Chasing Oumuamua: An apology for a cyclic gravity and cosmology, consistent with an adaptation of general relativity

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Abstract

Oumuamua was the first interstellar object observed to pass through the solar system. It did not follow the expected hyperbolic path, as if the pull of the Sun's gravity was less than expected. Off-gassing normally present in comets was not observed. A modified gravity hypothesis — cyclic gravity and cosmology (CGC) — is proposed here to explain this motion. This hypothesis also would entail a greatly simplified and cyclic cosmology, potentially resolving the Hubble tension controversy.

1 Introduction

Oumuamua displayed what was considered non-gravitational acceleration, despite lacking the observed off-gassing used to explain such movement in comets. There have been various proposals to explain this: Some propose the ejection of a transparent gas as in Desch (2021). Others have taken a more radical approach, assuming that the lack of observed off-gassing should be taken at face value, and also assuming that current gravitational theory is correct. In that case, the logic inescapably leads to an artificial origin, as in Loeb (2019).

Noting modified gravity theories that have been proposed to try to explain galactic rotation rates, as in McGaugh (2011) and Milgrom (2014), this presentation will use a modified gravity approach to explain the behavior of Oumuamua. The fact that Oumuamua was the first observed interstellar visitor and that it also displayed mysterious acceleration seems too great a coincidence; perhaps the fact that it is interstellar also explains its unusual acceleration. How might this be?

The coincidence of interstellar origin and anomalous acceleration suggests that the gravitational force in another star system (like the one where Oumuamua originated) might operate differently, which would be very strange. While many astronomical observations seem to follow the dictates of General Relativity (GR), some do not — galactic rotation rates, for example. Cyclic gravity and cosmology (CGC) is here proposed as a modified gravity hypothesis that begins by explaining the motion of Oumuamua. A similar explanation is then made for galactic rotation rates and cosmological expansion. The final part of this paper will deal with the topic of cosmology. The cyclic cosmology presented here has a similarity to the idea presented in Ijjas (2019), wherein the universe is described as going through cycles of expansion and contraction. CGC differs from Ijjas (2019) in that the cycles of expansion and contraction in CGC are due to the operation of gravity in Euclidean space.

2 Cyclic gravity and cosmology (CGC)

2.1 Central assumption

Some theorists have proposed that gravity may be an expression of Van der Waals forces, as in Puthoff (1989), Sernelius (2009), and Zhang (2013). This has been discounted because these forces decrease too rapidly with distance, as per Cole (2001).

The central assumption of Cyclic gravity and cosmology (CGC) is the existence of cyclic motions in the charge distribution within the nuclei of atoms. These motions take place without changing the overall charge on the atom. It is assumed that these cyclic motions permeate all matter at all times, and are not caused by temporary induced charge distributions on the surface of two masses in contact with each other, as in Van der Waals forces.

It is proposed that the nuclei of atoms of different masses affect each other's charge fluctuations enough that some small portion of these cyclic motions are brought into phase with each other, thus accounting for the gravitational force between the two masses. In the solar system, the cyclic motions within the Sun would tend to dominate the system; all of the planets over time would acclimate themselves to this solar "fingerprint." Oumuamua, because it came from outside the system, had not the time to acclimate itself to the Sun's gravitational fingerprint.

A material object like a planet is a complex assemblage of trillions of atoms with their associated nuclei. Quarks make up the nucleons, and quarks have charge. Researchers have not, thus far, been able to detect polarity in nucleons. It is reasonable to assume that quark charges are in such rapid motion within a nucleon, that the polarity is difficult to detect.

Since the rapid motion of these charges is constrained by the boundary of the nucleus of the atom, such motion can be approximated as a cyclic motion. A macro object is composed of trillions of atoms, and the nucleus of each atom contains within it as many cyclic charge fluctuations as it has nucleons.

The simplest schematic representation of one of these motions would be ↕. This would symbolize a slight, barely detectable (or, for practical purposes, undetectable) back and forth motion of an indeterminate number of nucleons. See figure 1.

2.2 Applying these assumptions to gravity between the Sun and the Earth

Imagine an interaction between one of these cyclic motions in the Sun and one of these cyclic motions in the Earth. A simplified description of the interactions between these two would be to describe them as two parallel wires thus: ↕↕ . In this conception, each wire has an alternating current within it; when they are in phase, the wires are attracted to each other. When they are anti-phase, the wires would be repulsed. The alternating current in a wire can be expressed as $I = I_0 \sin(\omega t)$, and the force between two parallel wires with alternating current in them can be modelled by:

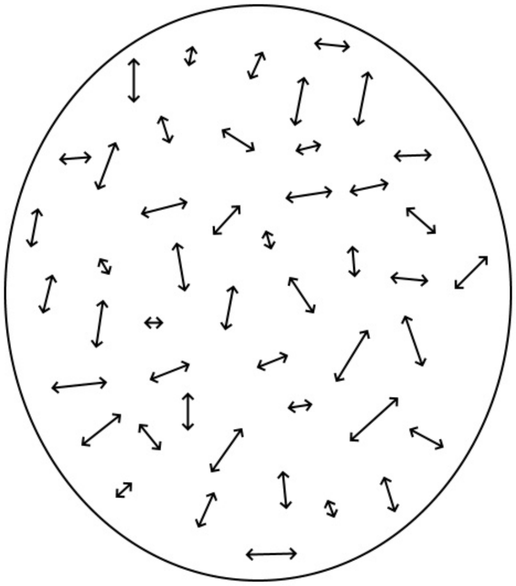

Figure 1: A schematic representation of cyclic charge motions in a mass.

$$F = \frac{\mu_0 I_1 \cos(\omega_1 t) I_2 \cos(\omega_2 t) l}{2\pi r} \tag{1}$$

μ_0 is the vacuum permeability, I is the current, ω is the angular frequency, l is the length of the wires, and r is the distance between the wires.

The presentation is greatly simplified by ignoring all constants, and the length of the wires. When considering the gravitational interaction between the Sun and the Earth, distance will also be treated as constant, since the Earth's orbit is approximately circular. With these simplifications, equation 1 becomes:

$$F \propto I_1 \cos(\omega_1 t + \phi_1) I_2 \cos(\omega_2 t + \phi_2) \tag{2}$$

Here ϕ represents the phase change between the cyclic currents. If the wires are nearly in phase with each other, they would tend towards an attractive force. The opposite would be true when they are anti-phase. Two anti-phase wires would experience a repulsive force.

Imagine two different large masses, such as the Sun and Earth, with trillions of microscopic cyclic fluctuations as schematically depicted in figure 1. With extended interaction, it is assumed that some of these fluctuations would come into phase with each other.

Even though they are going every which direction, only one part in trillions of these various motions would have to be properly aligned between two macro objects in order to fully account for the strength of the gravitational force, as demonstrated in subsection 2.3.

2.3 Comparing the electrostatic force with the gravitational force

Considering the forces that two protons would exert upon each other: The charge on a proton is $1.6 \times 10^{-19} C$. Therefore, the repulsive electrostatic force between the two protons would be:

$$\frac{(8.99 \times 10^9)(1.6 \times 10^{-19})^2}{r^2} N \tag{3}$$

The mass that a proton is supposed to have is $1.67 \times 10^{-27} kg$. Therefore, the attractive gravitational force between them would be:

$$\frac{(6.67 \times 10^{-11})(1.67 \times 10^{-27})^2}{r^2} N \tag{4}$$

Setting these two results proportional to each other would give:

$$\frac{\frac{(8.99\times10^9)(1.6\times10^{-19})^2}{r^2}}{\frac{(6.67\times10^{-11})(1.67\times10^{-27})^2}{r^2}} = 1.24 \times 10^{36} \tag{5}$$

The number stated above, 1.24×10^{36}, is how many times stronger the electromagnetic force is than the gravitational force — many, many orders of magnitude larger. Although CGC in its current form is being presented in terms of attraction caused by the magnetic field between alternating currents, rather than the electrostatic field, the strength relative to gravity would still be many orders of magnitude larger. This means that if there are cyclic motions of charges inside of macro objects, only one part in trillions would need to be approximately spatially aligned, approximately of the same frequency, and approximately in the same phase as those in another macro object in order to account for the gravitational force.

Trying to experimentally prove the existence of such small cyclic motions within two interacting macro objects is currently impossible. Furthermore, trying to prove that an appropriate microscopic quantity of them are in phase with those of another macro object would be even more difficult. Nevertheless, much circumstantial evidence can be presented to suggest that this idea may be true. The first item in the chain of evidence would be to show that the force on an object in circular orbit might stay approximately constant over time.

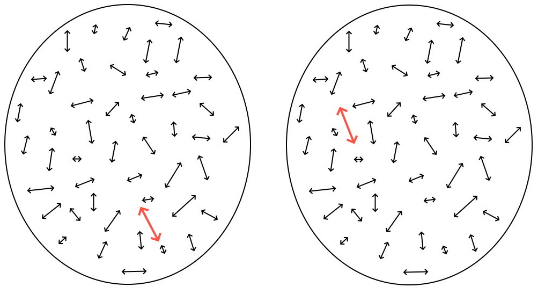

Figure 2: Schematic selecting somewhat aligned "partners"; one from the Sun, and one from the Earth

3 Modelling gravitational attraction between the Sun and the Earth

3.1 Four pairs of hypothetical Sun/Earth fluctuations

Figure 2 shows two similar fluctuations (in red): one within the Sun, and one within the Earth. They are considered similar because they are approximately aligned in direction, frequency, and phase. Although in reality the amplitudes of all these waves might vary greatly, here the amplitude of all waves will be treated as the same. In other words, the I_1 and the I_2 of equation 2 will be "1" for all fluctuations shown. A greatly simplified version of gravitational interaction will be illustrated using four pairs of "partners". In the following demonstration, amplitude might be considered gravitational potential, but the specific units of this potential, as well as the units of time, are considered temporarily irrelevant, in the interests of simplification.

Figure 3 shows four hypothetical wavelike gravitational potentials arriving at the Earth from the Sun,

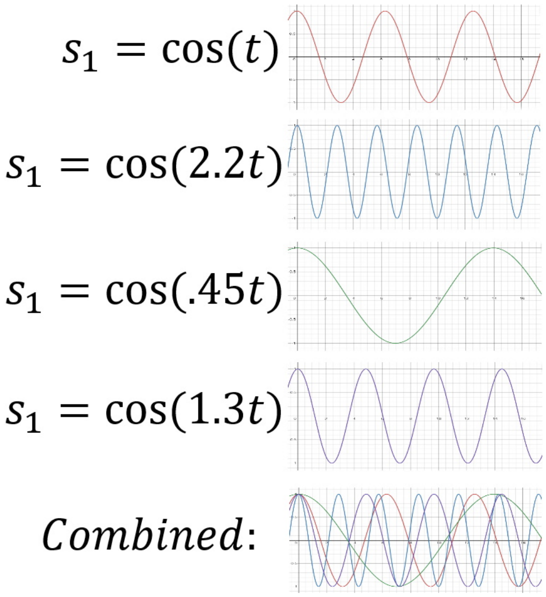

Figure 3: Force potential on vert. axis; time on horiz. axis. Four hypothetical fluctuations from the Sun, depicted arriving at the Earth, along with a combined view.

as well as what they would look like in combined form (not summed — for now just overlaid). Considering that the combined form is a jumbled mess of "noise" with only four components, one might imagine trying to represent accurately the trillions of such waves constantly arriving.

Because they are of all different amplitudes, frequencies, and phases, its net effect would be the same as charge-neutral – essentially random noise with no directional force at all.

While these waves from the Sun arrive, four somewhat similar waves are posited to be taking place within the Earth (here shown only in tables 1 and 2). Each of them is paired with its appropriate partner to produce a force. Depending upon the phase relationship, this force might be attractive, repulsive, or zero. Suppose that the Earthly fluctuations begin with a slightly different frequency and a different phase than their partner, as shown in table 1.

If each of the partners shown in table 1 generates a force according to equation 2, then summing these together would result in the force shown in equation 6.

Table 1: Four sets of paired Sun/Earth fluctuations; Those from the Sun are labelled $S_1 - S_4$; those from the Earth are $E_1 - E_4$

Sun	Earth
$S_1 = cos(t)$	$E_1 = cos(.98t + 1)$
$S_2 = cos(2.2t)$	$E_2 = cos(2.1t + 1.3)$
$S_3 = cos(.45t)$	$E_3 = cos(.52t + .5)$
$S_4 = cos(1.3t)$	$E_4 = cos(1.1t + .75)$

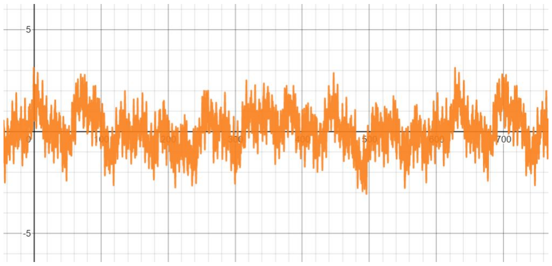

Figure 4: Force according to equation 6, using wave forms according to table 1.

$$F = S_1E_1 + S_2E_2 + S_3E_3 + S_4E_4 \tag{6}$$

A graph of equation 6 is shown in figure 4.

A few notes need to be made about the wavelike composite form of the graph of equation 6. First, the top of the wave of each cycle will have implications about the flat velocity curve in galactic rotation; this will be explained in section 9. Secondly, the repulsive gravity suggested by the negative portions of the wave will have implications about cosmological expansion; this will be explained in section 10. These implications arise out of the fact that, while the wave form is shown with time on the horizontal axis, a similar form would result if the horizontal axis were distance. In other words, gravity would alternate between attractive and repulsive as a function of distance.

3.2 Acclimated fluctuation

Through the process of acclimation explained in section 6, over time two interacting bodies like the Sun and the Earth will have some of their fluctuations come into phase with each other; table 1 would change into table 2.

When this happens, the force expressed by equation 6 would substantially change, becoming ap-

Table 2: After acclimation. Some paired Sun/Earth fluctuations adjust to each other to acquire the same frequency and phase.

Sun	Earth
$S_1 = cos(t)$	$E_1 = cos(1t + 0)$
$S_2 = cos(2.2t)$	$E_2 = cos(2.2t + 0)$
$S_3 = cos(.45t)$	$E_3 = cos(.45t + 0)$
$S_4 = cos(1.3t)$	$E_4 = cos(1.3t + 0)$

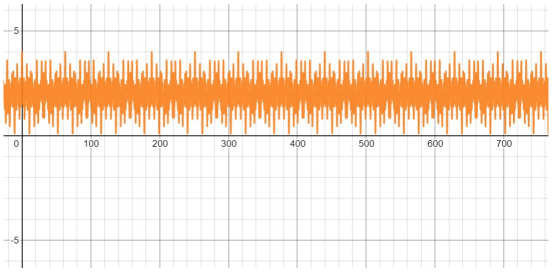

Figure 5: Force according to equation 6. Using wave forms according to table 2.

proximately constant. The graph of it is shown in figure 5.

3.3 New gravitational force law

While in figure 5 gravity is not precisely constant, it is approximately so. Considering that this is an approximation of a practically infinite series using only four terms, it can be supposed that as more and more pairs are added to the sum, it would become more and more truly constant. This suggests that equation 6 can be used to write a new force law for gravity, as shown in equations 7 and 8. Equation 7 would hold before two masses are completely acclimated, as between the Sun and Oumuamua, or the Sun and a body with a very eccentric orbit, such as a comet (see section 8). Equation 8 would hold once two masses have become completely acclimated to each other, with a substantial number of their fluctuations in phase.

$$F = \frac{\mu_0 A}{2\pi(r+k)} \sum_{i=1}^{n} \cos\left(\omega_{m1i} t + \phi_{m1i}\right) \cos\left(\omega_{m2i} t + \phi_{m2i}\right) \tag{7}$$

$$F = \frac{\mu_0 A}{2\pi(r+k)} \sum_{i=1}^{n} \left(\cos\left(\omega_i t + \phi_i\right)\right)^2 \tag{8}$$

Some notes on equations 7 and 8: k is an arbitrary constant inserted to indicate that at small scales, gravity would disappear. In other words, k would be made very large at atomic or molecular scales. At larger scales, such as describing gravity at the surface of a planet (or any scale larger than that), k is declared to be zero. μ_0 is vacuum permeability. The constant A combines the basal current along with the "lengths" of the hypothetical wires being used in the model. ω and ϕ represent the angular frequency and the phase of each ith term in the sum. r is the distance between the hypothetical wires. At small distances, no phase shift is considered that is due to the propagation velocity. This treatment, in other words, is looking at the phase of the Sun's waves as they are arriving at Earth. The phase leaving the Sun is not considered. If the equations are used in a context where propagation velocity has an effect, an appropriate phase shift must be added.

4 Adapting the force law to distance rather than time

While equations 7 and 8 might represent a real force law for gravity, they are useless for calculations. How would one detect and sum up all of the trillions of electromagnetic fluctuations and their effect upon one another? In order to use the force law, simplifying assumptions and adjustments have to be made, using observed data as a guide. Both Newtonian gravity and GR supply excellent working equations in nearly all contexts. Simplified equations will be presented here that will be less useful, but with a form that better communicates what is assumed to be the actual underlying force law.

Acclimation assumes that, over time, the frequency and phase of paired fluctuations will become and stay approximately constant, resulting in a bias towards circular orbits. Yet if there is radial travel, by a probe for example, the wave-form will change, because the relationship between fluctuation pairs would change. So distance and radial velocity would both affect the wave form. Because of this effect, pairs may change partners, may change frequency, or may adapt phase.

In addition, up until now wave forms have been treated in time as they were arriving at the Earth. Because of propagation at the speed of light, however, a waveform leaving the Sun will be phase shifted by $\frac{r}{c}$, where r is the distance from the Sun, and c is the speed of light.

The angular frequency, ω, changes in different scales. The period of equation 7 must be enlarged to explain the galactic rotation rates discussed in section 9 and the cosmological expansion discussed in 10. Enlarging the period causes different pairs of partner fluctuations between two masses to become dominant. Because of this, longer wavelengths are presumed to become dominant at larger distances. Equations 7 and 8 are adjusted in the manner shown below. The choice to stretch the phase by using $\ln\left(\sqrt{r}\right)$ is arbitrary, but there is no other realistic way to summarize the effects of trillions of fluctuations and combine them into one single force law, as is shown in equation 9.

$$a_s = \frac{A_s}{r} S_s \tag{9}$$

In equation 9: A represents the amplitude, r is the distance from the Sun, and S_s represents a sum that is similar to those employed in equations 7 and 8. This sum is shown in equation 10.

$$S_s = \sum_{i=1}^{4} \cos\left(\omega_{1i} \ln\left(\sqrt{r}\right) + \frac{\phi_{1i} r}{c}\right) \cos\left(\omega_{2i} \ln\left(\sqrt{r}\right) + \phi_{2i}\right) \tag{10}$$

The simplification of the force law for gravity (shown in equation 9) is unsatisfying. Unlike equations 7 and 8, equation 9 is arbitrary and ad hoc. Only four terms are used to represent what is practically an infinite sum. Units within the cosine functions are ignored. Output is assumed to be in $\frac{m}{s^2}$. Other methods of the appropriate stretching of the period might be devised. Note that the quantity $r + k$ might be used in place of r in order to avoid conveying the idea that gravity was either undefined or infinite when $r = 0$. This will become relevant when discussing "black holes" in section 16.

A graph of the acceleration due to the Sun's gravity for objects within the solar system, using the equation shown in equation 9, is shown in figure 6.

Interpreting figure 6 is problematic. It is not meant to claim a depiction of the real gravitational force caused by the Sun. Instead, it is to show that CGC force laws can be found that are consistent with observations. Of special interest is its perfect consistency with the acceleration of Oumuamua. One might wonder how fast it might have been acclimating, and if there are unexplained accelerations by other objects in this precise region? Perhaps close analysis of data from the Parker Solar Probe might

Table 3: List of parameters for use in the solar acceleration equation 9

Parameter	Value
A_s	6.8412×10^8
ω_1	11.4068
ω_2	3.07412
ω_3	7.12282
ω_4	2.02159
ϕ_1	5.40387×10^{-4}
ϕ_2	8.63483×10^{-4}
ϕ_3	2.54821×10^{-4}
ϕ_4	1.58907×10^{-3}

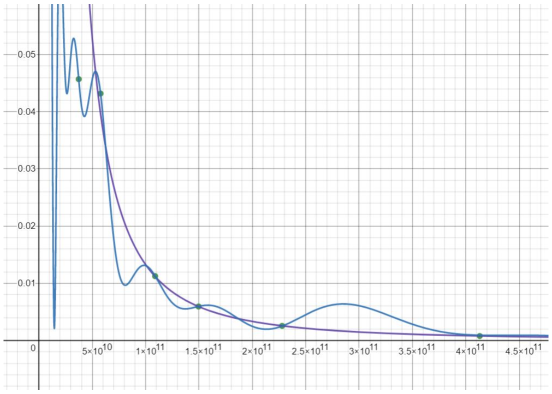

Figure 6: A graph of the acceleration due to the Sun's gravity in the solar system according to equation 9 (Blue line). Newtonian is the purple line. r is in meters, output is in $\frac{m}{s^2}$. The green dots, left to right, are: Oumuamua, Mercury, Venus, Earth, Mars, Ceres. $R^2 = 1$. The graph also has perfect correlation for Jupiter, Saturn, Uranus, and Neptune, though they are not shown.

help to answer this. A second interpretation might be that since Oumuamua might not have acclimated, its data should not have been included in the regression model — in which case a different regression model would have resulted.

5 A major result: Gravity behaves in different ways at different scales and in different contexts

The big questions in Cosmology are about mysterious accelerations at very different scales. How to explain Oumuamua? What drives cosmological expansion? Why are galactic rotation curves flat? How do planets form so quickly?

CGC assumes that gravity is a sort of near-infinite sum of various cyclic interactions between objects. Because these interactions propagate at the speed of light, different parts of the sum will be dominant at different scales. In other words, shorter wavelengths would be dominant at the scale of the solar system, while longer wavelengths would be dominant at the galactic scale. At the inter-galactic scale, the dominant wavelengths would be longer still. These changes of wavelength would mean that the gravitational force law might change dramatically at different scales. Finally, because gravity is caused by cyclic motions, it happens that sometimes, when cycles within two interacting objects are opposite phase, gravity is actually repulsive. Over a great deal of time, the attractive force is more likely to win out, because it would reinforce itself, pulling the objects closer. Depending upon the initial velocities, there is a good chance that they might either go into orbit around each other or else actually join together to form one larger object.

The repulsive interaction, however, would inhibit itself, because it would push the objects further apart, changing the phase of the interaction, until once again the distance is such that the phases are aligned, and then they would begin orbiting each other.

6 Acclimation

Objects over time will become acclimated. After this acclimation, many of their charge fluctuations would be in harmony with each other. At that point, there would be a very strong tendency towards circularization of orbits. Eccentric elliptical orbits that trace out the exact same path each cycle would not ever occur. This is because the phase signature of the interaction would substantially change over the course of the orbit because the gravitational interaction would not maintain a perfect proportion to r or r^2, as required by Bertrand (1873).

An object from outside of the solar system would not be acclimated to the Sun's gravitational "fingerprint," or "signature." If this object were to travel at a large velocity close to the Sun, its non-acclimated gravitational signature would become evident. This immediately suggests Oumuamua.

7 Oumuamua

Oumuamua is the first known interstellar object to pass through the solar system. It is strange that it should demonstrate anomalous acceleration. Various attempts to explain this acceleration have been made. Seligman (2019) explains it by positing off-gassing similar to that which is also used to explain the non-gravitational acceleration of comets. The difficulty is that such off-gassing was not observed. Various other explanations have been attempted.

If cyclic gravity and cosmology (CGC) are correct, the explanation is straightforward: Oumuamua did not have the time needed to acclimate to the Sun's gravitational signature. As it sped by, it's unique gravitational signature was evident, which was generally mistakenly interpreted as some sort of non-gravitational acceleration. This same sort of acceleration is observed in comets, where it is also mistakenly attributed to non-gravitational acceleration.

8 Comets

Comets display what is supposed to be non-gravitational acceleration. This is generally thought to be due to off-gassing, as demonstrated in Rafikov (2018). One would suppose however, that the off-gassing would generally be fairly uniform in all directions; therefore off-gassing is unlikely to be the explanation for these non-gravitational accelerations.

According to the hypothesis of CGC, comets' orbits are eccentric enough that their gravitational signature must be changing all the time as their distance from the Sun rapidly changes. This is why their motion does not exactly follow what would be expected from a strictly Newtonian force law. It also means that even absent the influence of all the planets and other objects in the solar system, they would never perfectly trace out the same orbital path, because their paths are not circular enough. According to Bertrand (1873), only force laws that are constantly proportional to $\frac{1}{r^2}$ or $\frac{1}{r}$ would be stable enough to trace out the same repeating path each period, unless the force was constant, and the object was moving in a circular orbit.

Several minor anomalies have been observed in the solar system where neither Newtonian gravity nor GR can fully explain the observed acceleration. Saturn's braided F-ring displays a sinusoidal form, seen in figure 7. While some have tried to explain its form as being due to "shepherding moons," CGC might explain it as being due to the breakup of some mass, the phase of whose fluctuations were then changed radically. After this radical change, the leftover dust and gas began experiencing cyclic attractive and repulsive forces from Saturn. CGC may explain the strange ejection of particles from the surface of Bennu. It would also explain why the rocks and boulders near the surface of Bennu were so lightly held in place that the Osiris spacecraft sank so easily into the surface. This would be caused by the radius of Bennu being such that the surface is located at a distance where gravity is much weaker than expected or even repulsive.

Both the flyby and the Pioneer anomalies would be explained by the instability of gravitational forces for objects travelling at high radial velocity (or very eccentric orbits), so that acclimation is not keeping up with their position. The same effect may be seen in the highly eccentric Molniya orbits of some satellites. All of these gravitational anomalies within the solar system are dwarfed by the largest known gravitational anomaly: galactic rotation.

9 Galactic rotation rates

Figure 8 shows actual versus expected rotational velocity of stars in Messier 33. The fact that the curve does not decline at larger distances presents a problem for Newtonian gravity and also for GR. Most scientists resolve this problem with a dark matter halo as in Wechsler (2018). A dark matter halo is associated with most galaxies according to the Lambda-Cold Dark Matter (ΛCDM) model. In contrast, CGC will instead follow a modified gravity approach, as in McGaugh (2011); Milgrom (2014).

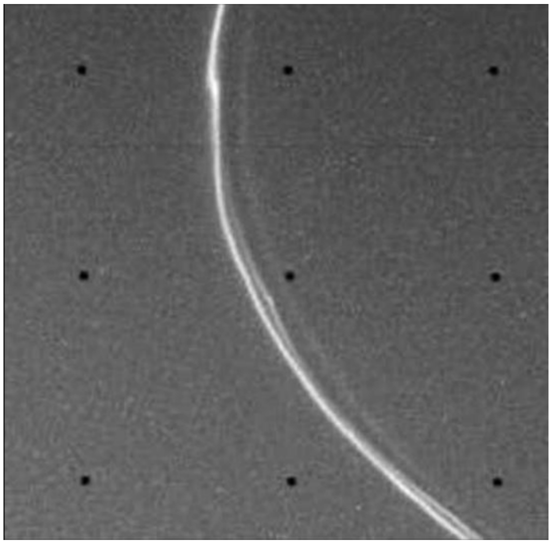

Figure 7: Saturn's braided F-ring; it was photographed at a range of 750,000 km (470,000 mi).

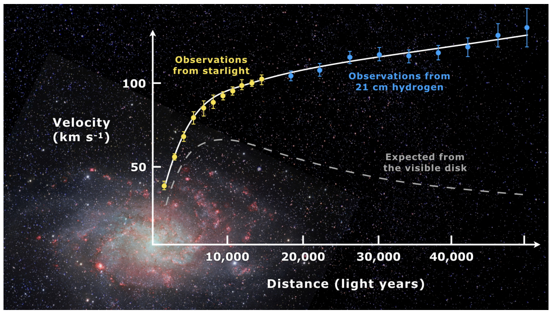

Figure 8: Rotation curve of spiral galaxy Messier 33 (Triangulum). 14 November 2018, by Mario De Leo.

Equation 9 may be converted to rotational velocity output as in equation 11.

$$a_g = \frac{A_g L}{r} S_g = \frac{v_g^2}{r} \ \therefore \ v_g = \sqrt{A_g L S_g} \tag{11}$$

Note that the amplitude of the velocity equation depicted in equation 11 *presents a different relationship to distance.* This recalls a_g's relationship

Table 4: List of parameters for use in the galactic velocity in equation 11. Note that the ω parameters differ from table 3 only in that they have been divided by 10^3; The ϕ parameters have been divided by 10^9.

Parameter	Value
A_g	1.458×10^8
k	8.5×10^{-21}
r_0	6×10^{20}
ω_1	1.14068×10^{-2}
ω_2	3.07412×10^{-3}
ω_3	7.12282×10^{-3}
ω_4	2.02159×10^{-3}
ϕ_1	5.40387×10^{-13}
ϕ_2	8.63483×10^{-13}
ϕ_3	2.54821×10^{-13}
ϕ_4	1.58907×10^{-12}

to distance in Milgrom (1983). Also note that the Sum expression used in equation 11 is identical to that used in equation 9, but the output is labelled as S_g (Sum galactic), rather than S_s (Sum solar). The L in equation 11 is a logistic function. Adding this function is necessary because the mass density of a galaxy changes significantly with distance and should no longer be considered a point mass, as in solar gravity. Equation 12 shows the logistic function used in equation 11.

$$L = \frac{187.94}{1 + e^{-k(r-r_0)}} \tag{12}$$

Once again, proper interpretation of the graph in 9 is very important. No claim is being made here that the gravitational force conforms closely to what is shown in the graph. Rather, it is to show that equations of similar form — i.e., a short sum of waves — can be made to fit the data. It is currently impossible to develop a completely accurate version of the equation applicable to all scales, so special summaries, or adaptations, must be adapted to each particular scale, and each particular context. It is presumed, for example, that other galaxies may each have their own distinctive signature, each requiring their own set of parameters. As the theory progresses, algorithms might be developed to adjust to the context and scale so that the predictive value of CGC approaches or surpasses ΛCDM. The next context to be considered will be that of cosmological expansion.

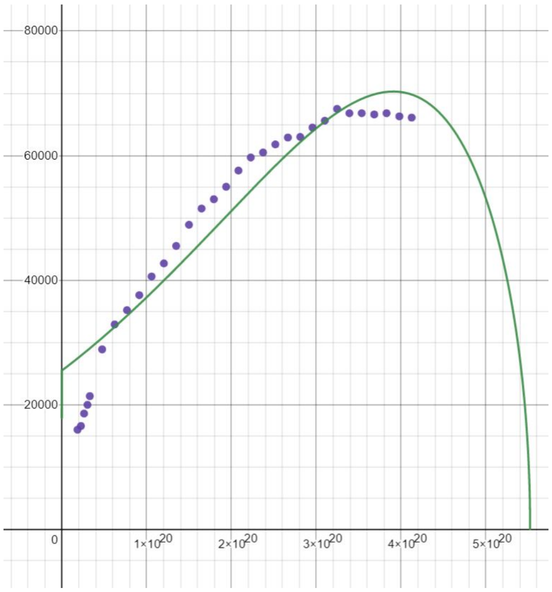

Figure 9: Rotation curve for Galaxy DDO-161. Horizontal axis is distance in meters. Vertical axis is velocity in $\frac{m}{s}$. Data is from Lelli (2020).

10 Cosmological Expansion

At this large scale some further simplifications are made, because it is assumed that fluctuations at such vast distances from each other become less acclimated. They become more like a simplified version of the graph shown in figure 4. *Note that gravity at these scales will alternate between attractive and repulsive values.* The expansion and contraction at this scale looks very similar to that posited in Ijjas (2019), although CGC explains this cyclic contraction and expansion through varying gravitational forces. (An article about this research has been linked in Appendix C.) Rather than doing a sum of four terms, the model can employ just one cosine term. Although at the cosmological level the mass density should need even more adjustment, to preserve continuity and simplicity, the same logistic function for L will be retained for the cosmological velocity function shown in equation 13. At such large scales the "orbital velocity" will not be relevant, but it will serve as an excellent way to depict the distances where gravity changes between attractive and repulsive. The "orbital velocity", unlike acceleration, does not decrease with distance.

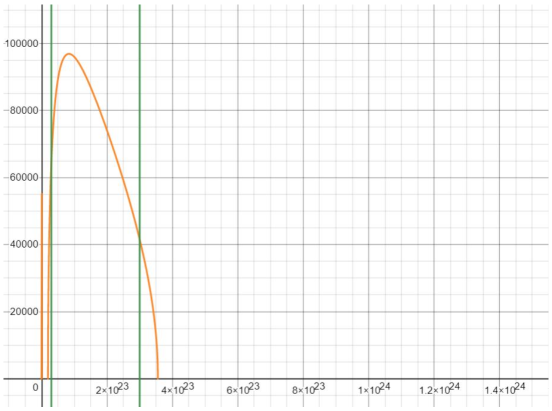

Figure 10: Velocity graph of equation 13 out to 50 megaparsecs. Velocity in $\frac{m}{s}$, distance in m. The green vertical lines enclose a region from about 1 to 10 MP; This is the size of galaxy clusters. Note that beyond this, in any region the graph is not shown, *gravity would be repulsive.*

Table 5: List of parameters for use in velocity equation 13. This equation is for use from about 1 to 10 megaparsecs.

Parameter	Value
A_c	5×10^{7}
k	8.5×10^{-21}
r_0	6×10^{20}
ω	2.17
ϕ_1	-97

$$v_c = \sqrt{\left(A_c L \cos\left(\omega_c \ln\left(\sqrt{r}\right) + \frac{\phi_c r}{\omega_c}\right)\right)} \qquad (13)$$

The disadvantage of graphing orbital velocity rather than acceleration is that regions of negative (repulsive) gravity are not shown, but their location is known by the disappearance of the velocity curve. Anywhere the velocity equation is undefined, being expressed as a negative value within the $\sqrt{}$ symbol, acceleration would be negative, resulting in a repulsive gravity. A negative acceleration would mean a force pushing galaxies away from each other, which accounts for cosmological expansion. The graph of equation 13 is shown in figure 10.

Note that the value for A_c, the amplitude of the wave, is less than the previous A_g. This should not be interpreted as meaning less mass. It would just mean that the specific sum of the specific fluctuations would be less — illustrating again the odd nature of a regression that turns out differently for different scales and different contexts. This is also the reason why A_g is not properly proportional to A_s (i.e. mass of a galaxy compared to the mass of the Sun).

Going out to an even larger scale, equation 13 can be slightly adjusted by changing ω to 1.406. When this is done, gravity is repulsive out to about 4.277×10^{3} megaparsecs. *After this, gravity would become attractive again.* Because the phase becomes larger in each cycle, one might assume that over the course of such large distances, the universe might change into an era of *cosmological contraction.* This suggests that there never was inflation or a big bang. There was no "expansion" in the sense of the deformation of space itself. *The universe is cyclic, which can be described as a cyclic cosmology. According to CGC then, the universe would be now as it always had been, in an endless cycle of expansion and contraction.* The current era is an era of expansion, but at some point when galactic distances cross a certain threshold, the universe would enter into an era of contraction. This would at first be difficult to detect, because of the effect of tired light, but would become more and more evident with time. Some might object that data from the Cosmological Microwave Background radiation (CMB) disproves a cyclic cosmology. The next section will deal with this objection.

11 The Cosmic Microwave Background radiation (CMB)

The CMB comes from all directions of space, even where there are no visible light sources. If the universe is finite, with no stretching of space, the outer reaches of the universe would be a density of the intergalactic medium (IGM) that is slowly decreasing with distance. The only possible source of the CMB would be the intergalactic medium (IGM). The intergalactic medium (IGM) is mostly ionized hydrogen gas. If light travels from stars, through a sufficient distance of the IGM, 100% of the light will eventually interact with the ionized gas, resulting in Compton scattering. The CMB is light returning to observers in the universe after Compton scattering in the outer reaches.

Light originates in stars, and then travels to the outer edge of the universe, where only the IGM exists. The light comes only from one direction, the interior universe. None of it is coming from the outside. If a photon of light is of low enough energy, it will be absorbed. If it is of high enough energy, it will be re-emitted. After being re-emitted, it will have a different frequency. The further light travels from the universe, the less light there will be, until there is none at all. No light ultimately escapes. From the outside, the universe would be opaque.

Compton scattering from the IGM explains why the CMB comes from a perfect blackbody. None of the light coming from a blackbody source is reflected. A blackbody source must be at constant temperature. Since light from Compton scattering results from an inelastic collision, the frequency of the light is changed. This is why the CMB does not seem to come from star light. In other words, the CMB is not reflected star light, even though its ultimate source was star light. The intergalactic medium, taken as a whole, remains at constant energy and temperature. The amount of EM radiation leaving it at any given time would be equal to the EM radiation entering. Thus the radiation emitted from it, returning to the universe, would be that from a perfect blackbody.

Note that what might be called the IGM could refer to two different regions. Regions within the observed universe that are in between observed galaxies might be called IGM. It is not necessarily true that these specific areas would emit light with a perfect blackbody profile. When this paper is using the phrase IGM, one must note that it is specifically referring only to that region of space beyond all visible galaxies. In other words, the reference is limited specifically to a region just outside the visible universe. The claim is that light coming from this specific region would have the profile of light from a perfect blackbody.

Some might object that red shifting of the most distant galaxies shows them to be receding at speeds faster than the speed of light. This would only be possible in an expanding universe. Goldhaber (2001) demonstrated that galaxies are travelling away from each other at increasing rates, disproving a "tired light" (alone) explanation for the red shift. But expansion and tired light are not mutually exclusive. They both might be happening at the same time. Over vast distances, light does lose energy as it travels through "empty" space, in addition to the energy lost to the Doppler effect. Tired light in this form acknowledges that galaxies are rapidly receding from each other. Thus, tired light would be an explanation for only part of the red shift, not all of it. The minimum part of the red shift caused by tired light might be determined by looking at the galaxies with greatest red shift. These are the galaxies receding most rapidly. They are so extremely red shifted that their velocity (determined from Doppler shift) is calculated to be faster than the speed of light. This is allowed under GR because the stretching of space allows an object to, in some sense, break the speed of light barrier. Faster than light travel would not be allowed in CGC, however, because there is no stretching of space. This would mean that, at a minimum, the portion of the red shift requiring faster than light travel would be due to tired light.

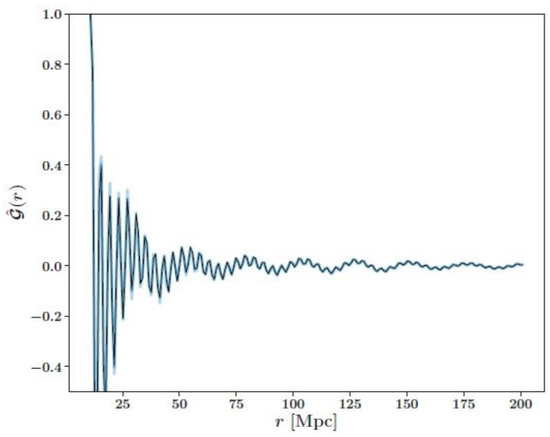

Figure 11: Shape of the force function, according to Pardo (2020), that would be necessary to explain large scale structure from the polarization of the CMB.

A gravitational force law according to CGC would have effects that would not be predicted by ΛCDM. Cyclic gravity would affect both the current distribution of matter, and also the path that was travelled by the CMB. Pardo (2020) did a regression to demonstrate the shape a gravity force law must take in order to make measurements of the large-scale structure of galaxies explainable from the microwave background polarization. The shape of the graph of the force law shown in Pardo (2020) is very suggestive. This hypothetical force law is shown in figure 11.

ΛCDM assumes that the CMB represents a relic of the "big bang," occurring in the distant past, that is now visible because the surface of last scattering has been expanding away from the observer due to cosmological expansion (in the sense of stretching space). CGC, on the other hand, while also assuming that the CMB is from the distant past — maintains that the CMB simply represents observers looking at themselves in a sort of mirror. The CMB is light that has made a long "there and back" journey spanning many megaparsecs. Along the way, its characteristics were changed by Compton scattering. Compton scattering in the outer IGM serves in the role of "surface of last scattering" in CGC. What both theories have in common, however, is the idea that the current large scale distribution of matter should be explainable from the CMB. It is an argument in favor of CGC that Pardo's function so well suggests a wave form that is consistent with CGC.

12 Special relativity

Cyclic gravity and cosmology (CGC) resurrects the idea of the Lorentz contraction to explain the outcome of the Michelson-Morely experiment, as in Lorentz (1892). Lorentz proposed that the length of anything travelling at relativistic velocity would contract, contrary to the position expressed in Special relativity (SR), where space itself is posited to contract. Lorentzian object contraction does not entail the deformation of space. Instead, the particles making up an object are objectively closer to each other in the direction of travel. Eventually, Lorentz's position was abandoned in favor of Einstein's, because it was considered ad hoc in the sense that it did not explain the time dilation and increase-of-mass that occur at relativistic velocities and in large gravitational potentials. Einstein's special relativity (SR) and general relativity (GR) together were able to do all of these things. In SR, it is not just the object that contracts in the direction of travel, but all of space. CGC retains the time dilation and increase-of-mass from SR, but explains them in a Euclidean space. CGC is able to retain Euclidean space because, like Lorentz, it posits that it is only the object itself that contracts. In this conception, retention of the word "relativistic" does not imply a non-euclidean space-time continuum. Instead, "relativistic" implies that the following three characteristics are affected in a way proportional to the objective velocity relative to the objective rest frame. First, the length of the travelling object contracts (rather than space itself). Secondly, the mass increases by this same proportion. Thirdly, time, as measured by a stationary (at rest) observer of the object, slows down, by the same proportion.

12.1 The solar system as an approximate rest frame

If the universe is cyclic, with alternating eras of expansion and contraction, then it would have a rest frame of reference. If the expansion and contraction were due to a cyclic gravitational force law, rather than a cyclic expansion and contraction of space itself (as in Ijjas (2019)), then the universe would also have a center. A rest frame does immediately suggest itself.

One might consider that a frame wherein the CMB is not Doppler shifted, to be on average, at rest with respect to the universe as a whole. Aghanim (2014) shows that the velocity of the solar system with respect to this frame is approximately 384 $\frac{km}{s}$, which is not large. This means that objective values for time dilation and increase-of-mass might all be systematically calculated in reference to the frame wherein the Doppler shift of the CMB would be zero. Why does the frame of reference matter?

The frame of reference matters because SR insists on both space deformation and time dilation that are relative between objects with no universal frame of reference. SR then results in a loss of simultaneity such that two different observers might disagree about the sequence of events. Cyclic gravity and cosmology (CGC) keeps an objective frame of reference. Observers might disagree about the specific time of an event, but they would not disagree about the order in which different events happened. Both observers would be able to calculate an objective order based upon the objective reference frame. CGC is able to incorporate time dilation and increase-of-mass while retaining an objective order of events.

12.2 Time dilation at relativistic velocities

Cyclic gravity and cosmology (CGC) adopts a universal rest frame wherein the Doppler shift of the CMB is zero. The phrase "at rest" theoretically assumes this frame. The speed of light, c, is constant, and at a minimum, only in this frame. It can have larger apparent values when viewed from other moving frames. In other words, a person doing a light experiment within the confines of his moving spaceship, will verify the speed of light is c. If the same person looks out of the window of his ship, he may observe wave fronts of light travelling much greater than c, when evaluated from his reference frame.

CGC and special relativity (SR) agree that the length of a relativistic object becomes smaller when viewed from the rest frame. This is shown in equation 14. The reduction in length means that the results of light experiments in an internal co-moving system (like a planet or spaceship) will conform to the results of the Michelson/Morely experiment.

$$L_1 = L_0\sqrt{1 - \frac{u_0^2}{c^2}} \tag{14}$$

L_0 is the length of the ship at rest. L_1 is the length of the ship while moving. Both L_0 and L_1 are *as viewed from the rest frame.* CGC disagrees with SR in that CGC only applies this length shortening to the object in motion, not to space in general. An observer in a spaceship travelling at relativistic velocity will disagree with an observer at rest about the length of the ship, but not about the distance travelled. Under CGC, the ship is objectively shorter because all particles making up the ship are objectively closer together in the direction of travel when measured from the rest frame. CGC and SR agree that the time experienced by a relativistic object is shortened according to equation 15. *As with the length, both t_0 and t_1 are as viewed from the rest frame*

$$t_1 = t_0\sqrt{1 - \frac{u_0^2}{c^2}} \tag{15}$$

Someone in the rest frame would say that time passes slowly for the moving frame. Someone in the moving frame would say rather that time passes quickly in the rest frame. CGC interprets time dilation as an objective physical phenomenon in that all particles making up the moving object are restricted in their movement or change. Change is inhibited, therefore time is objectively inhibited. Bacteria put into a refrigerator would be analogous to what happens to the moving particles. The cause of dilation will be explained in section 14. SR, in contrast, treats time as if it were a fourth dimension of space, and then assumes that time and space are deformed for the moving object.

CGC and SR disagree about the apparent velocity experienced by a moving observer. CGC agrees with SR in that any experiment on the speed of light done within the confines of the moving ship, will yield the standard value for c. CGC would say that if the traveller looked out of the window to assess his velocity, however, he would say he was moving at a higher velocity than what would be declared by an observer outside the ship, at rest. To the traveller, his apparent velocity would be shown in equation 16.

$$u_m = \frac{u_0}{\sqrt{1 - \frac{u_0^2}{c^2}}} \tag{16}$$

u_0 is the velocity of the ship as seen by an observer at rest. u_m is the velocity of the ship as seen by someone on the ship, when compared to objects at rest. Suppose that the ship has a rest frame velocity of $u_0 = .9952c$. Someone looking out the window of the ship, considering the progress being made compared to the position of outside objects, would say that they were travelling at an apparent velocity of $3.05 \times 10^9 \frac{m}{s}$. This is more than 10 times the speed of light. Suppose that there were a wave front of light travelling outside, along beside the spaceship, headed in the same direction. The source of the light is assumed to be at rest. A person looking out the window at the passing wave front would say that it had an apparent velocity of $3.063 \times 10^9 \frac{m}{s}$, when compared to the progress it was making against observed background objects. Relative to the ship, the wave front would have a velocity of $3.063 \times 10^9 \frac{m}{s} - 3.05 \times 10^9 \frac{m}{s} = 1.3 \times 10^7 \frac{m}{s}$.

The two different approaches (CGC vs. SR) may be compared by looking at a famous example. Frisch (1963) observed muons travelling from the top of Mount Washington, in New Hampshire, down to sea level.

Muons have a lifetime of $\tau = 2.20\mu s$ when at rest. The number of muons in a given sample should decrease with time according to $N(t) = N_0 e^{\frac{-t}{\tau}}$. N_0 is the number of muons at $t = 0$. In the Frisch experiment, 563 muons per hour (ph) were detected at starting time zero, at the top of the mountain. In the rest frame: the muons travelled 1907 meters at a velocity of $u_0 = .9952c$. 408 muons ph were detected at finish.

The amount of time it took the muons to travel this distance in the rest frame was $\frac{1907m}{.9952c} = 6.39\mu s$. If there were no time dilation, the detection rate at sea level is shown by equation 17.

$$(563 \text{ muons ph})e^{-\frac{6.39\mu s}{2.2\mu s}} = 31 \text{ muons ph} \tag{17}$$

31 muons ph would be expected at the finish if there were no time dilation. Instead, 408 muons ph were detected at the finish. CGC and SR both explain the result with time dilation. CGC and SR agree that an observer travelling along with the muons would experience less time. According to both GR and CGC, the lifetime of a travelling muon as viewed from the rest frame has changed according to equation 18.

$$\tau_1 = \frac{\tau_0}{\sqrt{1 - \frac{u_0^2}{c^2}}} = \frac{(2.20\mu s)}{\sqrt{1 - \frac{(.9952c)^2}{c^2}}} = 22.5\mu s \tag{18}$$

τ_1 is the lifetime of a moving muon, as viewed from the rest frame. τ_0 represents the lifetime of a muon at rest. u_0 is the velocity as measured in the rest frame. The lifetime of moving muons (*as viewed from the rest frame*) has increased to $22.5\mu s$. This is more than ten times longer than when they are at rest. The expected number of muons after incorporating time dilation is shown in equation 19.

$$(563 \text{ muons ph})e^{-\frac{6.39\mu s}{22.5\mu s}} = 424 \text{ muons ph} \tag{19}$$

The muon rate in equation 19 better matches the experimental value. So far CGC and SR agree.

They do not agree when interpreting the perspective of an observer travelling along with the muons, however. Someone in the moving frame would see the muon life span of $\tau = 2.20\mu s$ remain constant. How would such a person explain the ability of so many of them to arrive at the sea level destination? According to SR, space compresses in the forward direction so that the distance travelled changes according to equation 20. In other words, Mt. Washington has been squashed to less than $\frac{1}{10}$ its rest frame height.

$$x_m = x_0\sqrt{1 - \frac{u_0^2}{c^2}} = 1907m\sqrt{1 - \frac{(.9952c)^2}{c^2}} = 186.6m \tag{20}$$

Then the traveller's time for the entire journey would be $\frac{186.6m}{.9952c} = .625\mu s$. This value is used in equation 21 to find the expected muon rate from the moving perspective. Although it also matches the experimental value fairly well, it conflicts with an observer in the rest frame about the distance that has been travelled.

$$(563 \text{ muons ph})e^{\frac{-.625\mu s}{2.20\mu s}} = 424 \text{ muons ph} \tag{21}$$

According to CGC, however, space would not be compressed. How then can CGC get the same result? CGC claims that both the moving observer and the observer at rest would agree about the distance travelled, but they would disagree about the velocity of the muons. According to CGC, an observer moving along with the muons would describe his velocity using $v_3 = \frac{x_0}{t_3} = \frac{1907m}{.625\mu s} = 3.05 \times 10^9 \frac{m}{s}$. This is more than ten times the speed of light in the rest frame. v_3 is the velocity the moving observer ascribes to himself as he compares his movement with passing objects in the rest frame. This apparent velocity is greatly increased because time is passing much more slowly for him, compared to someone in the rest frame. t_3 is the time based upon a clock that is travelling along with him. Equation 22 shows how velocity evaluated in the moving frame is related to velocity evaluated in the rest frame.

$$u_3 = \frac{u_0}{\sqrt{1 - \frac{(u_0)^2}{c^2}}} = \frac{x_0}{t_3} = 3.05 \times 10^9 \frac{m}{s} \tag{22}$$

$$t_3 = t_0\sqrt{1 - \frac{(u_0)^2}{c^2}} = 6.39\mu s\sqrt{1 - \frac{(.9952c)^2}{c^2}} = .625\mu s \tag{23}$$

u_3 and t_3 are *as viewed from the moving frame.* The moving observer sees himself travelling more than ten times the speed of light. Outside objects wiz past, because time passes slowly for him. To summarize the results: in SR, the moving observer explains the muons ability to reach the sea by deforming space to say that the distance is smaller for him. Therefor it takes less time to cover the distance compared to the person at rest. In SR, he agrees with the observer at rest about the velocity. In CGC, he would say that his velocity is faster to him, because time has slowed down for him (meaning that less time has passed for him), compared to the time experienced by the person in the rest frame. In CGC, both the observer at rest, and the moving observer, would agree that this is due to an objective slowing of the rate at which particles making up the moving observer are interacting. They would both agree that there exists a rest frame wherein such slowing of time is minimized. They would also both agree that the distance travelled has remained unchanged. The reason that they disagree about velocity is due to the difference in the way time passes. The way that velocity increases mass will be discussed in the next section.

12.3 Increase-of-mass at high velocities

The increase of mass at relativistic velocities follows precisely the same form as the time dilation illustrated in the prior section. m_0 and m_1 are the rest mass and relativistic mass *as both are viewed from the rest frame.*. Equation 24 expresses this relation.

$$m_1 = \frac{m_0}{\sqrt{1 - \frac{(u_0)^2}{c^2}}} \tag{24}$$

The physical mechanism explaining the cause of both mass increase and time dilation will be explored in section 14. The next section will discuss the parallel changes that occur near large sources of gravity.

13 Adapting Einstein's general relativity (GR)

13.1 Time dilation near a massive object

CGC and GR agree on the way in which time is dilated by a large mass. The effect of mass on time is shown in equation 25.

$$t_1 = t_0\sqrt{1 - \frac{2GM}{rc^2}} \tag{25}$$

Both t_0 and t_1 are from the perspective of **an observer arbitrarily distant from the massive object.** In other words, the distant observer is unaffected by the gravitational field. G is the gravitational constant, M is the mass of the central object, r is the distance to the center of the object, and c is the speed of light in the rest frame. Time dilation near a massive object also explains the gravitational Doppler effect by proportionally increasing the wavelength of light leaving the massive object.

13.2 Precession of Mercury

Predicting Mercury's precession was one reason why general relativity gained rapid acceptance. CGC explains the precession of Mercury by noting that the force of gravity does not exactly match that predicted by Newton. The acclimation of a planet to the Sun's gravitational fingerprint does not remain constant because of the influence of other bodies in the system. In addition to this, there may be anomalies that can only be corrected or predicted by evaluating data over time involving the motion of objects in the specific context. CGC in its current form is therefore unable to predict the precession of Mercury. However, under CGC, the *existence of Mercury's anomalous precession would not be surprising at all.* A qualitative prediction of Mercury's precession is demonstrated in this simulation of solar system formation. The simulation shows many instances of planets having rosette-shaped orbits coexisting with other planets having approximately circular orbits.

A second reason for GR's quick acceptance was the prediction of the deflection of light near a large source of gravity. GR explains this behavior with mass bending space. This led to the now famous dictum, "Mass tells space how to bend, and space tells mass how to move." As discussed earlier, GR links time and space in a 4-dimensional non-Euclidean continuum such that time dilation is also explained.

CGC disallows non-Euclidean space. This presents two major problems for CGC that have not been adequately explained thus far in this paper:

1. If gravity is a relic of the electromagnetic force, and this force disappears at the quantum scale, how then might gravity indirectly cause a time dilation similar to that of the relativistic dilation of the muons discussed in section 12.2?

2. If gravity is a relic of the electromagnetic force, and the electromagnetic force does not perceptibly act upon light, how then can gravity cause the path of light to bend?

The solution to these two problems is presented in the next section.

14 Neutrinos as the cause of time dilation and deflection

14.1 Primary assumption linking the effects of motion and gravity

CGC posits the following to be true of neutrinos:

1. They are attracted to all baryonic matter, and this attraction increases as the velocity of matter relative to the rest frame increases.

2. This increase in attraction with velocity is because the EM force increases with velocity.

3. Neutrinos inhibit quantum processes in other particles in direct proportion to the number of neutrinos encountered by the other particles in a unit of time. This inhibition of quantum processes is expressed as the dilation of time.

4. Since neutrinos are attracted to mass, neutrino concentration is inversely proportional to r^2, where r is the distance from the center of the mass. In other words, large masses have more neutrinos around them.

CGC proceeds under these assumptions, while noting that light is known to interact with neutrinos via the weak force. CGC can then explain the deflection of light near a gravity source.

14.2 Deflection of light near a source of gravity

The interaction between light and neutrinos becomes observable with a high density of neutrinos. The density of neutrinos in figure 12 is shown to increase steadily as one nears the surface of the Sun.

Figure 12 shows that the deflection of light is actually a slight refraction of light. Light is refracted around a strong gravity source because it travels through layers that have different densities of neutrinos. This explains the deflection predicted by GR, while contradicting GR by retaining Euclidean space.

14.3 The effective rate of neutrino encounters and time dilation at relativistic velocities

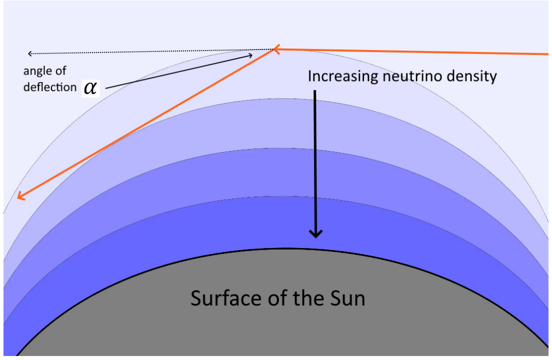

Figure 12: Schematic of Sun with increasing concentration of neutrinos as one moves downward in the diagram. Light passing near the Sun is depicted as the red line. The angle of deflection predicted by Einstein is exaggerated. CGC expresses the deflection as rather light being refracted by the rapidly changing density of the neutrino cloud surrounding the Sun.

CGC posits that neutrinos are responsible for time dilation. Neutrinos are attracted to, and congregate around, mass. Therefore, it is not surprising that time should dilate near a massive object. But why should time dilate at relativistic velocities?

The dilation of time at relativistic velocities is explained by the fact that the greater the velocity, the more neutrinos are encountered. Since greater velocity also increases the EM force, the effect of each neutrino encountered is also increased. Both the number of encounters and also the effectiveness of each encounter are increased with increasing velocity. Therefor, the dilation of time is also increased.

14.4 Increase of mass at relativistic velocities

CGC explains the gravitational force to be a relic of the electromagnetic force. The velocity of a charge greatly affects the magnitude of the electromagnetic force. Therefore it is not surprising that the gravitational force would increase with velocity. This can be expressed as a greater apparent mass, since the number of baryonic particles actually remains the same. Greater force is correlated with greater momentum, in turn correlated with greater energy. Table 6 compares increase of mass and also the time dilation effect across the two environments of relativistic velocity vs. near a large mass.

The reason that general relativity has tremendous predictive power is that it correctly notes a correlation between the environment of relativistic

Table 6: Time dilation and increase of mass at relativistic velocities compared with the same near a large mass. The table shows why both environments produce similar results.

Relativistic velocity	Strong gravitational field
Gravity is an EM force, so high velocity = increased EM force = acting as greater mass. High velocity also = more encounters (and greater effect of each encounter) = change inhibited = time slows down.	Massive object = more particles = increased EM force = gravity increases. Mass also attracts more neutrinos = more encounters = change inhibited = time slows down.

velocity and the environment near a large mass. CGC gives a physical explanation for this correlation that does away with the need for non-Euclidean geometry.

15 A return to Euclidean space

There are several special characteristics of 3-dimensional space that suggest that it is the best description of motion in reality at both the quantum and also the macro level. If the Planck length is taken as the smallest possible unit, then at the macro level, motion is, for all intents and purposes, continuous. Motion is a vector, meaning that the magnitude always has a direction associated with it. In regards to magnitude, it is assumed that if one moves from 1 to 2, for example, one has traversed all of the intermediate values. That is part of the definition of continuity.

Rotation might be thought of as a continuous movement through the various possible directions. This is why it is not really a "rotation" in one dimension, but rather a discrete change from positive to negative and back again. Thus rotation in one dimension suggests that something is missing because there is a lack of continuity. In two dimensions rotation operates in a way that is similar to continuity in magnitudes. If one makes a complete cycle, one knows that one has travelled in a continuous way through all possible directions in the plane. The continuity of two-dimensional rotation is similar to travel between magnitudes. If one travels from 1 to 2, one has automatically travelled through every intermediate value.

Rotation in two dimensions retains a discrete change, however. Reversing the direction of rotation from clockwise to counter-clockwise is discrete. Typically, a clockwise rotation is expressed as −, and counter-clockwise as +. Reversing the direction of rotation in two dimensions will result in a discrete change from positive to negative or vice-versa.

Three dimensions allow reversal of the direction of rotation in a gradual, continuous way, without a discrete change of sign. This is because a discrete sign change of rotation in one plane, can instead be expressed as a gradual change in two other perpendicular planes. Sign change of rotation is 3-dimensional. Because sign change of rotation is 3-dimensional, there are infinite ways that one might gradually reverse rotation in a continuous manner. Space should be defined as the minimum of dimensions necessary to ensure the ability of continuity in the reversal of rotation. This continuity ensures that there are no other dimensions necessary to describe motion in space. Rotational continuity in this form demonstrates the need for three, and only three, dimensions of space. Any further dimensions would introduce redundancies or discontinuities in motion. Just because time dilation is proven does not mean that time should be treated as if it were a fourth dimension of space.

Obviously, the study of multiple abstract dimensions has countless practical applications. What is being questioned here, however, is the inclusion of time as a fourth dimension of space in describing the physical universe. Cyclic gravity and cosmology (CGC) assume time is a record of discrete changes, and space is Euclidean. Two essays are linked in appendix A that explore rotation in Euclidean space in a way that may be useful in particle physics. The method may be useful because it expresses angles and rotation in terms of the Manhattan distance. Interestingly, this method of expressing angles allows polar vs. rectangular conversion without the use of transcendental functions, infinite sums, or imaginary numbers. The Manhattan distance is the sum of the perpendicular distances travelled by a point on a circle. EM radiation involves three perpendicular axis, so expressing angles in terms of the Manhattan distance may simplify some calculations in particle physics, though this is outside the scope of the present paper.

The view of time and space in CGC is therefore completely consistent with the standard model of particle physics. The standard model is not consistent with gravity as presented in GR. Gravity as presented in CGC is not consistent with the ΛCDM/GR view of singularities or black holes. Singularities and black holes are the subject of the next section.

16 Black holes

Gravity is a relic of the electromagnetic force — specifically caused by small, cyclic charge fluctuations. This means that on the quantum level, gravity will disappear. A demonstration of this appears at the macro level when liquids are cooled to near absolute zero. In that temperature range, cyclic charge fluctuations are substantially reduced, and the super-cooled liquid begins "feeling" more strongly the interactions with the sides of the container to the point where these forces can overcome the gravitational force; this is why the super-cooled liquid will spread upward and then downward all over the surface of the container.

If gravitational forces disappear at the quantum level, then "black holes" (understood as having singularities of infinite density at their center) do not exist. Under CGC, it might very well be possible for a neutron star to trap light, because the neutrino cloud might under some circumstances cause the total internal reflection of the light. A particular neutron star might "look like" a "black hole," but it would not have an infinitely dense "singularity" at its center.

CGC would imply that certain quantities of mass would be more stable than others because during formation there are cyclic zones of attractive and repulsive gravity surrounding the central object (see section 18). Going outside (above or below) one of the stable sizes would cause some of the mass to split from the main body. Therefore, only certain discrete levels of size are allowed to stars, including neutron stars. This is clearly shown by the fact that most stellar systems are binary. A solitary mass that is not of a stable size will eject any matter that is over the closest limit. In solitary systems, there will be gas giant planets taking up any excess that might have made the star unstable.

The CGC description of gravity means that matter will not disappear forever into something labelled a "black hole." The matter would be in a neutron star that can, at some point in the future, become unstable and break apart if it goes over the nearest stable limit of mass. Neutron stars have a stability in some ways analogous to the stability of atomic nuclei.

The CGC view of singularities has important implications at the cosmological level. In CGC, the universe is the ideal perpetual motion machine, where no mass or energy can ever escape. Everything is constantly changing form, being endlessly recycled, including the mass that is within neutron stars.

CGC also rules out a singularity at the "beginning" of the universe. There was no inflation, and there is no cosmological expansion in the sense of space itself stretching, although most galaxies are indeed accelerating away from us — but in Euclidean space.

At the quantum level, the idea of continuous movement breaks down, since any change of position or change in energy is a discrete quantum, rather than a continuous transition. At the quantum level, changes become more and more discrete and statistical, rather than continuous. The specific location of a particle in the next instant is going to be a random choice between a set of outcomes, each with their own probability. Gravity will never be detected at the quantum level. There is no need to seek a "Grand Unified Theory"; ***The Standard Model is it.***

16.1 LIGO

Section 16 will conclude with a few comments on LIGO. LIGO detects vibrations caused by distant massive gravitational events. These are mistakenly interpreted as waves in space — in the sense of space itself expanding and contracting. These vibrations are in fact measuring the direct minute expansion and contraction of the LIGO apparatus caused by the wavelike variation of gravity, rather than by gravity indirectly through the deformation of space. LIGO's results are completely valid in the sense that LIGO is genuinely detecting massive gravitational events — but CGC would describe the interactions as being purely between neutron stars rather than "black holes." CGC allows for gravitational forces that may sometimes be orders of magnitude larger than GR would expect, which would cause proportionally larger gravitational vibrations in matter on Earth. CGC is therefore consistent with the results

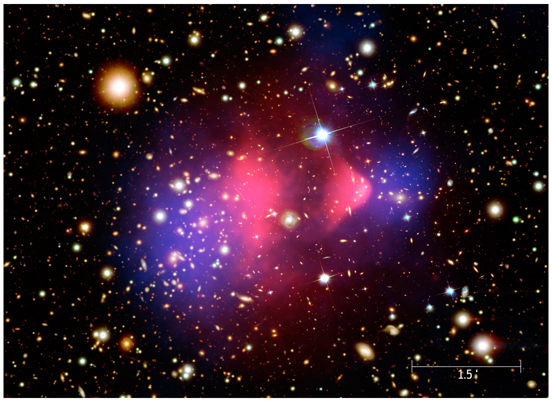

Figure 13: The Bullet Cluster. Blue depicts gravitational lensing associated with luminous baryonic matter. Red shows location of gas, which makes up most of the mass of a cluster. By NASA. M. Weiss. Chandra X-Ray Observatory. 1*E* 0657-56

at LIGO.

The next section will deal with a phenomenon that has been considered to be the "smoking gun" that proves the existence of dark matter.

17 What about the bullet cluster?

Although the common name is the "bullet cluster," figure 13 depicts two colliding galaxy clusters. In the following description, the word "baryonic" when applied to matter, simply means "not dark matter." When two clusters collide, the luminous parts that are made up of baryonic matter, generally pass through each other with minimal effect. The baryonic hydrogen gas, however, does collide with, interact with, and generally get hung up with, the gas from the other cluster.

The red and blue colors are added for clarity. Blue shows where gravitational lensing is strongest, so it is assumed to show where most of the mass is located. It coincides with the location of the luminous, baryonic galaxies of the cluster. Red shows the location of hydrogen gas, which makes up the majority of the baryonic mass of a cluster.

Gravitational lensing refers to the degree which the light from the background is warped by the gravity of the clusters (The clusters are in the foreground) on its way to Earth. If dark matter were not present, then most of the lensing would be around the red gas, because that is where most of the mass of the clusters should be. Instead, the lensing coincides with the luminous matter. Therefore, most of the mass is with the luminous matter, which is unexpected. The luminous matter should have less lensing because it has less mass than the gas. Instead it has more lensing. Until now, the only way this anomaly could be explained was to posit that "dark matter" had passed through the collision (since it is non-interactive) along with the luminous matter.

Since most of the baryonic matter should be with the gas, the fact that gravitational lensing shows it to be with the luminous matter, suggests that there is dark matter along with the luminous matter. The case for a dark matter origin for this phenomena is made very well in Clowe (2004).

CGC would explain the result in a different way. Before the two clusters collide, the gas within a cluster would have achieved some sort of acclimation (as in section 6) to all the other mass in that cluster. Because of this acclimation, the neutrino cloud associated with the cluster and its gas would have a generally well-defined neutrino gradient, like the one shown in figure 12.

During the collision, because the gas from each cluster strongly interacts and collides, all of the systemic fluctuations causing gravity would be thrown off and randomized, causing the force of gravity to take on a wave form that looks more like figure 4. Under the wave form of figure 4, the gas would have a much more random gravity signature. Because of this random gravitational signature, its neutrino cloud would also be randomized, losing its well-defined gradient. The lensing associated with the gas would be greatly reduced. The luminous baryonic matter (i.e. visible galaxies), which passed through the collision relatively unscathed, would retain their normal gravitational signature. They would also retain their well-defined neutrino gradient, resulting in greater lensing.

One hypothesis of CGC is that every system develops its own gravitational signature. Every system, when first forming, will exhibit circular zones of alternating attractive and repulsive gravity around the central mass. The system will then gradually acclimate, and the force law will be more generally attractive, with some exceptions. The force law for gravity of any system always begins its development looking like figure 4, and ends its development looking like figure 5. The Bullet cluster collision caused the gas from each cluster to revert back to a primitive gravitational force law resembling figure 4. The star system HL Tauri is in its early stages of planet formation. HL Tauri shows evidence of a gravitational force law similar to that shown in figure 4 and is the topic of the next section.

18 The formation of planetary systems

The young star system HL Tauri has generated a great deal of interest among scientists because its rings are forming into planets much more rapidly than current gravitational models allow. If one were to take into account the role played by acclimation, the mystery could be solved. Young stars are the perfect place to look for fluctuations in gravity. Because the various masses have not had time to acclimate, the gravity force law for them would tend towards a sinusoidal wave, as depicted in figure 4. For example, one would expect to find circular zones of both positive (attractive) and negative (repulsive) gravity, where matter is being pushed out of the negative zones (and pulled into the positive zones) more rapidly than would be expected according to Newtonian Theory. In the case of HL Tauri, the dark (empty) bands could then be understood as zones of repulsion, and the light bands as zones of positive gravity where planets are being formed.

The development of a planetary system similar to HL Tauri can be simulated using a sinusoidal gravity law similar to that shown in 4(cf video link). The first part of this simulation is set up with twelve planets in various positions and velocities around a sun. The wavelike nature of the gravity law in effect causes circular zones of alternating attractive and repulsive force, so that ten of the twelve planets quickly fall into the various bands of attraction, while the bands of repulsion are emptied — not unlike the development of HL Tauri. The second simulation is set up using the Newtonian force law, which proves to be much more unstable. As in all of the prior Newtonian simulations leading up to this one, ten of the planets are ejected, and the few planets that do remain follow an eccentric, elliptical orbit. A link to this simulation showing the formation of a planetary system under CGC is given below:

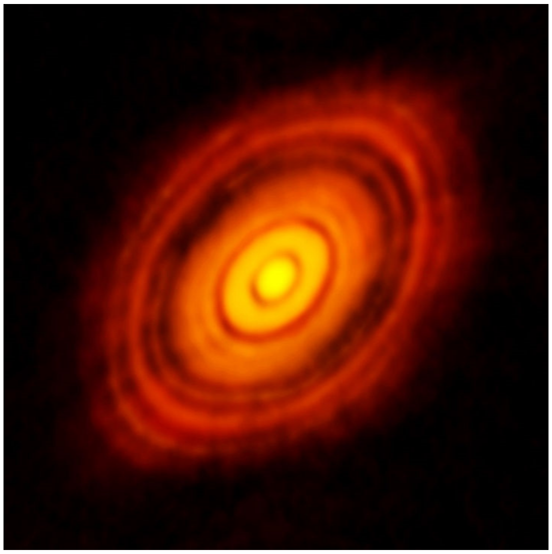

Figure 14: HL Tauri; a young star that is forming planets. According to CGC, the dark bands may be areas of repulsive gravity. ALMA (ESO/NAOJ/NRAO), 6 November 2014 (date released)

Simulation of planetary formation according to CGC

Interestingly, the model based on CGC seems to contradict Bertrand's famous law, because the system is shown to be stable even though the force law is not proportional to $\frac{1}{r}$ or $\frac{1}{r^2}$. Secondly, the CGC simulation also shows periodic and sometimes very dramatic instabilities. Although the system rapidly becomes stable once again, the model hints that planets in a solar system might, with little notice, substantially change their orbital radius for a short time. Considering what this might mean for planet like earth, the stability of the orbit in its circular path is a good thing! On the other hand, relatively small disturbances to the system might have very radical (although temporary) effects on the system as a whole. Periodic instabilities, where the orbit comes closer or further from the sun, could be cause for catastrophes not unlike the mass extinctions that took place in earth's distant past.

Earth is one of the inner rocky planets. The inner planets may have a distinct mechanism related to their inner core that determines how their charge fluctuations are expressed. There are recent geological discoveries challenging past models of the Earth's core, as in Frost (2021) and Bo (2021). Two articles discussing these developments are linked in Appendix B. The unexpected changes happening in the core may have bearing on the effort to detect the charge fluctuations predicted by CGC.

Section 16 explained why a star system might develop gas giant planets. The same CGC mechanisms that would explain the creation of gas giants would also apply to their charge fluctuations. The mechanisms of charge fluctuations in gas giants would be similar to those of the gaseous Sun.

19 Ways in which cyclic gravity and cosmology (CGC) might be validated

Section 11 claimed that the CMB was light returning to the universe after Compton scattering within ionized gas in the intergalactic medium (IGM). Researchers might try to simulate this effect. If CGC is true, then researchers should be able to show how a proportional sum of all the types of light in the universe might be sent into a blackbody box containing ionized gas similar to what is in the IGM, and then emerge with a blackbody spectrum that would be similar to the CMB after appropriate red shifting.

A satellite might be placed in a very eccentric orbit (like a Molniya orbit) around the Earth. CGC predicts that the acceleration displayed by the craft will be different than that predicted by GR, even after accounting for all known perturbations caused by other known masses.

A probe might be sent to follow the course of a comet. Under current theory, comets are subject to "non-gravitational acceleration." Current theory posits that this is caused by off-gassing. CGC predicts that if the off-gassing of a comet is very closely analyzed, it will be found to be relatively uniform in all directions, or else be such that it would not explain the non-gravitational acceleration of comets.

A modelling study might be done, along the lines of Pardo's work discussed in the paper, to see if a version of CGC might be able to explain the power spectrum displayed by the CMB. Then they might see if this model would solve the current Hubble constant tension controversy. One would think that if CGC were correct, then the controversy would be resolved in favor of astronomical observations of things like cepheid stars or red giants, rather than current models of the CMB.

IF CGC is approximately correct, then it may be possible in the future to demonstrate this conclusively using tech based upon Nuclear Magnetic Resonance Imaging (NMR). NMR detects magnetic moments caused by nucleons. To prove CGC, the resolution would need to be much finer, i.e., detection of such moments caused by quarks would be necessary.

Particle physicists might be able to model a neutrino interaction with other matter that would inhibit changes in the other matter at the quantum level. This might help to confirm the idea that neutrino concentrations cause time dilation.

Researchers starting with the general form of equations 7 and 8 might be able to develop a set of equations and algorithms that accurately model all motions including planets, probes, comets, galactic rotation, galactic clusters, and cosmological expansion. CGC suggests that the following parameters would have to be accounted for: Mass and density of the central object and also of the orbiting objects. The type of system: gaseous like a nebula, a lot of point masses like stars in a galaxy, large central object with orbiting small objects like the Solar System. Radial and tangential velocities. Element composition: The charge fluctuations of different types of nuclei might be substantially different. Lastly, the degree of acclimation – i.e. how long the system has been stable.

Close analysis of probe data might reveal a pattern of small deviations from expected acceleration that were mistakenly attributed to other causes. The Parker solar probe data would be a prime candidate. The Pioneer anomaly and the flyby anomaly might warrant another look.

The Earth might exhibit a pattern of detectable charge fluctuations that happen to be in phase with similar fluctuations from the sun.

20 Conclusion

ΛCDM, based upon GR, has been carefully constructed over decades. It has great predictive power. It predicts time dilation, increase-of-mass at high velocities, and length contraction (if interpreted as contraction of objects, rather than contraction of space itself). This paper has tried to show **why** GR is so successful. GR is successful because of the correlation between relativistic and gravitational effects.

GR has not been convincing, however, when applied to galactic rotation rates, or to the spatial origin or distribution of matter, or to cosmological expansion.

The reason that ΛCDM is not convincing in these contexts is because the math only works if one posits completely unexplained and unobserved masses, energies, and processes whenever and wherever they are deemed useful. Wherever an unexplained attraction occurs, the appropriate quantity and location of dark matter is inserted. When unexplained accelerating separation occurs, then dark energy is inserted as needed. When an entirely different rate of expansion is needed to explain the distribution of mass in the universe, then inflation is invented and inserted to serve this purpose. Then areas of infinite density are posited for the ultimate origin of the universe and also at the center of black holes. Yes, ΛCDM can be made to be mathematically consistent with all these things, but at what price?

Cyclic gravity and cosmology (CGC) in some senses presents a more complicated project of investigation. It posits a source for gravity that will be difficult to generalize into a universally applicable force law. It would require site-specific observations to obtain the local gravitational fingerprint of the central mass in planetary systems, and completely different algorithms for the fingerprint of gaseous, galactic, and inter-galactic systems. Even then, Oumuamua shows that objects from outside a given system might behave differently than other objects in the same gravitational field! No longer could scientists hope to derive a simple and elegant force law that applies to the entire universe in the same way. On the other hand, CGC presents a much simpler view of the universe than does ΛCDM: no exotic warping of space by an era of "inflation." No dark matter or dark energy. No black holes or singularities. No big bang or cosmological expansion explained as the stretching of space.

"Oumuamua" is Hawaiian for “a messenger from afar arriving first." Will the message be heeded?

Data Availability

The data for the rotation curve shown in figure 9 was provided by Lelli (2020), and is publicly available at SPARC: Mass Models for 175 Disk Galaxies with Spitzer Photometry and Accurate Rotation Curves.

References

Aghanim, Doppler boosting of the CMB Eppur si muove, Astronomy and Astrophysics, volume 571, Oct, A27

Bo Gyu Jang and Yu He and Ji Hoon Shim and Ho-kwang Mao and Duck Young Kim, 2021, Oxygen-driven enhancement of electron correlation in hexagonal iron at Earth’s inner core conditions

Bertrand, 1873, Théorème relatif au mouvement d’un point attiré vers un centre fixe, C. R. Acad. Sci. 77: 849–853.

Clowe, Douglas and Gonzalez, Anthony and Markevitch, Maxim, 2004, Weak-Lensing Mass Reconstruction of the Interacting Cluster 1E 0657 — 55, Direct Evidence for the Existence of Dark Matter, The Astrophysical Journal, April, pp. 596–603

Daniel C. Cole, Alfonso Rueda, and Konn Danley, 2001, Stochastic nonrelativistic approach to gravity as originating from vacuum zero-point field van der Waals forces, A Physical Review: 63, 054101 – Published 10 April 2001.

S. J. Desch and A. P. Jackson, 2021, 1I/‘Oumuamua as an N2 Ice Fragment of an Exo-Pluto Surface II: Generation of N2 Ice Fragments and the Origin of ‘Oumuamua , Journal of Geophysical Research: Planets.

David H. Frisch and James H. Smith, 1963, Measurement of the Relativistic Time Dilation Using μ-Mesons, American Journal of Physics 31, 342

Daniel A. Frost, Marine Lasbleis, Brian Chandler and Barbara Romanowicz , 2021, Nat. Geosci. 14, 531–535

Goldhaber, 2001, The Astrophysical Journal, American Astronomical Society, Sep, pages 359–368.

Ijjas, Anna and Steinhardt, Paul J., 2019, A new kind of cyclic universe, Physics Letters B, Elsevier BV, Aug., pages 666–672.

Lelli F., McGaugh S.S., Schombert J.M., 2020, SPARC: Mass Models for 175 Disk Galaxies with Spitzer Photometry and Accurate Rotation Curves

Loeb, Avi, 2019, On the Possibility of an Artificial Origin for ‘Oumuamua, Astrobiology.

Lorentz, Hendrik Antoon (1892), "The Relative Motion of the Earth and the Aether" , Zittingsverlag Akad. V. Wet., 1: 74–79

McGaugh, Stacy S., 2011, Novel Test of Modified Newtonian Dynamics with Gas Rich Galaxies, Physical Review Letters. American Physical Society (APS). 106 (12): 121303.

Milgrom, Mordehai, 1983, A modification of the Newtonian dynamics as a possible alternative to the hidden mass hypothesis. Astrophysical Journal. 270: 365–370.

Milgrom, Mordehai, 2014, MOND laws of galactic dynamics, Monthly Notices of the Royal Astronomical Society. 437 (3): 2531–2541.

Pardo, Kris and Spergel, David N., 2020, What is the Price of Abandoning Dark Matter? Cosmological Constraints on Alternative Gravity Theories ,Physical Review Letters, November 2020

Puthoff, H.E., 1989, Gravity as a zero-point-fluctuation force, A Physical Review, v. 39(5); p. 2333-2342.

Roman R. Rafikov, 2018, Non-Gravitational Forces and Spin Evolution of Comets, arXiv.

Darryl Seligman, Gregory Laughlin, and Konstantin Batygin, 2019, On the Anomalous Acceleration of 1I/2017 U1 ‘Oumuamua, The Astrophysical Journal Letters, 876:L26 (5pp), 2019 May 10.

Bo E Sernelius,GRAVITATION AS A CASIMIR EFFECT, 2009, INTERNATIONAL JOURNAL OF MODERN PHYSICS A, (24), 8-9, 1804-1812.

Wechsler, Risa H. and Tinker, Jeremy L., 2018, The Connection Between Galaxies and Their Dark Matter Halos, Annual Review of Astronomy and Astrophysics, volume 56, number 1, pages 435-487

Lei Zhang, 2013, arXiv: The van der Waals force and gravitational force in matter

A Rotation without transcendental functions or imaginary numbers

Included here are two essays presenting an approach to rotation that is not dependent upon transcendental functions, infinite sums, or imaginary numbers:
ROTATION WITHOUT IMAGINARY NUMBERS, TRANSCENDENTAL FUNCTIONS, OR INFINITE SUMS
ALGEBRAIC CONVERSION BETWEEN RECTANGULAR AND POLAR COORDINATES

B Earth’s inner core not what it seems

Oxygen-driven enhancement of electron correlation in hexagonal iron at Earth’s inner core conditions
Dynamic history of the inner core constrained by seismic anisotropy

C A model that incorporates cosmological contraction and expansion

A new kind of cyclic universe