constructing an antigravity device lives only in the minds of Hollywood science fiction producers. According to the DM-space model, if we can make space beneath an object devoid of DM-space particles we can simply decrease the gravitational attraction between the earth and the

object. But even if we do so, DM-space still exists all the way to the center of the earth which contributes to the gravitational attraction. On the other hand, it could be much easier to prove the self-repulsive concept of baryons by making space between objects devoid of DM elements so that they repel each other horizontally or in space. The mechanism could be the reverse of the packing mechanism of DM-space particles along the line of relative motion of objects as illustrated in figure 7 above. This can be achieved by a mechanical system of which two massive parts move away from each other at high speed, probably in the horizontal plane, hoping to drag DM-space particles with them and thereby make space between them devoid to some degree. Two light-weight particles positioned horizontally and at right angles to the two massive parts may feel the devoid-space between them and repel.

13. Mechanical Description of DM-Space

Space then as described above may be elastic with its unstressed state, but with larger elastic modulus when it is greatly compressed by the presence of normal mass through the proposed attractive force of metal-like gravitational interaction. Hence a mechanical treatment of propagation of light through space is then justified, and so is SR through precise compensation of the change of speed of light in the gravitationally "compressed" space relative to "space DM-element" between the two baryonic objects to maintain the constancy of speed of light between two observers as described by SR theory.

Mechanically, armed with Newton's second law, the speed of light in the DM-super highway is actually acoustic and can be expressed with Hook's law as

$$c = \sqrt{E/\rho} \qquad (2)$$

Where E = *DM*-space modulus of elasticity, ρ = *DM* density

The above relationship could describe the behavior of space element in SR with higher stiffness of compressed space by a fast moving baryonic object in space and therefore compressing space along the line of motion, producing higher density and smaller elastic modulus, thereby increasing the speed of light to a maximum of c in free space.

Furthermore, as would widely be believed true, SR equations may be derived classically from the mechanical behavior of space.

14. Length Contraction and Time Dilation

With the constancy of the speed of light, length contraction can simply be explained by the decreasing space between DM-space-elements (line elements) when baryonic objects obtain high speeds as illustrated by figure 7 above. Time dilation can be explained when time is relaxed under length contraction to maintain the required constancy of the speed of light as provided by the metal-like-DM-model presented here.

15. Metal-like Force in Newtonian Regime

The size and mass of the constituent baryonic objects of inner galactic cores are proportional on average as the majority of stars are main sequence ones. Following metal-like force; within a galactic core Newtonian regime is dominant as the DM sea of particles acts like a glue between the baryonic contents. In the Newtonian regime, the baryonic density is constant on average which leads to a constant DM as well. Therefore, with a constant average DM density within the inner core, the gravitational force is constant and can be expressed as Newtonian.

16. MOND Theory

The rotation curves of spiral galaxies become approximately flat at the largest radii observed [16, 17]. This is one of the strongest indications of the need for dynamically dominant DM in the universe. The inner shape of rotation curves is well predicted by the distribution of observed baryons [18]. There appears to be though a characteristic acceleration scale [19] at which baryonic material alone can no

longer account for the observed dynamics, hence the need for a DM halo in galaxies.

Modified Newtonian Dynamics (MOND) is a theory that modifies Newton's force law to explain observations of rotation curves of galaxies that most astronomers interpret as evidence for DM. MOND describes acceleration due to gravity with the empirical formula $a = \sqrt{GMa_0}/r$ and correctly accounts for spiral galaxies' missing mass. The formula introduces gravitational acceleration as dependent on the function $\mu(a/a_0)$ that approaches the value one for large arguments and a/a_0 for small arguments, where a_0 is a natural constant approximated to be 10^{-10} m/s^2 [3]. The centripetal acceleration of stars at the outskirts of spiral galaxies tends to be below a_0.

17. MONDian Regime and Galaxy Rotation Curves

The universality of the galactic rotation curves (RCs), in combination with the invariant distribution of the luminous matter, implies a universal DM distribution with luminosity-dependent scaling properties [20], i.e., luminosity, dictates the rotational velocity at any radius for any object, so revealing the existence of a universal RC.

With the success of MOND theory at least explaining RCs of spiral galaxies, there is the possibility that DM particles have properties that impose MOND-like phenomenology [21-23]. According to MOND's theory, the gravitational force in a MONDian regime is proportional to the inverse of the distance to the core and directly proportional to the square root of the baryonic gravitating mass. This is in obvious departure from Newtonian dynamics which is directly proportional to the baryonic mass and inversely proportional to the square of the distance.

MONDian regime is dominant in the galactic DM halo region. It is proposed here that a baryonic edge star's dynamics is mainly determined by the proposed metal-like gravitational relationship. Just as in the galactic inner core, the metal-like interaction is responsible for bonding the edge star to the

galactic core with the exception that the DM bonding particles are not distributed evenly and therefore the DM density is not constant.

The net baryonic core, since there is more baryonic mass than DM mass in the core and DM halo particles are self-repulsive, attracts DM halo particles with a proposed volume density proportional to r^{-2}. Observationally, flat rotation curves imply the existence of a dark halo, with mass density $\rho(r) \propto r^{-2}$. With the metal-like model, the dependence of DM halos on the baryonic content of galactic inner-cores and consequently the halos' DM density distribution as proportional to r^{-2} explains the success of MOND in explaining RC curves. An isothermal metal-like-DM model satisfies the requirement for DM density as proportional to r^{-2}.

Practically, in the MONDian regime, the force between the edge star and the galactic core can be described by equation (1) with varying G' that corresponds to varying DM density.

While MOND rejects DM existence, this model assumes its existence as widely believed. DM particles direct detection remains a challenge though since they constitute space itself according this model.

18. Could the Dark Matter be Antimatter?

With the absence of annihilation signature of DM and baryons in the cosmos, the option of DM being antimatter is obviously excluded. Also, following the weak equivalence principle of GR, since both matter and antimatter have positive inertial mass, antimatter should only attract matter. This excludes DM as antimatter, which allows a new categorization for it. The ubiquitous DM may therefore be the twin sister of normal matter which is proposed here to follow a Coulomb law.

19. Black Holes and Gravitational Singularities

As discussed above, metal-like gravity does not alter the theory of GR in principle as the curvature of space-time as described by the theory should hold for a baryonic structure with the “dynamic” mass that results from metal-like gravity is included in Einstein's equations. This leads to a no change of black hole dynamics from current proposed theories.

Metal-like gravity on the other hand sheds light on the interior dynamics of black holes. While GR analysis of the interior of a black hole introduces gravitational singularity at the core, due to infinite gravitational collapse of normal matter, metal-like gravity should remove it since DM-baryon repulsive-attractive gravitational forces eventually balance out, preventing a total collapse to singularity. It is interesting to see an event horizon made by a “gravitational-bond” as the end result of a gravitational collapse.

20. Evolution of the Universe and Cosmological Coincidence

The ad hoc positive cosmological constant of Einstein can account for the observed accelerated expansion of the universe. However the true nature of such an ad hoc term is still a mystery. It is usually modeled as a cosmological fluid with a constant density and negative pressure. In this paper, the source of the repulsive nature of such a hypothetical fluid is simply the self-repulsive DM particles of intergalactic space, and therefore the self-repulsive DM particles constitute the DE fluid that drives the universe to accelerate its expansion. The cosmological coincidence problem can simply be dismissed by unifying DE and DM into a single dark substance as proposed here.

It would be of optimum importance we could define DE, DM and inflation of the early universe as well as the evolution of the universe to date under a single conceptual framework. This is achieved under the metal-like model where the evolution of the universe should be no different than the accepted

Big Bang cosmology as the proposed metal-like force only describes Newtonian force as an apparent one which differs than the true force by a proportionality factor.

As obvious from the metal-like model, the relative galactic space was much larger since the early stages and throughout the evolution of the universe. While Newtonian cosmology doesn't allow expulsion of galactic material into intergalactic space as DM collapses the same way as baryons, in the metal-like cosmology self-repulsive DM nature allows that, as the non-contributing galactic DM particles is eventually expelled to intergalactic space. When galactic space got smaller with the redistribution of DM particles being pumped into intergalactic space due to virialization of galactic structures, the net intergalactic DM negative force became proportionally larger until finally it showed up universally at the same time cosmological virialization had completed. This started the era of accelerated expansion of the universe, hence the cosmic coincidence problem. This era marks the peak evolution of the cosmos and the existence of mankind which allowed detection of the era.

It is important to mention that for Big Bang event to occur under a metal-like cosmology, nucleation of the seeds of baryonic objects should be readily available. This might have occurred naturally under other forces of electroweak and strong interactions as inferred from early universe Primordial nucleosynthesis of Big Bang cosmology. This scenario confirms that DM is gravity-only entity.

21. Dwarf Satellite Galaxy and Cuspy Halo Problem

Dwarf satellite galaxy problem arises from numerical cosmological simulations that predict the evolution of the distribution of matter in the universe. Obviously cosmological models consider both DM particles and baryonic matter as self-attractive as well as attractive to each other which allows DM to clump in pure manner. This scenario is fundamentally different than the proposed self-repulsive DM

matter as the formation of “invisible” clumps of DM is prohibited. Hierarchical formation of the universe under this model is predicted to form less number of satellite galaxies since self-repulsive DM particles limit their formation and drive them apart.

It is important to assume DM particles as collisionless since collisions will serve to make halos round, in contrast to data that overwhelmingly indicates triaxiality, e.g. in clusters [24]. The limit of this constraint is that there can be DM self-interactions that are important at high densities and short distance scales, which may serve to erase small scale structure in galaxy halos, and erase the density cusps expected at the cores of galaxies. Cuspy halo problem can be resolved under metal-like model since in the Newtonian region it is the sea of DM-particles with constant density that is responsible for the baryon-baryon gravitational attractive force. Self-repulsive DM particles ensures their collisionless nature as well.

22. Conclusion

A model is investigated that describes dark matter and baryons as two types of gravitational mass that follow Coulomb law where like particles gravitationally repel and unlike particles attract. Accordingly, intergalactic dark matter (DM) particles are self-repelling resulting in accelerated expansion of the universe. DM particles are proposed to permeate all of space, and arguably define space-time itself. The model describes a metal-like force that suppresses baryonic self-repulsive gravitational nature and introduces Newtonian regime within galactic cores and MONDian regime beyond them. It also complies with Relativity Theory. The model introduces new physics and proposes solutions for many cosmological mysteries and anomalies such as flat galactic rotation curves, dwarf satellite galaxy problem, cuspy halo problem, cosmological coincidence problem and most importantly, the nature of dark energy.

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