ANTIGRAVITY MATTER

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Abstract – **In an attempt to solve the mystery of dark matter a hypothetical type of matter is proposed that is affected by a repulsive force similar to the reverse of gravity. This type of matter is referred to as antigravity matter. Its hypothetical behaviour is investigated and some effects it would have on normal matter objects are predicted. Various dark matter phenomena and results are considered and found to be consistent with the predicted effects of antigravity matter. Some common objections to the antigravity matter hypothesis are answered.**

I. INTRODUCTION

Many strange gravitational phenomena have been observed in space and the leading theories attribute these to the presence of dark matter. This paper explores the hypothesis that these phenomena are not produced by gravitationally attractive dark matter but by gravitationally repulsive antigravity matter. In particular this paper assesses whether the hypothetical antigravity matter can be used to develop explanations for the following observations:-

1. Spiral galaxies appear to be rotating too quickly for the gravity of their visible matter to hold them together [1].
2. The orbital velocity of a spiral galaxy's disc is usually fairly constant over a large part of the radius of the disc. This is commonly interpreted as evidence that much of the dark matter associated with a spiral galaxy is spread out in a halo in deep space around the galaxy and is not co-located with the visible matter [1].
3. The amount of apparent dark matter in spiral galaxies is highly variable. Some have even been detected that appear to be almost all dark matter with very little visible matter [2].
4. The dark matter content of elliptical galaxies has been estimated at about 80% of the mass of the visible matter. The margin of error on these measurements allows for all elliptical galaxies to have approximately the same ratio of normal matter to dark matter [3].
5. Unlike spiral galaxies, elliptical galaxies do not appear to have halos of dark matter in space around them. As far as can be detected their dark matter appears to be co-located with their visible matter [3].
6. Although dark matter is affected by gravity it does not appear to collapse towards its centre of gravity to create a dense object like normal matter does. It appears to remain at low density.
7. Many attempts have been made and are being made to detect dark matter directly by means that do not depend on gravity, for example CRESST [4]. However no dark matter particles have ever been conclusively detected.

The antigravity matter theory has been developed progressively between 2006 and 2014 at www.preston.u-net.com/AGMatter and since 2014 at www.antigravitymatter.co.uk.

II. THE ANTIGRAVITY MATTER HYPOTHESIS

In this paper we explore the hypothesis that there is no significant amount of gravitationally attractive dark matter in the universe. Instead the universe contains a large amount of antigravity matter. The hypothetical antigravity matter has the following characteristics:-

- Antigravity matter consists of particles which have positive mass and inertia.
- Particles of antigravity matter are repelled from each other. Particles of antigravity matter and normal matter objects are also repelled from each other. The strength of these repulsive forces is proportional to the masses of the affected objects and follows the inverse square law with respect to the separation distance of the objects. These repulsive forces are referred to in this paper as antigravity.
- Normal matter particles and antigravity matter particles rarely interact apart from via antigravity.
- Electromagnetic radiation is diverted away from antigravity matter but does not otherwise interact with it. Electromagnetic radiation is assumed to be affected by antigravity to the same degree that normal matter is.
- Antigravity matter has existed since shortly after the birth of the universe.

The following initial deductions and assumptions are made from the hypothesis above:-

- Antigravity matter has spread out to form a thin, approximately constant density atmosphere throughout most of interstellar and intergalactic space. However this atmosphere is repelled by normal matter, and there is therefore little or no antigravity matter near the sun, within the solar system, or near any other star.

- The deep space antigravity matter atmosphere behaves like a conventional theoretical ideal gas and has the bulk properties of density, temperature and pressure. These can affect its behaviour in addition to the effect of antigravity.
- Because of the expansion of the universe most of the antigravity matter atmosphere has a very low temperature and pressure. In this paper the pressure of the antigravity matter atmosphere is assumed to be negligible.
- In a gravity field free normal matter particles accelerate in the opposite direction to free antigravity matter particles relative to the source of the field. However in an antigravity field free normal matter particles and free antigravity matter particles accelerate in the same direction relative to the source. Therefore antigravity is not exactly the reverse of gravity.

The use of the term antigravity could be questioned, particularly in view of the last point. In reality we are discussing a repulsive force that may or may not be caused by a mechanism related to that which causes gravity. However the search for dark matter has been prompted by phenomena that others have assumed to be caused by gravity. On that basis we feel justified in using the term antigravity.

1) **Definitions**

In the following analysis we use the following definitions and assumptions:-

G_{nn} = Gravitational constant for normal matter to normal matter attraction. This is the same as conventional *G* and is given a subscript to distinguish it from the following items

G_{na} = Constant for normal matter to antigravity matter repulsion

G_{aa} = Constant for antigravity matter to antigravity matter repulsion

D_{ab} = The deep space background density of the antigravity matter atmosphere

In the following discussion there are several occasions when we envisage a universe containing an antigravity matter atmosphere. In each case this universe is a three dimensional space which is uniform in all directions. It is assumed to have expanded from a big bang and is otherwise like our own except as specified. The current rate of expansion of this universe is assumed to have negligible effect in the timescales of the discussion. All speeds of matter and all masses are non-relativistic.

The existence of a low temperature atmosphere does not imply a fundamental zero velocity reference frame in the universe. Low temperature antigravity matter particles have low velocity relative to other antigravity matter particles nearby.

2) A normal matter object in a universe with an antigravity matter atmosphere

Consider a universe containing only a low temperature antigravity matter atmosphere and a single normal matter object *M*. *M* is at zero velocity with respect to the antigravity matter atmosphere. Assume that all the matter in the universe is at equilibrium. The antigravity matter is spread out evenly throughout the universe except where it is affected by *M*. The local disturbance to the antigravity matter caused by *M* is symmetrical around *M*. The repulsion that M feels from the antigravity matter all around balances out and the net result is that M feels nothing.

3) A second normal matter object

Now we introduce a second normal matter object *N* as shown in Figure 1 which is fixed in position relative to *M*. *M* and *N* are both at zero velocity with respect to the antigravity matter atmosphere. *M* and *N* both repel antigravity matter and cause a local reduction in density. These influences are negligible outside the two dotted perimeters. We refer to these regions of reduced density as “Voids”.

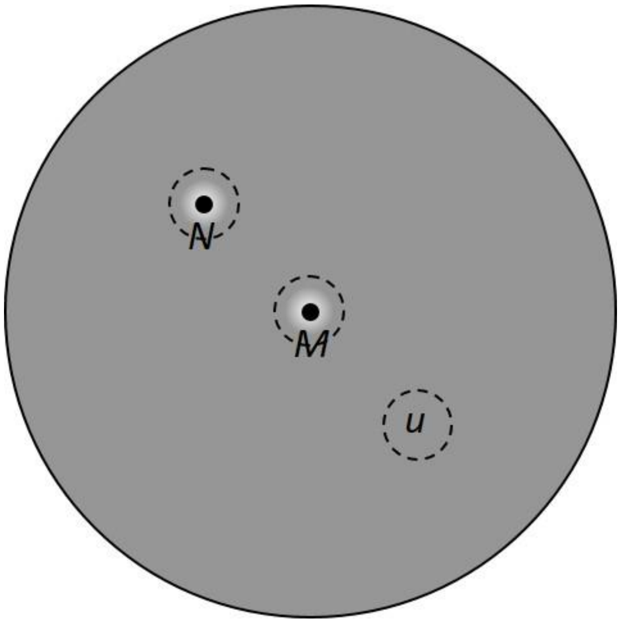

Figure 1 – Normal matter objects M and N in a universe with an antigravity matter atmosphere.

The total force felt by M is made up of two components:-

1. *M* feels a conventional gravitational attraction towards *N*.
2. *M* feels a repulsion from all the antigravity throughout the universe. This almost completely balances out to zero. However the repulsion from some of the antigravity matter in the region of space marked *u* in Figure 1 remains unbalanced because of the Void around *N*. *u* is equidistant to *N* from *M* but in the opposite direction. The net result of this is a force acting on *M* towards the Void around *N*.

The second component force above illustrates that the effect of a reduction in density of antigravity matter can be calculated by ignoring the antigravity matter throughout the universe and treating the antigravity matter Void as a gravitationally attractive object of equivalent mass and using the appropriate antigravity constant. This principle is used extensively in this paper as is referred to as “AGM Equivalence”.

4) The antigravity matter density profile around a normal matter object

We now consider how antigravity matter density varies within a Void around a normal matter object. We test the suggestion that at equilibrium the density of antigravity matter varies smoothly with radius.

Consider a universe containing a single normal matter mass *M* and a low temperature antigravity matter atmosphere. *M* is at zero velocity with respect to the antigravity matter atmosphere. The density of antigravity matter is constant throughout the universe a large distance from *M*. Close to *M* the density decreases smoothly as distance from *M* decreases. The density profile is the same in all directions around *M*.

Consider a small particle of antigravity matter of mass *m* at distance *r* from *M*. *m* feels a repulsion from *M*. Due to AGM Equivalence *m* also feels an attraction to the antigravity matter Void around *M*. The antigravity matter is at equilibrium so the force due to repulsion from *M* is equal to the force due to attraction to the Void. However because of Newton's Shell Theorem [5] and AGM Equivalence any reduction in density of antigravity matter at a radius greater than *r* will have no effect on the particle.

Let the total reduction in antigravity matter mass inside a sphere of radius *r* be *A*.

$$A \times {}^{mG_{aa}}/_{r^2} = {}^{mMG_{na}}/_{r^2}$$

$$A = M\, {}^{G_{na}}/_{G_{aa}} \qquad (1)$$

The antigravity mass reduction inside *r* is independent of *r*. If this is true for one particle at radius *r* then at any radius greater than *r* there cannot be any further reduction in antigravity matter density. Hence there must be a step change in density.

The location of this step change in antigravity matter density is referred to as the AGM Boundary.

5) **The radius of a normal matter object's AGM Boundary**

Continuing the analysis in Section II.4 above, let the radius of the AGM Boundary be R_b.

Since there is a step change in antigravity matter density:-

$$A = D_{ab}\,{}^{4}\!/_{3}\,\pi R_b{}^{3}$$

Therefore substitute in equation (1):-

$$D_{ab}\,{}^{4}\!/_{3}\,\pi R_b{}^{3} = M\,{}^{G_{na}}\!/_{G_{aa}} \qquad (2)$$

$$R_b = \sqrt[3]{{}^{3MG_{na}}\!/_{(4D_{ab}\pi G_{aa})}} \qquad (3)$$

6) **The stability of concentric AGM Boundaries with multiple normal matter objects**

In the situation discussed in Section II.3 and shown in Figure 1 we now know that that there is a step change in density of antigravity matter at the AGM Boundaries of the two normal matter objects *M* and *N*. If the two AGM Boundaries are concentric with their normal matter objects there will be no net force on any antigravity matter particle outside the two AGM Boundaries. That situation with concentric AGM Boundaries is therefore balanced. However we need to assess whether it is stable.

For example, if the AGM Boundary around *M* remains spherical but moves a small distance in the direction of *N* the situation would no longer be balanced. Antigravity matter particles around *N* would feel a small net attraction in the direction of *M*. This would move *N*'s AGM Boundary a small amount in the direction of *M*. We need to calculate whether this movement would provide enough gravity to support the original movement of *M*'s AGM Boundary. If it does then the situation of concentric AGM Boundaries is not stable.

In the following discussion we compare the strengths of several gravity fields or changes of gravity fields. Each of these strengths is expressed as an acceleration of antigravity matter particles at a given location.

Let $M = N$ and assume the situation is symmetrical.

Let the radius of *M* and *N*'s AGM Boundaries be R_b.

Let the distance between *M* and *N* be *R*.

Let the small movement of each particle's AGM Boundary towards the other be distance Δ.

Let *P* be the change to the strength of the gravity field at *M* and *N* caused by the movement of the other object's AGM Boundary.

$$P = G_{aa}D_{ab}\,{}^{4}/_{3}\,\pi R_b{}^{3}\{{}^{1}/_{(R-\Delta)^2} - {}^{1}/_{R^2}\}$$

Rationalise this removing terms which become negligible when Δ is small relative to *R* and R_b.

$$P = G_{aa}D_{ab}\,{}^{4}/_{3}\,\pi 2\Delta\{{}^{R_b}/_{R}\}^3$$

Let *Q* be the change to the strength the gravity field at *M* and *N* that would cause a movement of the AGM Boundary there of distance Δ.

To calculate Q consider a small antigravity matter particle of mass *m* at *M*'s AGM Boundary and on the axis between *M* and *N*. The entire AGM Boundary is offset towards *N* by a small distance Δ. A force *f* is required to hold *m* in position. *m* is at equilibrium so the attraction to the Void inside *M*'s AGM Boundary is equal to the repulsion from *M* plus *f*.

$$G_{aa}D_{ab}\,{}^{4}/_{3}\,\pi R_b{}^{3}\Big/_{R_b{}^2} = G_{na}Mm\Big/_{(R_b+\Delta)^2} + f$$

Substitute from equation (2) to remove *M* and rationalise, removing terms which become negligible when Δ is small relative to R and R_b.

$$Q = {}^{f}/_{m} = G_{aa}D_{ab}\,{}^{4}/_{3}\,\pi 2\Delta$$

Therefore:-

$$P/Q = (R_b/R)^3$$

The situation with concentric AGM Boundaries is stable if P is less than Q. Therefore it is stable if R_b is less than R. This must be true because the AGM Boundaries are separated. Therefore they will remain concentric.

The discussion above deals with the case of $M = N$. It also applies if there are many objects of the same size. Any other case of $M \neq N$ can be modelled as the addition of many smaller objects. Therefore this result is also true for $M \neq N$.

7) **The effect of the antigravity matter on a small normal matter object outside a large object's AGM Boundary**

Continuing the analysis in Section II.6 above consider a small normal matter object of mass *N* held at a fixed radius *R* outside the AGM Boundary of *M*. *N* feels an attraction to *M* and an attraction to the antigravity matter Void within *M*'s AGM Boundary. Due to AGM Equivalence:-

$$\textit{Total attractive force} = G_{nn}MN/R^2 + Dab\,{}^4/_3\,\pi R_b{}^3 N G_{na}/R^2$$

Substitute equation (3) and rationalise

$$\textit{Total attractive force} = G_{nn}MN/R^2\,\{1 + G_{na}{}^2/G_{nn}G_{aa}\} \qquad (4)$$

For example if $G_{nn} = G_{na} = G_{aa}$ the effect of the antigravity matter atmosphere is to double the apparent gravity of *M* outside its AGM Boundary.

8) **The effect of the antigravity matter on a small normal matter object inside a large object's AGM Boundary**

We now change the situation in II.7 above so that the small normal matter object *N* is inside *M*'s AGM Boundary. Now in addition to the attraction to *M*, *N* only feels an attraction to the portion of the antigravity matter Void that is within its radius *R*. This is due to Newton's Shell Theorem and the AGM Equivalence.

$$\textit{Total attraction} = {}^{G_{nn}MN}/_{R^2} + G_{na}D_{ab}\,{}^{4}/_{3}\,\pi RN \qquad (5)$$

Figure 2 shows how the strength of the attractions that *N* feels varies with radius. Inside the AGM Boundary the attraction caused by the antigravity matter Void is proportional to radius. Outside the AGM Boundary the attraction caused by the antigravity matter Void is proportional to the gravitational attraction due to *M*.

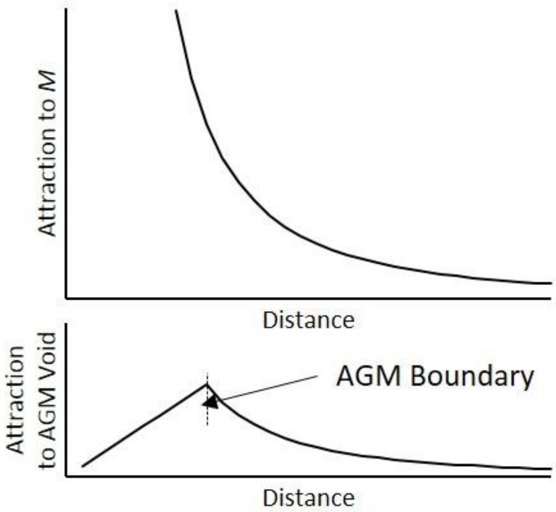

Figure 2 – The profile of the attraction that a small normal matter object feels towards a large normal matter object *M* and towards the Void within *M's* AGM Boundary

9) Concept Comparison

The diagram shown in Figure 3 illustrates how antigravity matter could give the impression of the existence of dark matter.

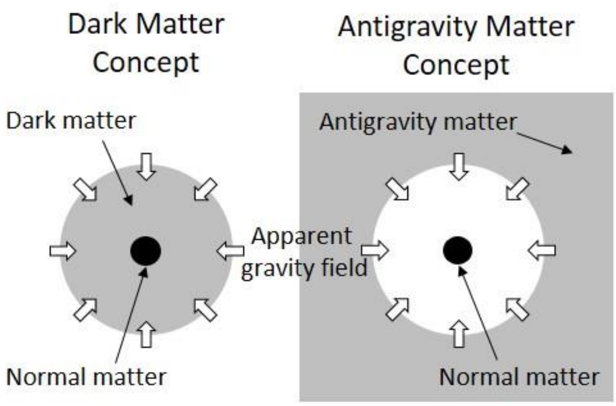

Figure 3 – Comparison of dark matter and antigravity matter concepts

In the universe on the right antigravity matter has formed a low temperature atmosphere in deep space with constant density except that it has been repelled from the central normal matter object to create an antigravity matter Void inside an AGM Boundary. Small normal matter objects feel an attraction to the large central normal matter object plus an attraction to the antigravity matter Void. This produces the same apparent gravitational effect as the universe on the left in which a normal matter object is within a region of gravitationally attractive constant density dark matter.

10) Antigravity matter drag

In all cases considered so far the antigravity matter and normal matter objects have been stationary with respect to each other. Now consider a normal matter object *M* moving relative to the antigravity matter atmosphere as shown in Figure 4.

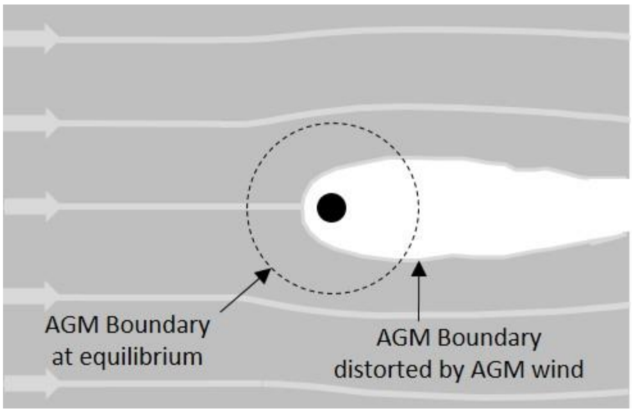

Figure 4 – Antigravity matter flow around normal matter object *M*

The momentum of the antigravity matter wind drives the antigravity matter closer to *M* at the leading face of the AGM Boundary. It also increases the density of the antigravity matter at that location. It drags the AGM Boundary away from *M* at the trailing face and reduces the density there. The result is that *M* feels a greater repulsion from the antigravity at the leading face than at the trailing face. This has the effect of a drag force acting on *M*. Energy is transferred to the antigravity matter atmosphere where it takes the form of movement, turbulence and heat.

11) The antigravity matter vortex

Now we investigate the effect of the rotating disc of a spiral galaxy on the antigravity matter. Consider a universe containing a low temperature antigravity matter atmosphere and the rotating disc of a spiral galaxy. Assume that the radius of a typical star's AGM Boundary is smaller than the average distance between neighbouring stars in the disc and that the antigravity matter atmosphere fills much of the space between stars in the disc. We start the analysis by assuming that the antigravity matter is stationary with respect to the centre of the galaxy and its density is constant outside any star or other normal matter object's AGM Boundary. As the galaxy disc rotates the stars pass through antigravity matter and experience a drag force. The reaction to the drag force acts on the antigravity matter and causes it to move. However unlike the normal matter objects in the disc, the antigravity matter does not initially feel any net attraction to the centre of the galaxy so it is swept outwards. This causes a reduction in density of the antigravity matter in interstellar space within the galaxy. That reduction in density starts to attract antigravity matter inwards towards the centre of the galaxy. Antigravity matter away from the disc near the axis of rotation flows inwards.

Antigravity matter in the disc follows a spiral path as it is swept outwards. The result is a flow pattern shown in Figure 5. This is referred to as an antigravity matter vortex.

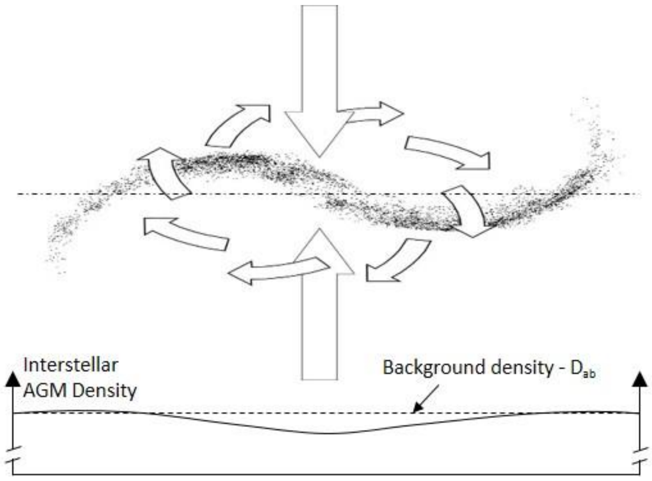

Figure 5 – The antigravity matter flow pattern caused by the rotating disc of a spiral galaxy and the resulting interstellar antigravity matter density profile along a cross section through the galaxy

Some of the antigravity matter that has been swept outwards in the plane of the galaxy circulates back towards the axis of rotation above and below the plane of the galaxy. This causes a general rotation of antigravity matter in the volume of space containing the galaxy and causes the region of reduced density antigravity matter to extend above and below the plane.

The displaced antigravity matter that has been swept outwards piles up around the outer extremity of the galaxy. This is so that stationary antigravity matter in deep space even further away remains at equilibrium.

The arrangement of the antigravity matter caused by the vortex is therefore quite complex. However for simplicity in this paper we model the arrangement as a spherically symmetrical region with reduced density at low radius, increasing to slightly raised density around the outer radius of the galaxy, reducing to D_{ab} well away from the galaxy. This is shown in Figure 5.

12) Component forces

A normal matter object orbiting a spiral galaxy can therefore be influenced by several forces:-

- It is attracted to the other normal matter objects in the galaxy by gravity.
- It is attracted to the antigravity matter Voids inside the AGM Boundaries of the other normal matter objects.
- It is attracted to the antigravity matter density reduction in interstellar space caused by the vortex. While this density reduction may be small the volume of space is large and the effect can be greater than the first two.
- It is affected by the antigravity matter at its own AGM Boundary. The main effect of the object's own AGM Boundary is likely to be to cause a drag force pushing against the direction of orbit and pushing away from the centre of the vortex.
- If it is within the galaxy and inside the outer shell of displaced antigravity matter it is not affected by the outer shell because of Newton's Shell Theorem. However if the orbiting normal matter object is well away from the galaxy and outside the displaced shell the effect of the shell cancels out the effect of the inner density reduction. This may offer a testable prediction. Objects orbiting within a spiral galaxy may give the impression of there being a dark matter halo, while other isolated objects orbiting well away from the same galaxy give the impression of no dark matter halo.

III. DARK MATTER PHENOMENA

In this section we assess the observations listed in Section I that are usually attributed to dark matter to see whether they are consistent with the predictions in Section II about antigravity matter.

Observation 1) Spiral galaxies appear to be rotating too quickly for the gravity of their visible matter to hold them together [1].

According to the antigravity matter theory this is because normal matter objects orbiting in the disc are attracted towards the centre of the galaxy by some or all the forces listed in Section II.12.

Observation 2) The orbital velocity of a spiral galaxy's disc is fairly constant over a large part of the radius of the disc. This is usually interpreted as evidence that much of the dark matter associated with a spiral galaxy is spread out in a halo in deep space around the galaxy and is not co-located with the visible matter [1].

For simplicity we assume that the apparent dark matter is arranged spherically and that it dominates the gravity field of the galaxy. To produce a completely flat orbital velocity profile the density profile of dark matter would have to be as shown in Figure 6 in which the horizontal axis of the graph covers the visible radius of the galaxy disc.

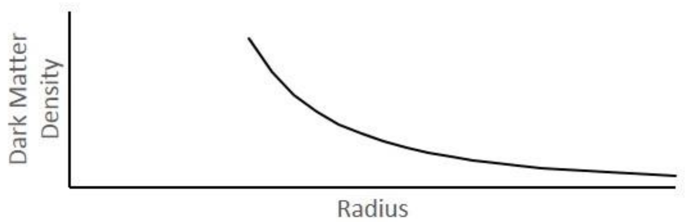

Figure 6 – Dark Matter density profile required to give a constant normal matter orbital velocity in the galaxy disc

According to the antigravity matter theory this attraction is caused by a reduction in density of antigravity matter within an antigravity matter vortex. The antigravity matter density profile that would give a completely flat orbital velocity profile is of the form shown in Figure 7 if the antigravity matter density reduction was also spherical.

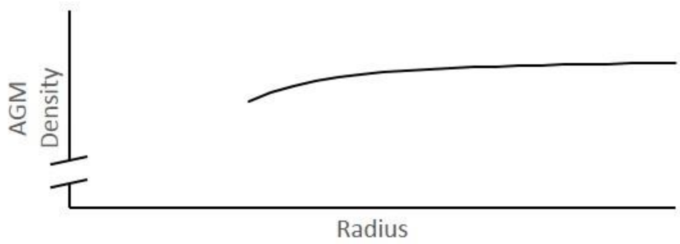

Figure 7 – Antigravity matter density profile required to give a constant normal matter orbital velocity in the galaxy disc

This curve has been produced by inverting, factoring and transposing the dark matter curve in Figure 6. This is due to the AGM Equivalence. In Figure 7 the density of antigravity matter is constant in deep space away from the galaxy but reduces closer to the centre. This profile is consistent with part of the predicted antigravity matter density profile in Figure 5 and Section II.11.

Observation 3) The amount of apparent dark matter in spiral galaxies is highly variable. Some have even been detected that appear to be almost all dark matter with very little visible matter [2].

According to the antigravity matter theory the strength of the antigravity matter vortex is not simply dependent on the amount of visible matter currently in the galaxy. A vortex has its own inertia and gets stronger with time in a newly formed galaxy or after two galaxies merge. It takes time to die away if the visible matter is removed by some other cataclysmic event. It may be affected by the antigravity matter wind from nearby galaxies or within a galaxy cluster. It may be driven by multiple orbiting black holes rather than be visible matter. This observation is therefore consistent with the antigravity matter hypothesis.

Observation 4) The dark matter content of elliptical galaxies has been estimated at about 80% of the mass of the visible matter. The margin of error on these measurements allows for all elliptical galaxies to have approximately the same ratio of normal matter to dark matter [3].

According to the antigravity matter theory an elliptical galaxy does not have an antigravity matter vortex. The apparent gravity field of the galaxy is therefore generated by the normal matter objects and the Voids within the AGB Boundaries of the normal matter objects. In Section II.7 Equation (4) we showed that in the absence of a vortex and outside a normal matter object's AGM Boundary the apparent total gravity of the normal matter object would be increased by a constant factor of $\{1 + {G_{na}}^2 / G_{nn}G_{aa}\}$.

Therefore this elliptical galaxy observation is consistent with the antigravity matter hypothesis and suggests that:-

$$ {G_{na}}^2 / G_{nn}G_{aa} \approx 0.8 \qquad (6) $$

Observation 5) Unlike spiral galaxies, elliptical galaxies do not appear to have halos of dark matter in space around them. Their dark matter appears to be co-located with their visible matter [3].

As stated for Observation 4) above, according to the antigravity matter theory an elliptical galaxy does not have an antigravity matter vortex. The extra gravity of an elliptical galaxy is caused by the Voids within the AGB Boundaries of the normal matter objects. This observation is consistent with the antigravity matter theory if a typical star's AGM Boundary is no more than a few light years radius.

Observation 6) Although dark matter is affected by gravity it does not appear to collapse towards its centre of gravity to create a dense object like normal matter does. It appears to remain at low density.

According to the antigravity matter theory and due to AGM Equivalence a region of apparent dark matter is actually a region of reduced density antigravity matter. The density of antigravity matter cannot go below zero. That means there is an upper limit to the possible apparent density of dark matter.

Observation 7) Many attempts have been made to detect dark matter directly by means that do not depend on gravity, for example CRESST [4]. However no dark matter particles have ever been conclusively detected other than by gravity.

According to the antigravity matter theory firstly there is no need for dark matter, and secondly the nearest antigravity matter is outside the solar system.

IV. OBJECTIONS AND CONSISTENCY CHECK

Objection 1) - A gravity increase due to antigravity matter (or dark matter) has not been observed in the solar system.

Section II.8 Equation (5) predicts that the apparent gravity of a normal matter object will be increased by $G_{na}D_{ab}\,{}^{4}\!/_{3}\,\pi r$ within its AGM Boundary where *r* is the radius of the object. The Sun and the solar system have been studied in great detail and no increase in apparent gravity due to antigravity matter (or dark matter) has been detected. The best estimates of the Sun's mass is $1{\cdot}9884 \times 10^{30}$ kg $\pm\ 2 \times 10^{26}$ [6]. This error band means that if this universe does contain the hypothetical antigravity matter the increase in gravity within the solar system must be less than a factor of $\{1 + 10^{-4}\}$. Therefore we can conclude that for any object within the solar system:-

$$G_{na} D_{ab} \, {}^{4}\!/_{3} \, \pi r < 10^{-4} \times {}^{G_{nn} M}\!/_{r^2}$$

This is most limiting when r is large. For example Voyager 1 is the most distant man made object from the Sun. It is currently about 2×10^{13} m from the Sun [7]. Therefore:-

$$G_{na} D_{ab} < 4 \times 10^{-25}\ \text{s}^{-2} \qquad (7)$$

Objection 2) – Antigravity matter would cause drag in space.

A normal matter object such as the Sun repels antigravity matter and causes an antigravity matter Void within an AGM Boundary. The Sun's AGM Boundary is assumed to be outside the solar system. There is no antigravity matter within the solar system so planets, moons and other normal matter objects are not affected by drag.

However according to this hypothesis there is antigravity matter between the stars in a spiral galaxy's disc. This causes drag and a spiral galaxy gradually loses energy. This has serious implications for our understanding of the dynamics of galaxy formation and galaxy lifecycle. However that subject is outside the scope of this paper.

If the antigravity matter was too dense the spiral galaxy would hardly rotate at all. This suggests an upper limit on the deep space density of antigravity matter. It is probably no more dense than the average density of the normal matter in a galaxy disc. If we assume our local environment is typical, take the distances to the nearest few stars, and assume they all have about the same mass as the sun we come to a normal matter density and an upper limit on the background antigravity matter density such that:-

$$D_{ab} \leq 7 \times 10^{-21}\ \text{kg m}^{-3} \qquad (8)$$

Consistency Check

In this paper the following equations have been developed:-

From Section III Observation 4 Equation (6)

$${G_{na}}^2 / G_{nn}G_{aa} \approx 0.8$$

From Section IV Objection 1 Equation (7)

$$G_{na}D_{ab} < 4 \times 10^{-25}\ \text{s}^{-2}$$

From Section IV Objection 2 Equation (8)

$$D_{ab} \leq 7 \times 10^{-21}\ \text{kg m}^{-3}$$

Also in this paper the following assumptions were made about the radius of an AGM Boundary:-

1) In Section II Initial Deductions we assumed there was no antigravity matter in the solar system.
2) In Section III Observation 7 and Section IV Objection 1 and Objection 2 we assumed that the Sun's AGM Boundary was outside the solar system.
3) In Section II.10 we assumed that the radius of a typical star's AGM Boundary was smaller than the average distance between stars.

We can make some guesses to test whether these equations and assumptions can be consistent. For that purpose only we guess that:-

$$G_{nn} = G_{na} = G_{aa} = 6.67 \times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{s}^{-2}$$

$$D_{ab} = 7 \times 10^{-21}\ \text{kg m}^{-3}$$

Then

$$G_{na}D_{ab} = 4.67 \times 10^{-31}\ \text{s}^{-2}$$

Therefore equations (6), (7) and (8) are consistent. Equation (7) is satisfied by a factor of about a million. That means that with these guessed at figures we would require the measurement of the Sun's mass to be about a million times more accurate before we could detect the effect of antigravity on the orbits of objects in the outer solar system.

The AGM Boundary of the Sun (still assuming that antigravity matter pressure is negligible) can be calculated from Equation (3) in Section II.5 as about 4×10^{16} m which is about 4 light years. This is consistent with the assumptions in 1) and 2) above but is a little high for 3). However this value is for the condition of no antigravity matter wind. When there is an antigravity matter wind the AGM Boundary is driven closer as shown in Figure 4. Also the antigravity matter may be driven closer if antigravity matter pressure is not negligible but that is outside the scope of this paper. We therefore conclude that with the present degree of analysis the antigravity matter theory can be self-consistent.

V. CONCLUSION

The dark matter observations listed in Section I are all consistent with the hypothesis that the universe contains a thin low temperature atmosphere of antigravity matter and does not contain a significant amount of gravitationally attractive dark matter. Two objections have been answered.

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