The Electrodynamic Origin of the Force of Gravity—Part 3
($F = G m_1 m_2 / r^2$)

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Abstract. The force of gravity is shown to be a small average residual force due to the fourth order terms in v/c of the derived universal electrodynamic contact force between vibrating neutral electric dipoles consisting of atomic electrons vibrating with respect to protons in the nucleus of atoms. The derived gravitational force has the expected radial term plus a new non-radial term. From the radial term the gravitational mass can be defined in terms of electrodynamic parameters. The non-radial term causes the orbits of the planets about the sun to spiral about a circular orbit giving the appearance of an elliptical orbit tilted with respect to the equatorial plane of the sun and the quantization of the orbits as roughly described by Bode's law. The vibrational mechanism that causes the gravitational force is shown to decay over time giving rise to numerous phenomena, including the expansion of the planets (including the earth) and moons in our solar system, the cosmic background radiation, Hubble's red shifts versus distance (due primarily to gravitational red shifting), Tifft's quantized red shifts (Bode's law on a universal scale), Tifft's measured rapid decay of the magnitude of red shifts over time, the Tulley-Fisher relationship for luminosity of spiral galaxies, the unexpected high velocities of the outer stars of spiral galaxies, and Roscoe's observed quantization of the luminosity and size (Bode's law) of 900 spiral galaxies. Arguments are given that this derived law of gravity is superior to Newton's Universal Law of Gravitation ($F = G m_1 m_2 / r^2$) and Einstein's General Relativity Theory ($G_{\mu\nu} = -8\pi G/c^2\, T_{\mu\nu}$).

Review of Part 2. In part 2 of this paper the corroborating circumstantial evidence for the first term of the gravitational force derived from the universal electrodynamic force law was presented. This radial force term requires that the force of gravity decay by giving off light or radiation. Requiring that the current strength of the gravitational force be what is observed today allows the gravitational force law to predict the wavelength and distribution of the radiation due to gravitational decay. It was found to be the currently observed cosmic background radiation with a blackbody distribution centered about one millimeter peak wavelength for hydrogen which comprises about 75 percent of the universe. The size of the vibration amplitude of the electron with respect to the proton was found to be about one percent of the radius of the hydrogen atom which is very reasonable. Evidence for the decay of gravity in terms of the expansion of the planets and moons of our solar system was also found. No previous theory of gravity had ever given an explanation for the cosmic background radiation and the expansion of the planets and moons of our solar system.

Computation of Non-Radial Gravitational Force Term. In a manner similar to that for the radial term, the non-radial term of the gravitational force may be calculated from equation (6) to be

$$\vec{F}_{2+,1+} = \frac{e^2}{\left|\vec{r}_2 - \vec{r}_1\right|^2}\left(\hat{r}_{12}\cdot\vec{\beta}\right)\{\hat{r}_{12}\times\left(\hat{r}_{12}\times\vec{\beta}\right)\}[1][1] \tag{24}$$

$$\vec{F}_{2+,1-} = \frac{-e^2}{\left|\vec{r}_2 - \vec{r}_1\right|^2}\left(\hat{r}_{12}\cdot\vec{\beta}\right)\{\hat{r}_{12}\times\left(\hat{r}_{12}\times\vec{\beta}\right)\}\left[1+\left(\frac{A_1\omega_1}{c}\sin\left(\omega_1 t_1+\varphi_1\right)\right)^2\left(\frac{1-3\cos^2\theta}{2}\right)+\left(\frac{A_1\omega_1}{c}\sin\left(\omega_1 t_1+\varphi_1\right)\right)^4\left(-\frac{3}{8}-\frac{9}{4}\cos^2\theta+\frac{15}{8}\cos^4\theta\right)\right]$$

$$\vec{F}_{2-,1+} = \frac{-e^2}{\left|\vec{r}_2 - \vec{r}_1\right|^2}\left(\hat{r}_{12}\cdot\vec{\beta}\right)\{\hat{r}_{12}\times\left(\hat{r}_{12}\times\vec{\beta}\right)\}\left[1+\left(\frac{A_2\omega_2}{c}\sin\left(\omega_2 t_2+\varphi_2\right)\right)^2\left(\frac{1-3\cos^2\theta}{2}\right)+\left(\frac{A_2\omega_2}{c}\sin\left(\omega_2 t_2+\varphi_2\right)\right)^4\left(-\frac{3}{8}-\frac{9}{4}\cos^2\theta+\frac{15}{8}\cos^4\theta\right)\right]$$

$$\vec{F}_{2-,1-} = \frac{e^2}{\left|\vec{r}_2 - \vec{r}_1\right|^2}\left(\hat{r}_{12}\cdot\vec{\beta}\right)\{\hat{r}_{12}\times\left(\hat{r}_{12}\times\vec{\beta}\right)\}\left[1+\left(\frac{A_2\omega_2}{c}\sin\left(\omega_2 t_2+\varphi_2\right)+\frac{A_1\omega_1}{c}\sin\left(\omega_1 t_1+\varphi_1\right)\right)^2\left(\frac{1-3\cos^2\theta}{2}\right)+\left(\frac{A_2\omega_2}{c}\sin\left(\omega_2 t_2+\varphi_2\right)+\frac{A_1\omega_1}{c}\sin\left(\omega_1 t_1+\varphi_1\right)\right)^4\left(-\frac{3}{8}-\frac{9}{4}\cos^2\theta+\frac{15}{8}\cos^4\theta\right)\right]$$

From the symmetry of the integrals the average force of equation (6) for the non-radial terms may be reduced to

$$\vec{F}(\vec{r}) = \frac{1}{T_1}\int_0^{T_1}dt_1\frac{1}{T_2}\int_0^{T_2}dt_2\frac{1}{2\pi}\int_0^{2\pi}d\varphi_1\frac{1}{2\pi}\int_0^{2\pi}d\varphi_2\frac{1}{\pi}\int_0^{\pi}\sin\theta d\theta\,\vec{F}(r,\theta,\varphi,\vec{A}_1,\omega_1,\varphi_1,t_1,\vec{A}_2,\omega_2,\varphi_2,t_2) \tag{25}$$

$$= \frac{\omega_1}{2\pi}\int_0^{2\pi/\omega_1}dt_1\frac{\omega_2}{2\pi}\int_0^{2\pi/\omega_2}dt_2\frac{1}{2\pi}\int_0^{2\pi}d\varphi_1\frac{1}{2\pi}\int_0^{2\pi}d\varphi_2\frac{1}{\pi}\int_0^{\pi}\sin\theta d\theta\frac{e^2}{\left|\vec{r}_2-\vec{r}_1\right|^2}\left(\hat{r}_{12}\cdot\vec{\beta}\right)\{\hat{r}_{12}\times\left(\hat{r}_{12}\times\vec{\beta}\right)\}6\frac{A^2{}_2\omega^2{}_2}{c^2}\sin^2\left(\omega_2 t_2+\varphi_2\right)\frac{A^2{}_1\omega^2{}_1}{c^2}\sin^2\left(\omega_1 t_1+\varphi_1\right)\left(-\frac{3}{8}-\frac{9}{4}\cos^2\theta+\frac{15}{8}\cos^4\theta\right)$$

$$= \frac{\omega_1}{2\pi}\int_0^{2\pi/\omega_1}dt_1\frac{\omega_2}{2\pi}\int_0^{2\pi/\omega_2}dt_2\frac{1}{2\pi}\int_0^{2\pi}d\varphi_1\frac{1}{2\pi}\int_0^{2\pi}d\varphi_2\frac{e^2}{\left|\vec{r}_2-\vec{r}_1\right|^2}\left(\hat{r}_{12}\cdot\vec{\beta}\right)\{\hat{r}_{12}\times\left(\hat{r}_{12}\times\vec{\beta}\right)\}6\frac{A^2{}_2\omega^2{}_2}{c^2}\sin^2\left(\omega_2 t_2+\varphi_2\right)\frac{A^2{}_1\omega^2{}_1}{c^2}\sin^2\left(\omega_1 t_1+\varphi_1\right)\frac{-3}{2\pi}$$

$$= -\frac{\omega_1}{2\pi}\int_0^{2\pi/\omega_1}dt_1\frac{\omega_2}{2\pi}\int_0^{2\pi/\omega_2}dt_2\frac{e^2}{\left|\vec{r}_2-\vec{r}_1\right|^2}\left(\hat{r}_{12}\cdot\vec{\beta}\right)\{\hat{r}_{12}\times\left(\hat{r}_{12}\times\vec{\beta}\right)\}6\frac{A^2{}_2\omega^2{}_2}{c^2}\frac{1}{2}\frac{A^2{}_1\omega^2{}_1}{c^2}\frac{1}{2}\frac{3}{2\pi}$$

$$= \frac{-e^2}{\left|\vec{r}_2-\vec{r}_1\right|^2}\left(\hat{r}_{12}\cdot\vec{\beta}\right)\{\hat{r}_{12}\times\left(\hat{r}_{12}\times\vec{\beta}\right)\}\frac{A^2{}_2\omega^2{}_2}{c^2}\frac{A^2{}_1\omega^2{}_1}{c^2}\frac{9}{4\pi}$$

where

$$\frac{1}{\pi}\int_0^{\pi}\sin\theta d\theta\left(-\frac{3}{8}-\frac{9}{4}\cos^2\theta+\frac{15}{8}\cos^4\theta\right) = \frac{1}{\pi}\int_{-1}^{1}d\cos\theta\left(-\frac{3}{8}-\frac{9}{4}\cos^2\theta+\frac{15}{8}\cos^4\theta\right) \tag{26}$$

$$= \frac{1}{\pi}\left(-\frac{3}{8}\cos\theta-\frac{9}{4}\frac{\cos^3\theta}{3}+\frac{15}{8}\frac{\cos^5\theta}{5}\right)\Big|_{-1}^{+1}$$

$$= \frac{1}{\pi}\left(-\frac{3}{8}2-\frac{9}{4}\frac{2}{3}+\frac{15}{8}\frac{2}{5}\right) = -\frac{3}{2\pi}$$

From equations (15) and (25) the full gravitational force may be rewritten using the definition of mass from the first term to show this second term in more familiar notation as

$$\vec{F}_G \approx -G\frac{m_{g1}m_{g2}}{\left|\vec{r}_2-\vec{r}_1\right|^2}\hat{r}_{12} - \frac{45}{8}G\frac{m_{g1}m_{g2}}{\left|\vec{r}_2-\vec{r}_1\right|^2}\left(\hat{r}_{12}\cdot\vec{\beta}\right)\left\{\hat{r}_{12}\times\left(\hat{r}_{12}\times\vec{\beta}\right)\right\} \quad (27)$$

$$\approx -G\frac{m_{g1}m_{g2}}{\left|\vec{R}\right|^2}\hat{R} - \frac{45}{8}G\frac{m_{g1}m_{g2}}{\left|\vec{R}\right|^2}\left(\hat{R}\cdot\vec{\beta}\right)\left\{\hat{R}\times\left(\hat{R}\times\vec{\beta}\right)\right\}$$

The first term is Newton's universal gravitational force for non-relativistic velocities. The second term is a new term that gives rise to a corkscrew type of spiraling motion. The strength of the second term is much less than the first due to the β^2 factor. The first term causes planets to orbit the sun with an elliptical orbit in the equatorial plane of the sun. The second term modifies the orbit to lie on the surface of a toroid that is centered on the equatorial plane of the sun. Is this notion supported by observations?

Corroborating Circumstantial Evidence for Orbits on the Surface of a Toroid. Astronomers have found that the elliptical orbits of the various planets are tilted with respect to the equatorial plane of the sun as shown in Figure 13 [16]. This is also true of the orbits of the moons about the planets. The origin of the planetary orbit tilt can be seen from Figure 14. As a planet goes around the sun on a toroidal surface it goes around the cross section of the toroid once in one circuit of the sun. The effective orbit appears to be an elliptical orbit tilted with respect to the equatorial plane of the sun.

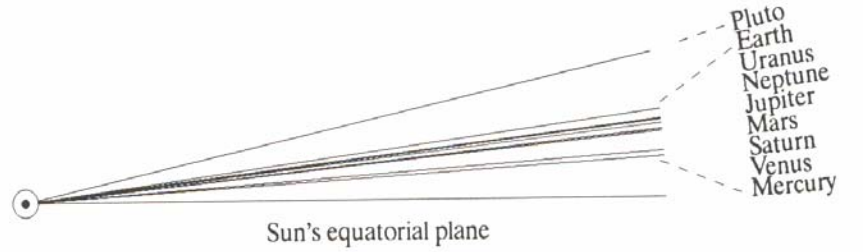

Figure 13. Tilt of Planetary Orbits with Respect to the Equatorial Plane of the Sun [16]

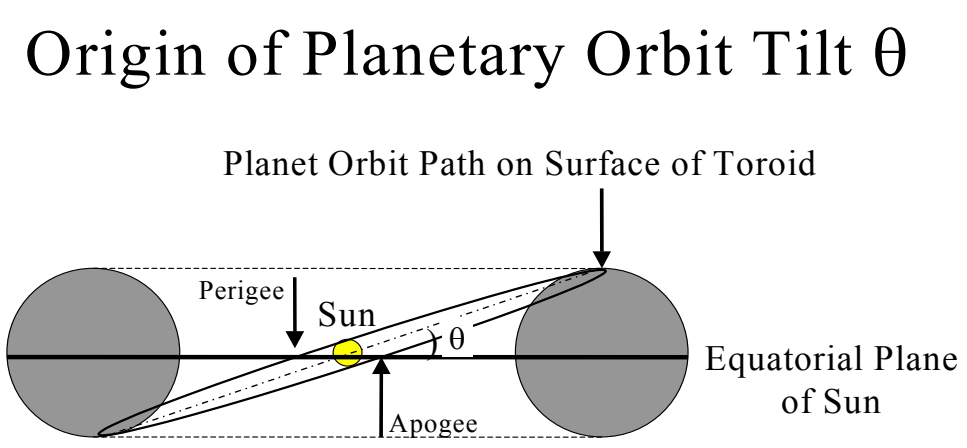

Figure 14. Toroidal Model of Planetary Orbits

NASA in a flyby of Jupiter recorded a lot of data about its moon Io. Io is volcanic and spews out a cloud of volcanic dust that forms a toroidal ring about the planet Jupiter that is centered on its equatorial plane. The orbit of the moon Io was discovered to not be in the center of this toroidal ring as expected, but rather on the surface of the toroidal ring as predicted by the force of gravity as derived from the universal electrodynamic force law. Io's orbit appears to be an ellipse tilted with respect to the equatorial plane of Jupiter as shown in Figure 15.

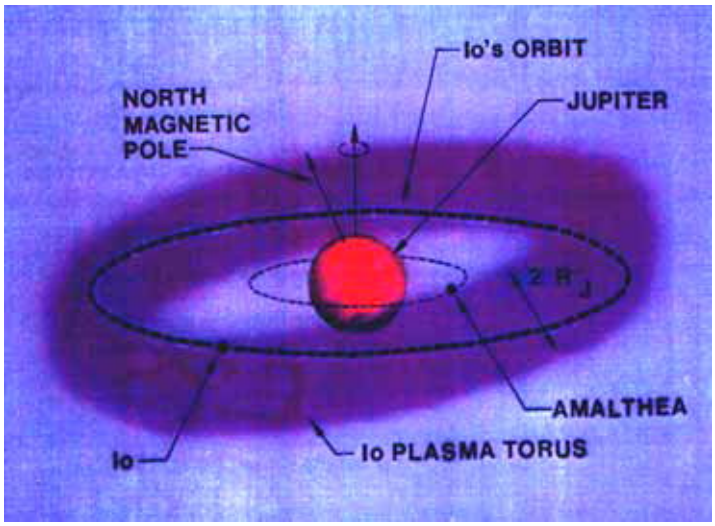

Figure 15.
Orbit of Moon Io about Jupiter on the Surface of a Toroidal Volcanic Ash Ring

Figure 16 shows the motion of four of Jupiter's moons about the orbit of Jupiter on the toroid about the sun. Note the spiral or corkscrew orbits of the moons about Jupiter's orbit. Also note the relative periods of the spirals are integer multiples of one another, i.e. Io = 2, Europa = 4, Ganymede = 8, Callisto = 16. The quantization of the orbits of the moons of Jupiter is a necessary condition for the stability of a system in order to periodically return to the same point on the toroidal surface of its orbit.

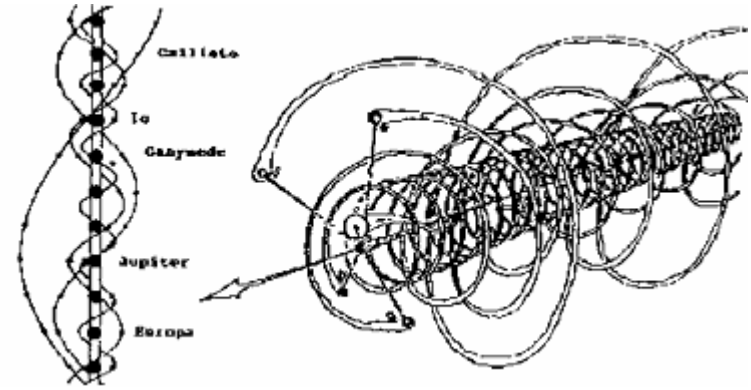

Figure 16.
Map of the Spiral or corkscrew orbits of the moons Io, Callisto, Europa, and Ganymede around the planet Jupiter

The electrodynamic theory of gravity appears to be the only theory of gravity able to explain the tilting of the orbits of the planets with respect to the equatorial plane of the sun and the quantization of these orbits. In contrast Newton's Universal Law of Gravitation and Einstein's General Theory of Relativity predict that the orbits of all the planets of the sun should lie totally in the equatorial plane of the sun and there is no quantization of orbits due to gravity.

Origin of Hubble's Law. Edwin Hubble discovered that the light from distant stars is shifted in color toward the red part of the spectrum as shown in Figure 17. The farther away the star the greater the red shift.

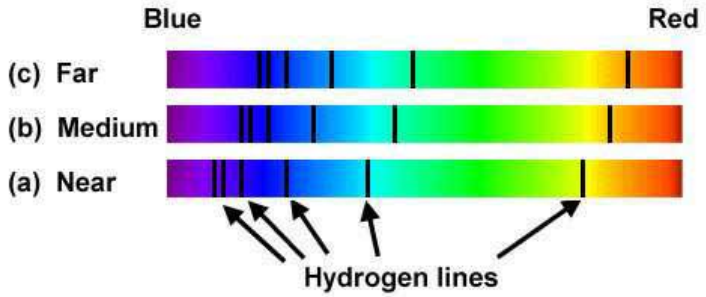

Figure 17.
Red shift of Hydrogen Absorption Lines for Near, Medium, and Far Distance Stars [17]

The decrease in the force of gravity over time has a significant effect on the light that we see from distant stars. From conservation of energy light emitted from a stellar surface on a star of mass M and radius R is expected to have a red shift equal to the difference in gravitational potential. Using G for Newton's universal gravitation constant this potential at the stellar surface is $-GM/R$ and zero at infinity, so the red shift z may be defined as

$$z = \frac{\Delta\lambda}{\lambda} = \frac{GM}{c^2 R} \quad (23)$$

This equation for the gravitational red shift was confirmed experimentally by Pound & Rebka in 1960 [17].

If the force of gravity is decreasing, then GM/R would have been greater in the past when gravity was stronger. Thus, in general, the gravitational red shift of light from stars should be larger the farther away the star is, independent of the star's velocity or type as shown in Figure 18. The star's velocity can add to or reduce the red shift due to the Doppler Effect. Also the star's size affects the rate of decay of gravity. Larger galaxies decay more slowly than smaller galaxies. Thus a large and small galaxy bound together would have two different red shifts with the larger galaxy having the larger redshift. This has been confirmed by Arp [34].

An examination of the data that Hubble used to formulate his famous law that red shifts are roughly proportional to distance is shown in Figure 18. Note that the Doppler red shift due to velocity and other effects causes deviations from a

perfect straight line, which are small in comparison with the main effect of the gravitational red shift from earlier times. According to equations (22) and (23) the gravitational red shift could have been more than 10^9 larger in the past than it is today where the electrons vibrate with very small amplitudes.

Thus the electrodynamic theory of gravity is the only theory of gravity that is able to describe Hubble's Law for red shifts as a function of distance, or equivalently time, for light emitted in the past to reach the earth.

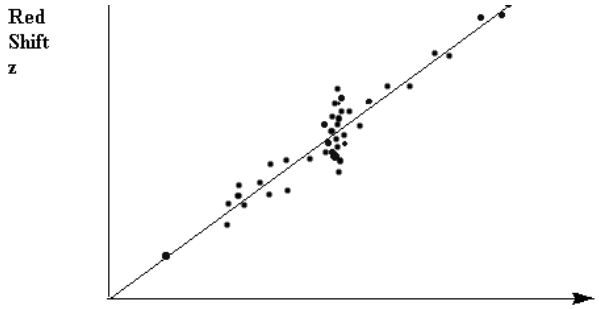

Figure 18. Hubble's Law red shifts are proportional to distance or brightness

Significance of Quantized Red Shifts. One consequence of the classical universal electrodynamic force law is that all forces have a $1/R^2$ dependence on all size scales. This implies that the universe must have a center just as elementary particles have a center, the atom has a center, the solar system has a center, galaxies have a center, and nebula have a center.

In the case of our solar system matter, in the form of planets, only exists at particular quantized radii as represented by Bode's Law. Also the matter of the moons about the planets such as Uranus only exists at particular quantized radii as represented by Bode's Law. Thus one might suspect that on a very large scale in the universe matter might also exist at particular quantized radii as represented by Bode's Law. (See Figures 19, 20, and 21.)

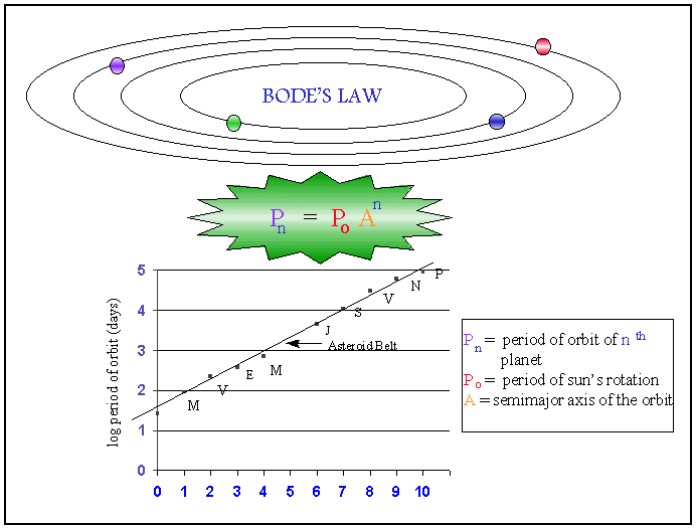

Figure 19. Planetary Data supporting Bode's Law

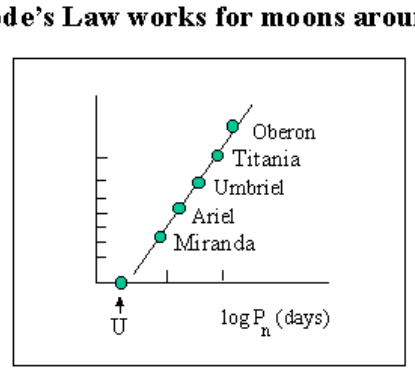

Figure 20. Uranus Moon Data Supporting Bode's Law

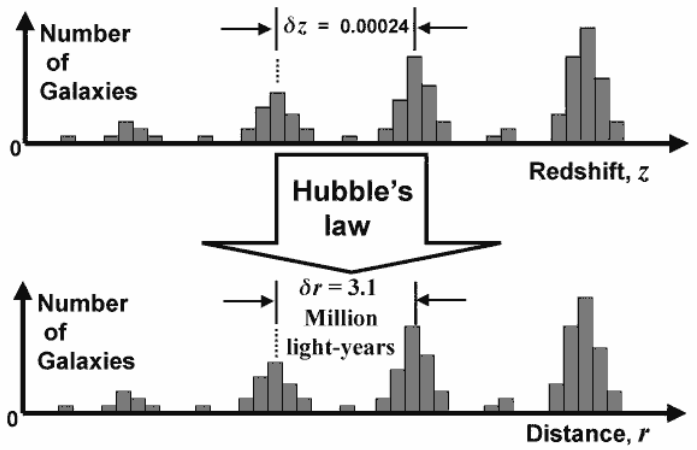

Figure 21.
Tifft's Quantized Red Shifts Support Bode's Law on Universal Scale - idealized format without background [18]

In the early 1970s William Tifft [19] at the Steward Observatory in Tucson, Arizona was analyzing the red shift data and began transforming the data into "power spectra" that show how the various spacings in the red shift data occur. This statistical technique shows difficult-to-see regularities as peaks rising above the random noise in a plot. The noise could be due to such things as the "local" or "peculiar" motions of the galaxies and different sizes of galaxies. Tifft [19] noticed a surprisingly strong peak corresponding to an interval between red shift *z*'s of about 0.00024 and a weak peak at ½ of 0.00024.

In 1984 Tifft and Cocke[20] examined the 1981 Fisher-Tully survey of red shifts in the radio wave (21 cm wavelength line from hydrogen) part of the spectrum. They found sharp periodicities at exact submultiples ⅓ and ½ of 0.00024.

However, despite Tifft's steady stream of publications, astronomers remained skeptical about the notion of quantized red shifts. Then in 1997, an independent study of 250 galaxy red shifts by Napier and Guthrie [21] confirmed Tifft's basic observations. They found the red shift distribution to be strongly quantized in the

galactocentric frame of reference with a very high confidence level. The galactocentric frame of reference is the frame at rest with respect to the center of our own galaxy, the Milky Way. When they compensated for the earth's motion around the sun and the sun's motion around the galaxy center, the quantizations appeared more clearly.

In 1996 and 1997 Tifft [22, 23] showed that it is important to compensate the galactrocentric red shifts further by accounting for our galaxy's motion with respect to the cosmic microwave background radiation. Doppler shifts of the microwaves show that our galaxy is moving about 560 km/s in a direction south of the constellation Hydra [24]. Accounting for this motion converts the galactocentric red shifts to a frame of reference which is at rest with respect to the cosmic background radiation and presumably at rest with respect to the universe as a whole. In this frame the red shift groups are much more distinct from one another suggesting that the universe has a defined center. Additional periodicities of 1/4 and 1/8 of 0.00024 were observed. See Figure 22 for the skewing effect of observing the red shifts away from the center of the universe.

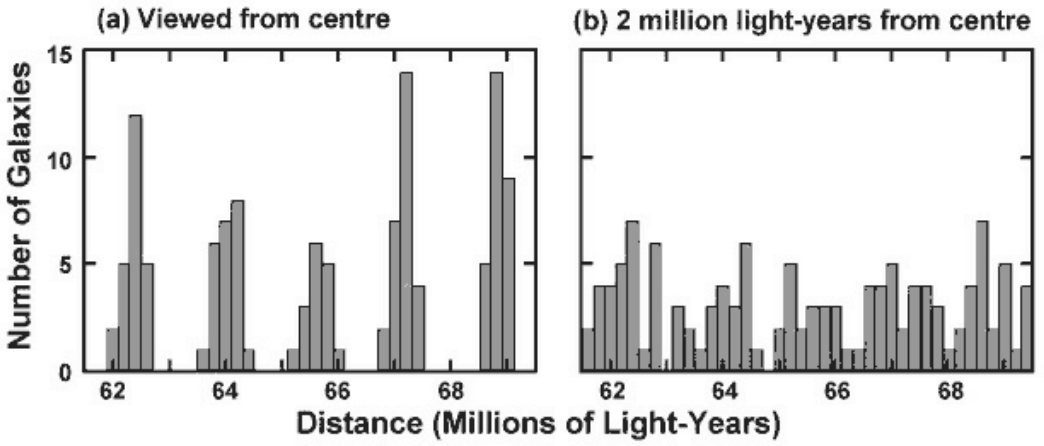

Figure 22. Effect of Observing Red Shifts Away from the Center of the Universe

In 1992 Tifft [25] in an anonymous paper claimed that galactic red shifts have actually decayed slightly in just a few years. This is consistent with red shifts being primarily gravitational red shifts and the force of gravity declining rapidly far away near the edge of the universe. The electrodynamic theory of gravity is the only theory of gravity that predicts the general decay of all red shifts in the universe.

MOND vs. Dark Matter. The observed rotational speeds of objects in extragalactic systems exceed what can be explained by the visible mass of stars and gas. One approach to explain this discrepancy is to infer that there is more mass than meets the eye, i.e. dark matter and dark energy exist. Another approach that appears to be less drastic is to assume that there is a modified Newtonian dynamics (MOND) in these regions. Figure 23 shows the plot of the rotational velocity *V* versus distance R from the center of a typical spiral galaxy NGC 6946 and compares that with the predicted Newtonian values [26].

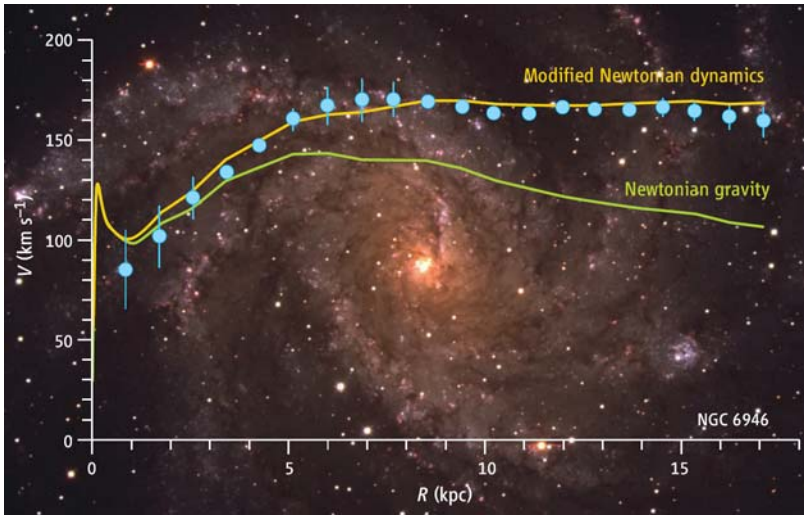

Figure 23.
NGC 6496 Spiral Galaxy with graph of rotational
Velocity *V* vs. Distance R from the Center

The astronomical data indicates that the velocity of rotation of the outer spiral arms is significantly higher than would be predicted by Newtonian dynamics which is expected to be valid in this region. Milgrom [27] in 1983 was the first astronomer to suggest that many different types of data could be explained by assuming some sort of Modified Newtonian Dynamics (MOND). He documented that MOND correctly maps the observed mass to the observed dynamics. Tulley-Fisher [28] examined many spiral galaxies and found a linear relationship between the orbital speed of a galaxy's outskirt stars and the galaxy's brightness. This data also matched the MOND predictions. (See figure 24 below.) However, astronomers are still looking for a satisfactory explanation of why the velocity increases like it does.

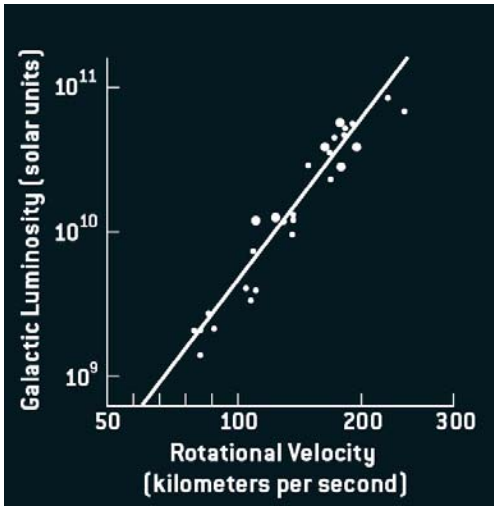

Figure 24.
Tulley-Fisher Relationship showing Linear Relationship
between Rotational velocity and Galactic Luminosity [28]

In 1999 Roscoe [29] performed an extensive analysis of 900 Tulley-Fisher rotation curves for spiral galaxies. He confirmed the Tulley-Fisher relationship to a very high level of confidence greater than 95% as shown in Figure 25.

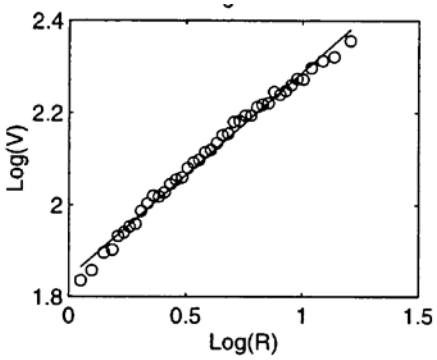

Figure 25. Analysis of 900 Optical Rotation Curves of Galaxies [29]

Furthermore, Roscoe [29] was able to confirm by analysis that the size of spiral galaxies and their luminosities were discrete or quantized as shown in Figure 26. Bode's law is reappearing here as it did for the red shifts. Thus we see a consistency.

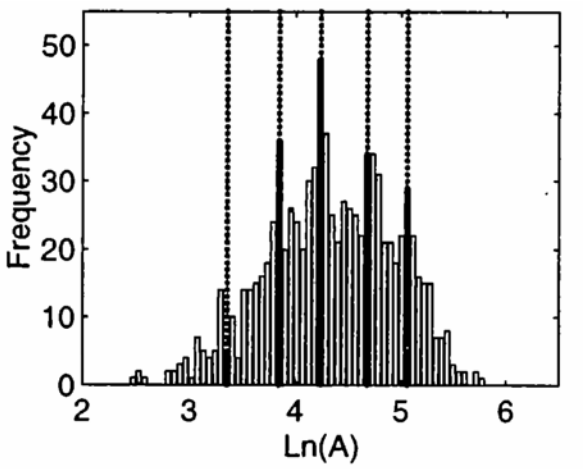

Figure 26. Quantization of Galaxy Luminosity and Size [29]

The electrodynamic theory of gravity gives a satisfying explanation of the increased velocities of the outer arms of spiral galaxies over what would be expected from Newtonian dynamics. According to the derived electrodynamic theory of gravity, the mass in the outer stars of the galaxy decays much faster than the mass in the center of the galaxy. Conservation of kinetic energy for the outer stars indicates that at some time in the past the mass of the galaxy center was significantly greater, such as when it was originally formed. Thus the outer stars in the spiral galaxy are now in the process of escaping from the galaxy whose mass has decayed to the point that it can no longer hold them captive. This electrodynamic approach to gravity does not require the invention of the illogical and unphysical dark matter and dark energy. Also its second term (described

below) is able to explain the discrete sizes of the spiral galaxies in a fashion consistent with Bode's law for the solar system and Tifft's measured quantization of red shifts.

Differences Between This Work and Previous Investigators. In 1992 and 1995 Assis [30, 31] and Dragone [32] in 1990 also attempted to show that gravity was an electromagnetic effect between oscillating neutral electric dipoles. The differences with this work are

1. Assis and Dragone utilized a different force law between the charges in the oscillating dipoles. They did not include the correct angular dependence as observed in accelerator experiments.

2. Dragone did not average over the phases of the electric dipoles causing him to identify gravity as a second order term in v/c.

3. Assis did not perform a separate time average over each oscillating dipole.

4. Assis did not perform a proper integral average over all angles of orientation of the oscillating dipoles but did an approximate average over 9 fixed orientations.

5. Neither Assis nor Dragone identified the Cosmic Background Radiation as a confirmation of the electrodynamic explanation of gravity.

6. Neither Assis nor Dragone noted that the strength of the gravitational force must decline over time causing astronomical objects such as the earth to expand

7. Neither Assis nor Dragone identified the second non-radial term in the gravitational force giving rise to tilted planetary orbits with respect to the equatorial plane of the sun.

8. Neither Assis nor Dragone noted that gravity accounts for Hubble's law for red-shifts.

9. Neither Assis nor Dragone were able to interpret Tifft's quantized red-shifts in terms of Bode's law for quantized orbits

10. Neither Assis nor Dragone predicted the decay of the gravitational red-shifts over time due to the decay of the gravitational force.

11. Neither Assis nor Dragone noted that the decay of gravity could explain the unexpected high velocities of the outer stars of spiral galaxies.

12. Neither Assis nor Dragone were able to explain Roscoe's quantized luminosities and sizes of spiral galaxies in terms of Bode's law for galaxies.

13. Neither Assis nor Dragone noted that the second gravitational term was responsible for the quantization of gravity.

Summary. From the previously derived universal classical electrodynamic contact force law for finite-size elastic particles the force of gravity was identified as a small average residual effect of the order $(v/c)^4$ due to vibration of atomic electrons with respect to the protons in the nucleus of neutral atoms. This electrodynamic force of gravity can also be derived from the action-at-a-distance covariant relativistic electrodynamic force law based on Maxwell's equations making it compatible with both versions of electrodynamics. The derived gravitational force was found to have the customary radial term of Newton's Universal Law of Gravitation ($F = Gm_1m_2/R^2$) plus a new non-radial term. From the radial term the gravitational mass can be associated with certain electrodynamic parameters. The non-radial term gave rise to an $\mathbf{R}\times(\mathbf{R}\times\mathbf{V})$ effect which causes the orbits of the planets about the sun to spiral around on the surface of a toroid giving the appearance of an elliptical orbit tilted with respect to the equatorial plane of the sun.

The vibrational mechanism causing the gravitational force was found to decay over time giving rise to the cosmic background radiation and Hubble's red shifts versus distance due to gravitational red shifting. A reasonable range of vibrational amplitude for the electron is able to explain at least nine orders of magnitude change in the observed red shifts of light from distant stars. The vibrational mechanism combined with the $\mathbf{R}\times(\mathbf{R}\times\mathbf{V})$ effect also explained Tifft's quantized red shifts as a type of Bode's Law indicating that there is a geometrical center to the universe. The vibrational mechanism by which gravity decays by radiation over time explained Tifft's measured rapid decay of the magnitude of red shifts over time. The Tulley-Fisher relationship for luminosity of spiral galaxies and Roscoe's observed quantization of the luminosity of 900 spiral galaxies in a manner reminiscent of Bode's Law is explained by the $\mathbf{R}\times(\mathbf{R}\times\mathbf{V})$ term of the electrodynamic theory of gravity. The unexpectedly high velocity of the outer stars of spiral galaxies is explained simply by the decay of mass and conservation of energy without resorting to the use of outlandish ideas such as dark matter and dark energy. The measured quantization of the luminosity and size of spiral galaxies is also explained by the new $\mathbf{R}\times(\mathbf{R}\times\mathbf{V})$ term in the derived gravitational force.

This electrodynamic explanation of gravity appears to indicate that mass is not a fundamental quantity of nature. Thus the notions of mass that are intrinsic to Newton's Universal Law of Gravitation and Einstein's General Relativity Theory appear to be false. This is further emphasized by the unexpectedly large number of diverse astronomical phenomena explained by this electrodynamic approach to gravity.

In the paper [33] that derives the force of inertia from the universal electrodynamic force, the electrodynamic definition of inertial mass was found to be equal to the definition of gravitational mass of this paper. When Albert Einstein developed his general theory of relativity, he started with the assumption that the correspondence between inertial and gravitational mass is not accidental: that no experiment will ever detect a difference between them. *In General Relativity theory the effects of* ***gravitation*** *are ascribed to space-time curvature*

instead of a ***force.*** Thus in General Relativity Theory gravitation is not a force, and not subject to Newton's third law. So from the framework of General Relativity Theory the equality of inertial and gravitational mass remains an unexplained mystery.

Finally this approach to gravity, which is based on a derived universal electrodynamic force law, is more satisfying than all previous approaches. *First,* it confirms Bode's Law and the quantization of gravitation due to the $\mathbf{R}x(\mathbf{R}x\mathbf{V})$ term which requires all physical systems involving motion to be quantized in order to have stability. The motion of the planets around the sun on the surface of the toroid must return to the same starting point on the toroid or there is no stability. *Second*, this approach is simpler, since it is based on a single universal force law. Furthermore, this force is a local contact force based on the electromagnetic fields of a charge extending the range of the force instead of an action-at-a-distance concept like that used in Newton's Universal Force Law and Einstein's General Relativity Theory which employ unphysical point-particles. Natural philosophers have known for thousands of years that there is no such thing as an action-at-a-distance force. Some mechanism is needed to transfer forces. *Third*, this approach explains more gravity-relevant data than all previous theories of gravity combined including Bode's law for the quantization of gravity, the tilts of the orbits of the planets about the sun, the expansion of the planets and moons of the solar system, the origin of the cosmic background radiation, Hubble's law for red shifts, the quantization of red shifts, the general decay of all red shifts, the quantized Tulley-Fisher relationship for luminosity and size of spiral galaxies, and the unexpectedly high velocity of the outer stars of spiral galaxies.

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24. Scott et al. (2000) in **Allen's Astrophysical Quantities, 4th Edition**, edited by A. N. Cox (Springer-Verlag, New York, 2000) pp. 658, 661. The sun is moving 370.6 $\pm$ 0.4 km/s with respect to the cosmic microwave background toward galactic longitude and latitude ($264.^{0}31 \pm 0.^{0}17$, $48.^{0}05 \pm 0.^{0}10$) or a right ascension and declination of about (11^{h}, 9^{0}S). That direction is a little below the constellation Leo, in the lesser known constellation Sextans. From data in the reference one can calculate the following: the sun's velocity with respect to our galaxy's center is 240 km/s toward galactic coordinates (88^{0}, 2^{0}) and the velocity of the center of our galaxy with respect to the cosmic background is 556 km/s toward galactic coordinates (266^{0},29^{0}). The latter corresponds to right ascension and declination (10^{h} 30^{m}, 24^{0}S) below the constellation Hydra. Note that the speeds above are much larger that the earth's average orbital velocity around the sun of 29.79 km/s.

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