Redefining Gravity

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Abstract

The purpose of this paper is to present a hypothesis that redefines gravity. The current definition for gravity is: The natural force of attraction between any two massive bodies, which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

The current definition explains the force of attraction between two massive bodies. Einstein's well-known equation, $E = mc^2$, relates mass and energy. So, this paper expands upon that premise and proposes that gravity is not the force of attraction between two massive bodies but is rather the force of attraction between two *energy bodies*.

Gravity – the natural force of attraction between any two energy bodies, which is directly proportional to the product of their energies and inversely proportional to the square of the distance between them.

This proposed definition of gravity predicts the bending of light by a massive body. And may also be used to improve our understanding of how galaxies rotate. If supported by experimentation, we may then be able to combine gravity into a Grand Unified Theory.

1. INTRODUCTION

Sir Isaac Newton proposed a theory of gravity in the late 1600's. Due to its accurate prediction of the motion of celestial masses in our solar system his theory became the accepted Universal Law of Gravitation. This theory alone was one of the greatest advancements of physics and our understanding of the universe in history, not to mention his other great achievements in mathematics and science. It is likely that no one individual has contributed and advanced our understanding of the natural universe more than Sir Isaac Newton.

With respect to Sir Isaac Newton, his theory of gravity accurately predicted any phenomena attributed to gravity that he could have observed in his time. However, we are now able to observe more closely and see farther into space than he could have possibly imagined, and many of these observations cannot be completely explained by Newton's Universal Law of Gravitation. Not until the early 1900's, when Albert Einstein proposed his theory of General Relativity, did anyone attempt to explain certain phenomena currently not explained by Newton's law of gravity. But do alternative explanations exist?

Since Newton's Law of Gravity, $F_g = G\, m_1 m_2 / r^2$, accurately predicts the motion of massive objects, let us assume it is basically correct. Newton states that gravity is the natural force of attraction between any two massive bodies, which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. If this statement is basically correct, what relationship of these variables can be modified?

Since gravity, F_g, is the force we are trying to determine, let us concentrate on $G\, m_1 m_2 / r^2$. Given two massive bodies acting upon each other, the variable, '*r*', is the distance between the two massive bodies. Einstein chose to modify '*r*', or bend space and time. Is there another explanation? If we keep '*r*' constant, can we modify the definition of the two massive bodies?

What do we know about matter that we did not know three hundred years ago? We know that matter is composed of mostly empty space, and in that empty space are highly energetic particles. These energetic particles transfer and absorb energy in small bundles, called *quanta*, and therefore matter itself must be composed of quanta, or quantized energy. Hence, any massive celestial body is essentially a collection of small bundles of energy, or an *energy body*.

If we substitute 'energy body' for 'massive body' and 'energies' for 'masses' into Newton's Universal Law of Gravitation we get:

> *Gravity* – the natural force of attraction between any two energy bodies, which is directly proportional to the product of their energies and inversely proportional to the square of the distance between them.

2. DERIVATION

The current definition of gravity is: The natural force of attraction between any two massive bodies, which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Sir Isaac Newton proposed the Universal Law of Gravitation in the late 1600's. Newton developed his theory, which later became a law of physics, to understand the motion of the planets.

The Universal Law of Gravitation is:

$$F_g = G\, m_1 m_2 / r^2 \qquad (1)$$

'F_g' is the force of gravity in newtons; '*G*' is the universal gravitational constant, $6.673 * 10^{-11}$ m^3 / (kg * s^2); 'm_1' and 'm_2' are the masses of the celestial bodies in kilograms; and '*r'* is the distance between the centers of mass of the celestial bodies in meters. See Figure 1.

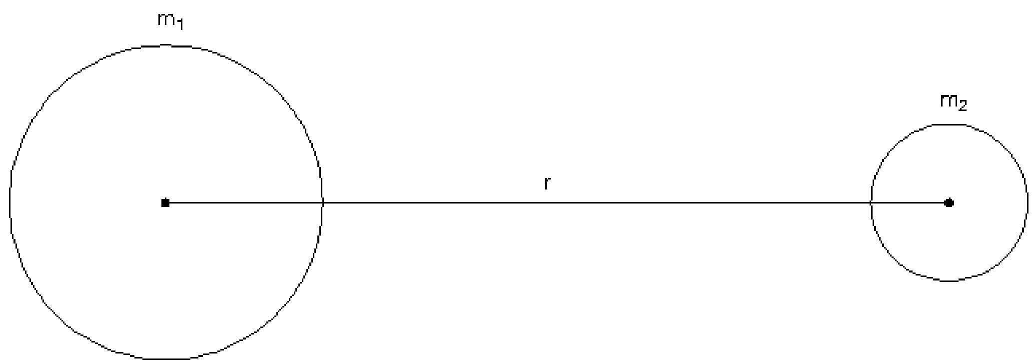

Figure 1.

According to Albert Einstein's well-known equation,

$$E = mc^2 \qquad (2)$$

energy (E) and mass (m) are directly related by the square of the constant, c, which is equal to the speed of light. In fact, mass (matter) is another form of energy - an extremely condensed form. If matter is simply condensed energy, then we really have energy attracting energy. In the case of celestial bodies like the Earth and the Sun, we have very massive energy bodies attracting each other.

Gravity – the natural force of attraction between any two energy bodies, which is directly proportional to the product of their energies and inversely proportional to the square of the distance between them.

We define energy body as a collection of quantized energy. In the case of a planet, like Earth, the total energy would equal the mass of the Earth plus the thermal, chemical, electrical, and electromagnetic energies concentrated in and around it (kinetic and potential energy were intentionally excluded). Generally, we can consider Earth a closed system. It radiates heat and absorbs much of the light energy that hits it. But these transfers of energy are miniscule compared to the energy that is stored as mass in the Earth. Even energy from our Sun, which radiates approximately $4 * 10^{33}$ ergs per second, is insignificant when compared to its energy stored as mass.

Based upon our new definition of gravity,

$$F_g = G_W \, e_1 \, e_2 \, / \, r^2 \qquad (3)$$

As illustrated in Figure 2, F_g remains the force of gravity in Newtons; e_1 and e_2 are the total energy of each energy body; 'r' remains the distance between the centers of the two bodies; and G_W, "Wescoup's Gravitational Constant", becomes the new gravitational constant, defined below.

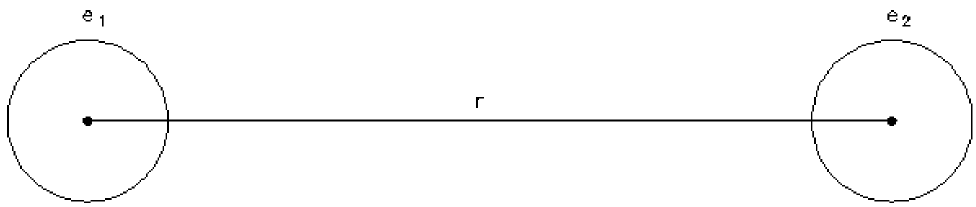

Figure 2.

The derivation of G_W is simple, starting with Einstein's equation,

$$E = mc^2$$

therefore,

$$e_1 = m_1 c^2 \text{ and } e_2 = m_2 c^2$$

Now we take Newton's Universal Law of Gravitation,

$$F_g = G\, m_1 m_2 / r^2$$

and multiply both sides by $c^2 * c^2$,

$$c^2 c^2 F_g = G\, (m_1 c^2) \times (m_2 c^2) / r^2$$

then substitute e_1 and e_2,

$$c^4 F_g = G\, e_1 e_2 / r^2$$

and divide both sides by c^4

$$F_g = G\, e_1 e_2 / (r^2 c^4)$$

To reduce constants, we can divide Newton's gravitational constant by c^4, and define G_W as:

$$G_W = G / c^4$$

The units for G_W are:

$$(m^3 / (kg * s^2)) / (m^4 / s^4) = s^2 / (kg * m^2), \text{ or } 1 / N$$

So,

$$G_W = 8.260 \times 10^{-45}\ N^{-1}$$

This gives us equation 3, the new equation for gravity

$$F_g = G_W\, e_1 e_2 / r^2$$

3. EVALUATION

We will now evaluate the new definition of gravity. First, we will compare it to Newton's Universal Law of Gravitation. Second, we will see how light is affected by this hypothesis. Last, we will apply this hypothesis to understand how galaxies spin.

3.1 Comparison to Newton's Universal Law of Gravity

In Newton's Universal Law of Gravity, the force of attraction between two celestial bodies is governed by equation 1:

$$F_g = G\, m_1 m_2 / r^2 \qquad (1)$$

By applying this equation to determine the force of attraction between the Sun and the Earth (see Figure 3), where:

$m_1 = 1.9889 \times 10^{30}$ kg	Mass Sun
$m_2 = 5.9742 \times 10^{24}$ kg	Mass Earth
$G = 6.673 \times 10^{-11}$ m^3 (kg-s^2)	Gravitational Constant
$r = 1.5 \times 10^{11}$ m	Distance from Sun

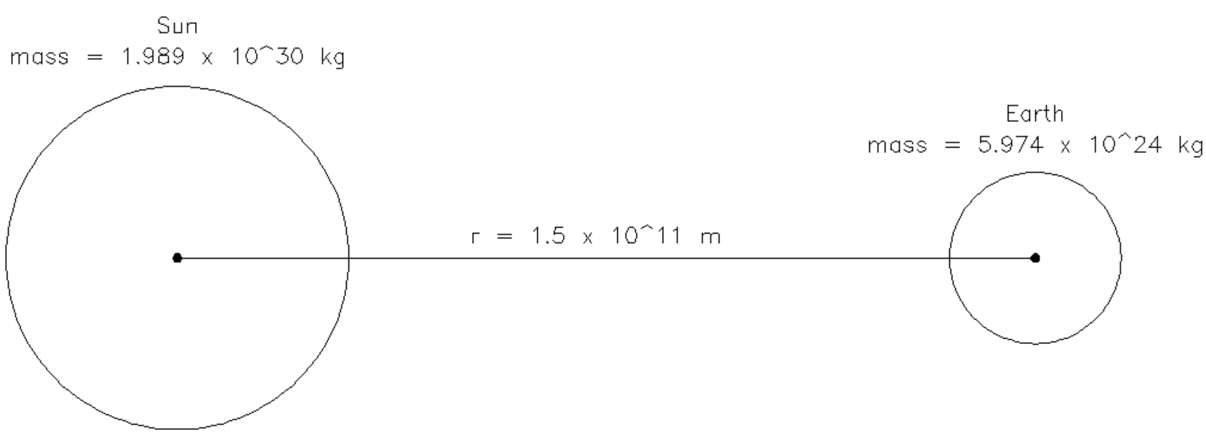

Figure 3.

the force is gravity is calculated to be:

$$F_g = 3.524 \times 10^{22} \text{ N}$$

By comparison, using the new definition of gravity, the force of attraction between any two energy bodies is governed by equation 3:

$$F_g = G_W\, e_1 e_2 / r^2 \qquad (3)$$

In this case we do not know the total energy of the bodies, but we can assume that the net energy loss or gain in each body is negligible compared to the energy stored in the mass of the body. So, by substituting mc^2 for e, to make the following equation:

$$F_g = G_W (m_1 c^2) (m_2 c^2) / r^2 \qquad (4)$$

and using the preceding values for m_1, m_2, and r, and the following constant values:

$c = 2.998 \times 10^8$ m/s	the speed of light
$G_W = 8.260 \times 10^{-45}$ N^{-1}	Wescoup's Gravitational Constant

The calculated Force of Gravity also yields:

$$F_g = 3.524 \times 10^{22} \text{ N}$$

This analytical comparison therefore shows agreement between Newton's Universal Law of Gravitation and the new definition of gravity. But in this case, since we only know the mass, using equation 4 offers no advantage over Newton's equation.

3.2 Deflection of Light by a Celestial Body

Newton's Universal Law of Gravitation accurately predicts the behavior of massive celestial bodies. But in the case of energy forms that do not have mass, such as light energy, gravity would have no effect. However, we do know from observation that massive bodies do, in fact, bend light.

We will now apply the new definition and equation for gravity to this phenomenon. We will assume that a light ray with a frequency of 5.75×10^{14} Hz, visible light, passes 1.738×10^6 m distance from the center of the Moon (approximately equal to the radius of the Moon) as shown in Figure 4.

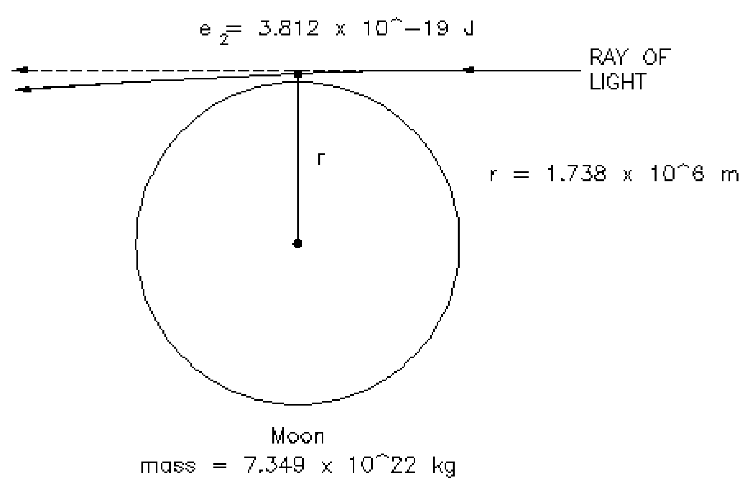

Figure 4.

The energy for a ray of light is given by Maxwell Planck's equation

$$e_2 = h\,f \qquad (5)$$

where h is Planck's constant, 6.63×10^{-34} J-s. The energy for the ray of light is

$$e_2 = 3.812 \times 10^{-19}\ \text{J}$$

Substituting $m_1 c^2$ in for e_1 in equation 3, the equation is then:

$$F_g = G_W\,(m_1\,c^2)\,e_2 / r^2$$

where:

$e_2 = 3.812 \times 10^{-19}$ J	energy of light ray
$m_1 = 7.349 \times 10^{22}$ kg	mass of Moon
$c = 2.998 \times 10^{8}$ m/s	the speed of light
$G_W = 8.260 \times 10^{-45}$ N^{-1}	Wescoup's Gravitational Constant
$r = 1.738 \times 10^{6}$ m	distance from Moon

Calculating the Force of Gravity yields:

$$F_g = 6.886 \times 10^{-36}\ \text{N}$$

The resulting force is the force acting upon the light ray as it travels by the Moon at a distance of 1.738×10^{6} m.

It is now necessary to determine how this force deflects the ray of light.

$$F = m\,a \qquad (6)$$

This equation describes how a force acts on a mass. To determine how this force acts on an energy body it is necessary to return to equation 2.

$$E = m\,c^2 \quad \text{or} \quad m = E / c^2$$

Substituting 'E / c^2' in for 'm' into equation 6 yields,

$$F = (e_2 / c^2)\,a \qquad (7)$$

Solving for acceleration,

$$a = F_g\,c^2 / e_2$$
$$a = (6.886 \times 10^{-36}\ \text{N}) \times (2.998 \times 10^{8}\ \text{m/s}) / (3.812 \times 10^{-19}\ \text{J})$$
$$a = 1.623\ \text{m/s}^2$$

It takes about 1.16×10^{-2} seconds for light to cross the diameter of the Moon. We will assume that the Moon acts upon our ray of light for this amount of time imparting a small velocity perpendicular to its original bearing.

$$V = a\,t \qquad (8)$$

$$V = 1.623\ m/s^2 \times 1.16 \times 10^{-2}\ s = 1.882 \times 10^{-2}\ m/s$$

From this we could calculate an angle of deflection; however, the actual amount of deflection in this example is unimportant. The purpose of this demonstration was to show that the proposed definition of gravity predicts the deflection of light by a massive body.

3.3 Light as Dark Matter

For years cosmologists have attempted to prove the presence of a significant amount of unobserved matter that must exist in and around galaxies. The reason for this quest is to attempt to explain why galaxies do not revolve in a manner that can be explained by our current understanding of gravity. In theory the stars nearer the center of a galaxy should revolve faster than stars further from the center, just like the planets closer to the Sun revolve faster than the more distant planets. However, observation shows that all of the stars revolve around the center of a galaxy in approximately the same period.

Based upon our current understanding of gravity, a great amount of mass, currently unaccounted for, must exist in and around a galaxy to explain this behavior. Therefore, cosmologists predict that a significant amount of “dark matter” (matter that is cool and does not radiate light energy) must exist.

Dark matter certainly does exist. It also makes sense that the amount of dark matter would increase moving away from the nucleus of a galaxy, there is simply more space available. While astronomers have searched for dark matter, they have not found it in the abundance necessary to explain the behavior of galaxies.

While stars are extremely massive, the space between stars, in and around a galaxy is immense. In each cubic meter of space there is a certain amount of light energy traveling through it in a given period of time. According to our new definition of gravity, energy is attracted to energy, and matter is an extremely condensed form of energy. In the last example where the Moon exerted a gravitational force and deflected a ray of light, it can also be reasoned that the ray of light applied the same force on the Moon. Based upon the proposed definition of gravity, could light energy traversing through a galaxy account for the lack of observed dark matter? The following demonstration only considers light energy but remember the new definition of gravity applies to all forms of quantized energy.

This demonstration uses the Sombrero Galaxy, a well-researched galaxy with relatively consistent data. First let us calculate the total energy stored in the mass of the Sombrero Galaxy, hereafter referred to as M104.

$m_{M104} = 800 \times 10^9$ solar masses
$m_{Sun} = 1.9889 \times 10^{30}$ kg
$m_{M104} = 1.591 \times 10^{42}$ kg

Using $E = mc^2$ to convert mass to an equivalent amount of energy yields

$$e_{M104} = (1.591 \times 10^{42}\ \text{kg}) \times (2.998 \times 10^{8}\ \text{m/s})^{2} = 1.430 \times 10^{59}\ \text{J}$$

Next let us calculate the energy radiated by M104 over a period of time. This will be the light energy in and around the galaxy.

Magnitude = +8.7
Luminosity M104, $L_{M104} = L_{Sun} \times (D_{M104} / D)^{2} \text{ X } 10^{\,0.4}\ (m_{Sun} - m_{M104})$

where:

$L_{SUN} = 3.826 \times 10^{26}$ J/s
$D_{M104} = 2.838 \times 10^{23}$ m
$D_{SUN} = 1.50 \times 10^{11}$ m

Then,

$L_{M104} = 8.407 \times 10^{43}$ J/s

L_{M104} represents the rate at which light energy is emitted by the galaxy. This means over a given time there will be a certain amount of light energy produced. Or, in a particular radius (of a sphere), a certain amount of light energy will be contained. Table 1 calculates the amount of light energy within a sphere of a given radius based upon the amount of time it takes light to travel from the center of the galaxy to the specified radius.

Table 1.

Light energy contained within a sphere of a given radius centered about the M104 galaxy. Which is equal to the light radiated by the M104 galaxy in a given period of time.

Case	Luminosity	Radius	Time	Description	Energy
1	8.407×10^{43} J/s	2.365×10^{20} m	25.0×10^{3} yrs	Radius of M104	6.63×10^{55} J
2	8.407×10^{43} J/s	4.730×10^{20} m	50.0×10^{3} yrs	Diameter of M104	1.33×10^{56} J
3	8.407×10^{43} J/s	2.838×10^{23} m	30.0×10^{6} yrs	Distance to Earth	7.96×10^{58} J

In Case 1 (Figure 5), the energy contained in a sphere with a radius equal to the radius of M104 is 6.63×10^{55} J, and represents the light energy in the M104 galaxy. In Case 1 the light energy is about 0.05% of the energy that is contained in the mass of M104.

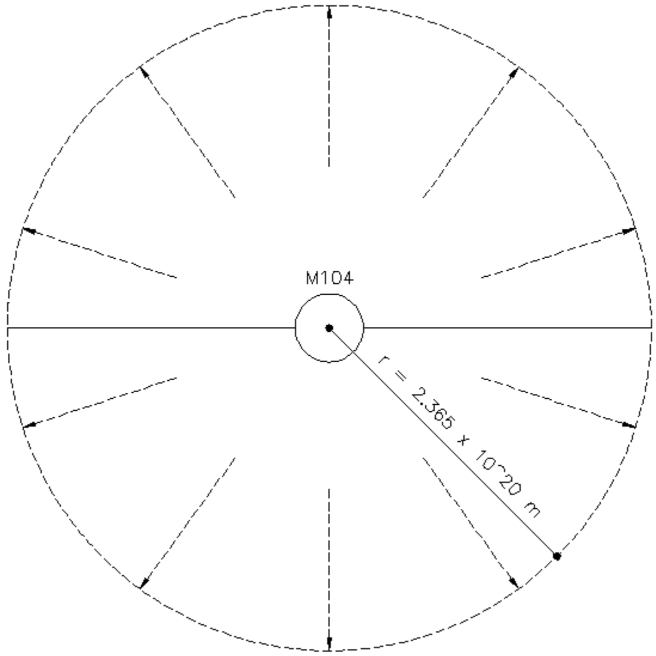

Figure 5.

In Case 2 (Figure 6), the energy contained in a sphere with a radius equivalent to the diameter of M104 is 1.33×10^{56} J, and represents the light energy in and around the M104 galaxy. In this scenario the light energy is about 0.1% of the energy that is contained in the mass of M104.

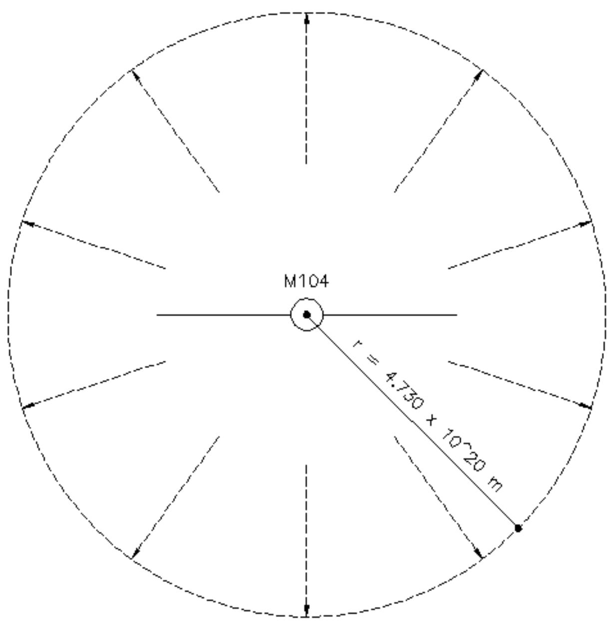

Figure 6.

The third scenario (Figure 7) represents the energy contained in a sphere with a radius that extends to our galaxy, 7.96 x 10^{58} J. In this scenario the light energy is about 55.7 percent of the energy that is contained in the mass of M104.

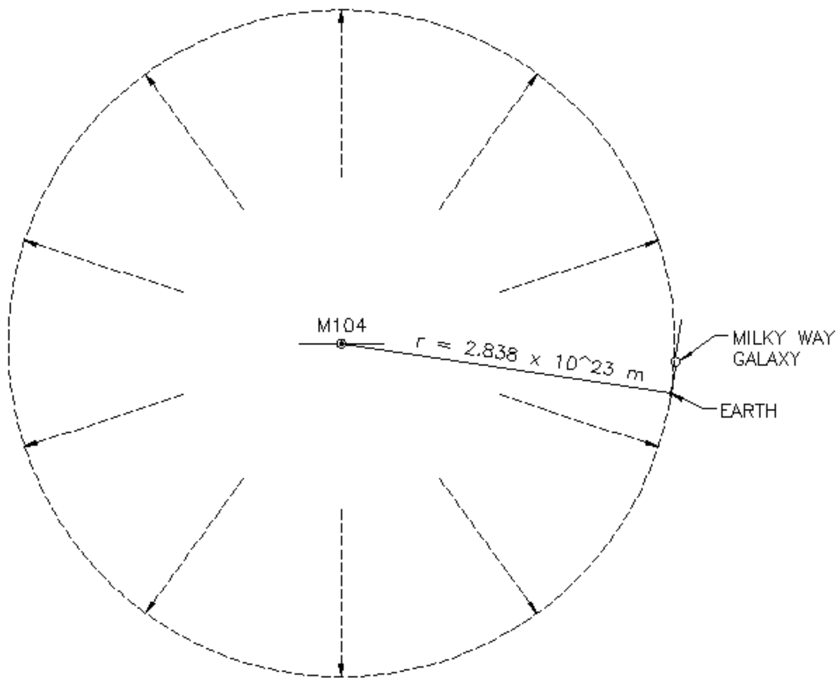

Figure 7.

At what distance would the light energy radiated by the M104 galaxy no longer have an affect on the galaxy?

The above scenarios are very conservative. They only account for the amount of light being radiated by the M104 galaxy. They do not account for light energy in the galaxy that is absorbed by masses in the galaxy nor the light from other sources that approach the M104 galaxy.

The purpose of this demonstration was only to determine if the amount of light energy in and around a galaxy could be significant, but our model would need to include all forms of quantized energy that exist in and around the galaxy to be comprehensive. The proposed definition of gravity applies to more than just light energy. Based upon the proposed definition of gravity, light and other forms of quantized energy would reduce the amount of dark matter necessary to account for how galaxies spin. An actual model that would predict this behavior is beyond the scope of this paper.

4. CONCLUSIONS AND FUTURE WORK

This paper proposes the definition of gravity as the natural force of attraction between any two energy bodies, which is directly proportional to the product of their energies and inversely proportional to the square of the distance between them.

This proposed definition of gravity predicts an attraction not only between matter but between all forms of quantized energy. In Section 3.1 we showed that this proposed definition of gravity agrees with Newton's Universal Law of Gravitation. But it also makes other predictions. The proposed definition predicts that light will be affected by massive energy bodies, Section 3.2. It is therefore reasonable that gravity would also affect subatomic particles and energy transfer processes which may explain time dilation by atomic clocks based upon their distances from a massive energy body (Earth). Also, how would the mass, or total energy, of a particle be affected when subjected to a large magnetic field, such as a particle accelerator? It is not the purpose of this paper to disprove General Relativity, which is currently used to explain these phenomena. Instead, we must explore the effects and predictions proposed by this new definition of gravity independent of other gravitational theories.

Based upon the affect of a massive energy body on light, as show in Section 3.2, we can conclude that light also affects massive energy bodies. This affect may be the key to our understanding of how galaxies spin. Our current understanding of gravity requires that a large amount of dark matter must exist in and around a galaxy. We have currently not observed dark matter in sufficient quantity to explain how galaxies spin. In Section 3.3 we discuss how light energy in and around a galaxy might account for some of the dark matter that we have not been able to observe.

Recent experiments trying to determine the exact value of Newton's Gravitational Constant have found small fluctuations in the value of 'G'. The proposed definition of gravity may account for these small fluctuations since changes in the total energy (fluctuations in light, radio waves, microwaves, magnetic fields, and radiation) around the experiment would cause fluctuations in gravity. The value of 'G_W' is based upon the relationship '$E=mc^2$'. If it discovered that this is not the correct relationship between matter and energy, the value of 'G_W' will need to be altered based upon the correct relationship.

If experimentation supports the hypothesis proposed by this paper, there will be fundamental changes to our understanding of physics and our universe. Based upon this proposed definition of gravity, as an attraction between energy bodies, or an interaction of energy, it may make it possible to incorporate gravity into a Grand Unified Theory.