Who Needs Dark Matter? An Alternative Explanation for the Galactic Rotation Anomaly

Raymond HV Gallucci, PhD, PE
8956 Amelung St., Frederick, Maryland, 21704
e-mails: gallucci@localnet.com, r_gallucci@verizon.net

Borrowing concepts from the Electric/Plasma Universe theories [1], I examine a possible explanation of at least part of the observed behavior for the galactic rotation anomaly for spiral galaxies by considering an idealized case where the combined magnetic fields from the galactic core (assumed to be a rotating charged sphere) and spiral arms (assumed to be a rotating charged disk exhibit a trend toward the 'flatness' in these rotation curves as one proceeds outward radially from the galactic core to its edge. This hopefully is a plausible addition to the various alternate explanations for this anomaly that do not invoke the likely fiction of 'dark matter,' alleged to comprise roughly 85% of the total matter in the universe (and, with the other likely fiction 'dark energy,' alleged to comprise roughly 95% of the total mass-energy of the universe). In the process, I provide at least an introduction to some of these other alternative explanations for the galactic rotation anomaly.

1. Introduction

As discussed in "Dark matter" [2]:

"Dark matter was postulated by Jan Oort in 1932, … to account for the orbital velocities of stars in the Milky Way and by Fritz Zwicky in 1933 to account for evidence of 'missing mass' in the orbital velocities of galaxies in clusters. Adequate evidence from galaxy rotation curves was discovered by Horace W. Babcock in 1939, but was not attributed to dark matter. The first to postulate dark matter based upon robust evidence was Vera Rubin in the 1960s–1970s, using galaxy rotation curves. … Together with fellow staff-member Kent Ford, Rubin announced … that most stars in spiral galaxies orbit at roughly the same speed, which implied that the mass densities of the galaxies were uniform well beyond the regions containing most of the stars (the galactic bulge), a result independently found in 1978 … Eventually other astronomers began to corroborate her work and it soon became well-established that most galaxies were dominated by 'dark matter' … [B]y the 1980s most astrophysicists accepted its existence."

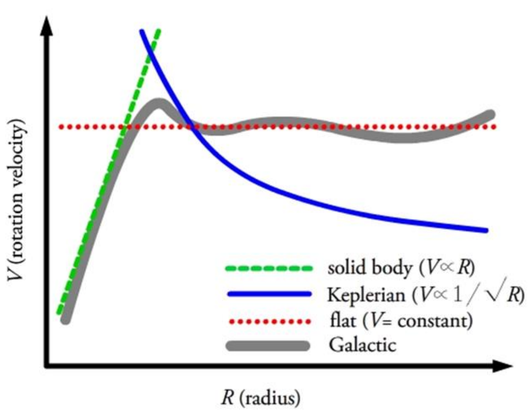


FIGURE 1. Rotational curves for a disk [3]

Since dark matter has not actually been observed or detected, but only inferred by circumstantial evidence, primarily due to the alleged anomaly in galactic rotation curves (see Figure 1), dissident physicists have offered other explanations for the relative flatness of the rotational velocity of galaxies with increasing radius. That is, while the presumably densely packed galactic core (essentially a sphere of stars) rotates like a solid body (green, thick-dashed line in Figure 1), once into the disk region, galactic rotational speed flattens out, such that structures such as spiral arms continue to rotate as if 'fixed' like the spokes of a wheel (albeit 'bent backward' in a logarithmic spiral).

2. Some Explanations without Dark Matter

Review of some of these 'dissident' websites uncovers alternate (to dark matter) explanations, both gravitationally- and electromagnetically-based, such as the following.

> "This theory attributes the anomaly in galactic rotation to the effects of time dilation on Newtonian speeds when making observations from the Earth's frame of reference … A spherical time rate field. The spherical time rate field around any mass is similar to a gravity well … [F]or relatively short radii from the centre of any mass and even for those at solar system scales, we do not notice much physical effect from the time dilation diminishing with 'r' … We might then envisage that the relentless continuation of this time rate increase (time dilation decay), from the galactic centre outwards, will accumulate … and so become significant in terms of the red and blue shift of Newtonian rotation speeds … The only radial position that shows us a REAL, unshifted Newtonian rotation speed … is therefore at a radius similar to our own position in the Milky Way (for galaxies of similar mass and distribution) … So, we need to raise the calculated Newton curve so it crosses the observed curve at this position. We therefore deduce there is more mass at the centre, [and that] … all Newtonian speeds are redshifted and slowed down relative to our frame of reference, increasingly so, as you look

closer toward the galactic centre. The Newton curve inboard, therefore becomes increasingly lowered from the inverse square form as you move inwards and this brings the Newton curve down to match the observed. Outboard, … all Newtonian speeds are blueshifted relative to our frame and so appear increasingly faster than Newton with increasing 'r' … Both these effects, inboard and outboard, result in a good 'fit' between time shifted Newtonian speeds and the observed curve of rotation speeds." [4]

"Electric Universe theory asserts that there is a model of spiral galaxy formation that has long been demonstrated by laboratory experiment and 'particle in cell' (PIC) simulations on a supercomputer. But, the particles are charged and respond to the laws of electromagnetism. This seems … obvious … when … more than 99.9 percent of the visible universe is in the form of <u>plasma</u> … Plasma responds to electromagnetic forces that exceed the strength of gravity to the extent that gravity can usually be safely ignored. This … suggests why gravitational models of galaxies must fail … [C]omputer simulations have been backed up by experiments in the highest energy density laboratory electrical discharges—the Z-pinch machine [that] … verify each stage in development of the PIC simulations … [T]he beautiful spiral structure of galaxies is a natural form of plasma instability in a universe energized by electrical power. [5]

Continuing with the Electric Universe arguments, "[o]ne of the reasons for the assumption of large amounts of Cryogenic (or Cold) Dark Matter (CDM) in the Gravity Model is to explain the observed rotation of galaxies … However, there is another way stars could be made to orbit a galaxy in this fashion. Michael Faraday found … that a metal disk rotating in a magnetic field aligned with the axis of the disk would cause an electric current to flow radially in the disk … Galaxies are known … to possess magnetic fields aligned with their axes of rotation, and they also have conducting plasma among their stars. Assuming that currents exist in the plane of the galaxy similar to the equatorial current sheet known to exist in the Solar System, then the conditions appear to be similar to that in a Unipolar Inductor or Faraday Motor ... [I]t is at least possible that it is these electrical effects that are causing the anomalous rotation that we see, not some huge quantity of invisible Dark Matter." [6]

One of the more unique explanations asserts that "the mutual [gravitational] perturbations among the component stars in a Spiral Arm can be shown to have far greater effects than previously noted. The inverse-square nature of gravitation causes the effect to be very strong at the relatively short distances within a Spiral Arm … One interesting consequence of this research is the realization that the Sun and all other stars slowly weave back and forth across the Spiral Arm! … The analysis … [suggests that]: {1} A general tapering shape of an Arm is necessary to produce the effect described here. This suggests a reason for the common existence of spiral arms in galaxies. {2} A tapered Arm shape is a necessary resultant consequence of the meta-stable situation described here. These two statements suggest a mechanism for the genesis and persistence of spiral arms in many galaxies. {3} [T]he Sun and everything else in each Arm apparently laterally oscillate across the width of the Arm ... [W]ithin the Spiral Arms, a substantial previously undescribed conventional gravitational net force vector [coupled with] … [t]he tapering shape of a Spiral Arm … results in a meta-stable situation that establishes the stability and persistence of the Spiral Arm, including the circumstance where the Arm revolves in the observed non-Keplerian way ... [A]s long as the Arm tapers as it extends outward, there is significant force active on each constituent star to pull it along and also toward the axis of the Arm ... This therefore explains the lasting integrity of the Arm structure, and also suggests a much less massive galaxy. It may remove the need for dark matter, exotic particles, materials, or objects to account for a lot of unseen distributed mass in the Galaxy. The question of Missing Mass as to explaining the rotation of the Galaxy is no longer necessary or appropriate." [7]

As can be seen, both gravitational (first and last) and electromagnetic (second and third) alternative explanations to dark matter as being responsible for anomalous galactic rotation have been proffered. While my hypothesis will align mainly with the electromagnetic explanation, I draw significantly from aspects of that developed by Johnson, albeit not its gravitational effects. The interested reader is directed to Johnson's website for the details of the simulations he performed to substantiate his hypothesis, too intricate and lengthy to be reproduced here.

3. Another Possible Explanation

My analysis begins with mathematically constructing a representative spiral galaxy, whose spherical, central core has a radius $R_s = 1$ and whose three, logarithmically spiraling, equi-spaced arms extend out from the core through the disk to radius $R_d = 5$ (Figure 2). (Logarithmic spirals, with an equation $r = \exp[a\theta]$ in polar coordinates, reasonably approximate the arms of spiral galaxies, including our own Milky Way. [8])

Photographs indicate the number of spirals in galaxies which are reasonably symmetric range from the minimum of two to around five. Three are postulated for my representative analysis.) The arms are shown as uniformly tapering, from a maximum width where they meet the core (black circle) of $\pi/3$ down to zero such that, if unwound and straightened spokes, each would comprise a triangle of base $\pi/3$ and height 16.12 (based on logarithmic spirals with the equation $r = \exp[\theta/\{2\pi/\ln 5\}]$ for three equally-spaced spirals).

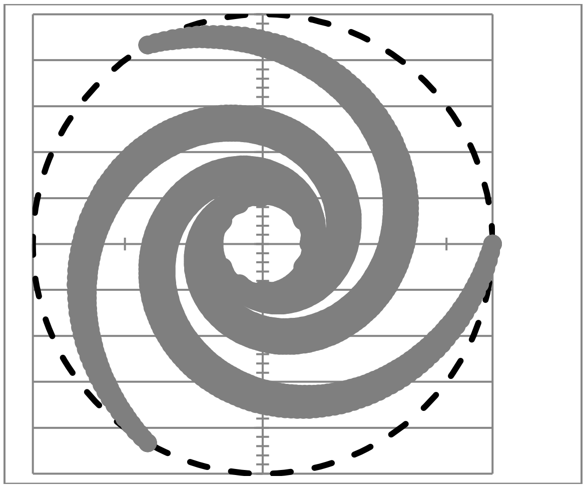


FIGURE 2. Representative Three-Armed, Logarithmic Spiral Galaxy

3.1 Magnetic Effects

The equation for the component of the magnetic field B aligned with the axis of galactic rotation in the disk of the galaxy (ecliptic) outside a rotating charged sphere (the galactic core) at radius r is as follows [9]:

$B_s(r) = \mu_0 Q_s \omega R_s^2/12\pi r^3$ [1]

where Q_s = total charge on the sphere (galactic core) and ω = rotational speed of the sphere (galaxy).

For the disk, the B field always aligns with the axis of rotation and has the following magnitude for a disk of radius r within the plane of the disk itself (also assumed to be rotating at ω) [10]:

$B_d(r) = \mu_0 \sigma \omega r/2$ [2]

where σ = charge density = $q(r)/(\pi[r^2 - R_s^2])$ for $R_s < r \leq R_d$ and q(r) = total charge on disk from R_s through r (at R_d, $q[r] = Q_d$, the total charge of the disk).

Assume $q(r) = k(r)Q_s$, where k(r) = fraction of charge in disk relative to Q_s (for convenience, assume the disk charge Q_s cannot exceed that of the sphere, i.e., $0 < k(r) \leq 1$). Within the plane of the disk itself,

$B(r) = (\mu_0\omega/2\pi)(k[r]Q_s r/[r^2 - R_s^2])$ [3]

Combining Equations [1] and [3] yields

$B(r) = (\mu_0\omega Q_s/2\pi)(R_s^2/6r^3 + k[r]r/[r^2 - R_s^2])$ [4]

With $Q_s = 1$ and $R_s = 1$ (such that all further calculations will be scaled to the sphere's charge and density), this simplifies to

$B(r) = (\mu_0\omega/2\pi)(1/6r^3 + k[r]r/[r^2 - 1])$ [5]

where $R_s < r \leq R_d$, i.e., $1 < r \leq 5$.

For subsequent analysis, define the following scaled value for the B field

$B'(r) = B(r)/(\mu_0\omega/2\pi) = 1/6r^3 + k[r]r/[r^2 - 1]$ [6]

It is evident that, as one proceeds outward radially along the disk, the contribution from the sphere drops off as r^3 while that from the portion of the disk between the sphere and r only as 1/r, given the previous constraint on k(r).

When speaking of the 'disk,' I recognize that we really have three spiral arms lying within the galaxy's ecliptic. I will view this as if the charge (and mass, both of which I assume are directly proportional to each other) was uniformly distributed in the annulus between the sphere and radius r of the disk as one proceeds outward to $R_d = 5$. Thus, k(r) will increase from 0 at the sphere ($r = R_s = 1$, where the disk begins) to its maximum value of $Q_d/Q_s \leq 1$ at $R_d = 5$. How k(r) increases with r depends on the shape of the spiral arms. Figure 2 shows them as tapering. Another possibility is a uniform cross-section, i.e., no tapering (we will not consider the possibility of them widening as r increases as this is not evident from galactic photographs). Figure 3 shows this variation for the two 'extremes.'

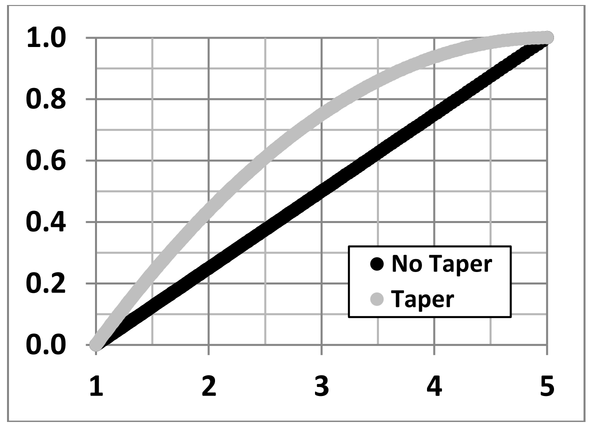


FIGURE 3. Variation in Disk Charge Fraction Based on Spiral Arm Tapering

3.1 Gravitational Effects

What about gravitational effects? Assuming the mass of the sphere (galactic core) = M_s (also assumed directly proportional to Q_s), the gravitational field G(r) solely from the sphere as a function of r is

$G(r) = \Gamma M_s/r^2$, $R_d < r$ (using Γ as the symbol for the gravitational constant). [7]

Approximating the contribution from the disk mass as one proceeds outward ($R_s < r \leq R_d$), and assuming the same behavior of the mass fraction as for the charge fraction (i.e., again using k[r], now as $m[r]/M_s$), i.e., the ratio of the mass of the disk in the annulus from the sphere to r to the total sphere mass), we can modify Equation [7] as follows:

$G(r) = \Gamma M_s(1 + k[r])/r^2$, with $0 < k(r) \leq 1$ as before. [8]

Analogous to setting $Q_s = 1$, we now set $M_s = 1$ (such that all further calculations will be scaled to the sphere's mass), thereby simplifying this to

$G(r) = G(r)/\Gamma = (1 + k[r])/r^2$ [9]

where $R_s < r \leq R_d$, i.e., $1 < r \leq 5$.

For subsequent analysis, define the following scaled value for the G field

$G'(r) = \Gamma\,(1 + k[r])/r^2$ [10]

It is evident that, as one proceeds outward radially along the disk, the contribution drops off as r^2, given the previous constraint on k(r).

4. Results

What we have shown so far is that the expected variation as one proceeds radially outward from the sphere along the disk for the B' field should be somewhat flatter (due to the 1/r variation becoming dominant over the $1/r^3$ variation) than that for the G' field, with its $1/r^2$ variation. Note that we are not comparing the relationship between the absolute strengths of the two types of field, magnetic vs. gravitational (the former is known to be much stronger), but only their variation relative to their maximum values (at the sphere). The results of the comparison are shown in Figure 4 for both the tapering and non-tapering spiral arms, and indicate the expected trend toward 'flattening' of the B' field vs. the G' field. (Just to be clear, Figure 4 does not represent any relative strengths among the three charge [Q] ratios for the B' field, the three mass [M] ratios for the G' field, or between the two sets [B' and G']. Each specific case has been scaled to its maximum value [at the sphere] such that all curves have a value of 1.0 at R_s. [or just infinitesimally farther out in the case of the B' fields since their maximum does not occur until at least an infinitesimal bit of the disk is included]. While one can readily surmise that the B' field increases with charge ratio, and the G' field increases with mass ratio, their strengths relative to each other are not represented in the Figure. The Figure solely illustrates the trend in each individual field's strength as one proceeds radially outward from the sphere along the disk solely for the purpose of illustrating the degree of 'flattening' in each particular case. This caveat holds for Figures 5 and 6 as well.)

Comparing this with Figure 1, and assuming rotational velocity is reasonably proportional to field strength, one sees behavior closer to that of the flat or galactic curves for the B' field than for the G' field, at least beyond a radius of ~2. This is especially pronounced when the spiral arms are assumed not to taper. The average between the taper and no taper behavior is displayed in Figure 5 for an easier view, further illustrating the trend.

5. Conclusion

Hopefully I have at least made a plausible argument for one possible explanation for the galactic rotation anomaly, at least as one proceeds radially outward from the galactic core, for an idealized spiral galaxy to add to the lexicon of other such arguments that do not invoke the likely fiction of 'dark matter' (and its sibling 'dark energy'). Borrowing from the Electric/Plasma Universe theories, which assert that the much greater strength of the electromagnetism vs. gravity may explain much of the observed behavior of the universe, I attempt to show mathematically that magnetic forces could account for at least some of the supposedly anomalous 'flattening' observed in rotational speed of a galaxy as one proceeds radially outward. It is by no means a rigorous treatment of the subject, but hopefully at least demonstrates that such an explanation merits further investigation.

6. References

1. *http://www.electricuniverse.info,www.plasma-universe.com*
2. *http://en.wikipedia.org/wiki/Dark_Matter*
3. *http://upload.wikimedia.org/wikipedia/commons/d/dc/ Rotation_curve_eqs.jpg*
4. *http://www.thenakedscientists.com/forum/index.php?topic=39624.0* (Ken Hughes).
5. *http://www.holoscience.com/wp/electric-galaxies/* (Wallace Thornhill).
6. *https://www.thunderbolts.info/wp/2012/02/29/essential-guide-to-the-eu-chapter-10/* (David Talbott).
7. *http://mb-soft.com/public/galaxyzz.html* (Carl Johnson).
8. *http://en.wikipedia.org/wiki/Logarithmic_spiral*
9. I. Vagner, et al., *Electrodynamics of Magnetoactive Media*, Springer Series in Solid State Sciences, ISSN 0171-1873; 135 (2004)
10. *http://physicspages.com/2013/04/17/magnetic-fields-of-spinning-disk-and-sphere/*
11. *http://en.wikipedia.org/wiki/Globular_cluster*

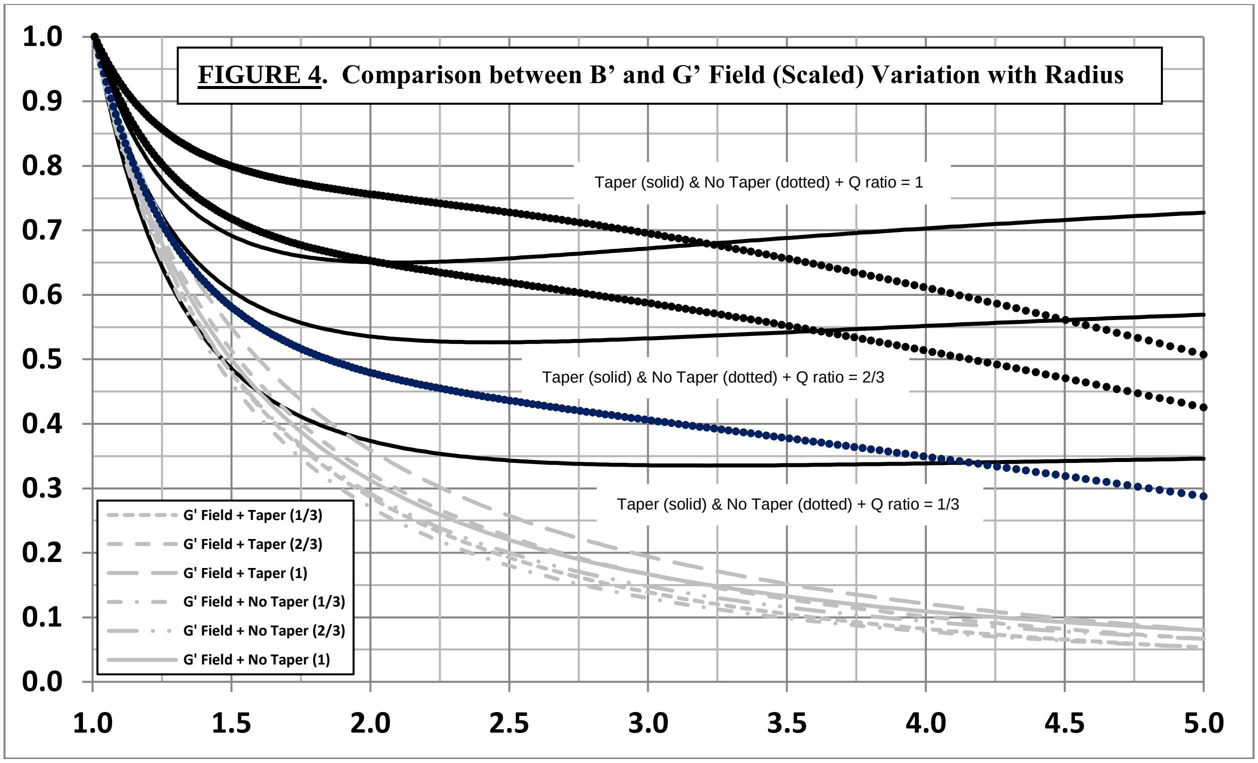


FIGURE 4. Comparison between B' and G' Field (Scaled) Variation with Radius
Taper (solid) & No Taper (dotted) + Q ratio = 1
Taper (solid) & No Taper (dotted) + Q ratio = 2/3
Taper (solid) & No Taper (dotted) + Q ratio = 1/3
G' Field + Taper (1/3)
G' Field + Taper (2/3)
G' Field + Taper (1)
G' Field + No Taper (1/3)
G' Field + No Taper (2/3)
G' Field + No Taper (1)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

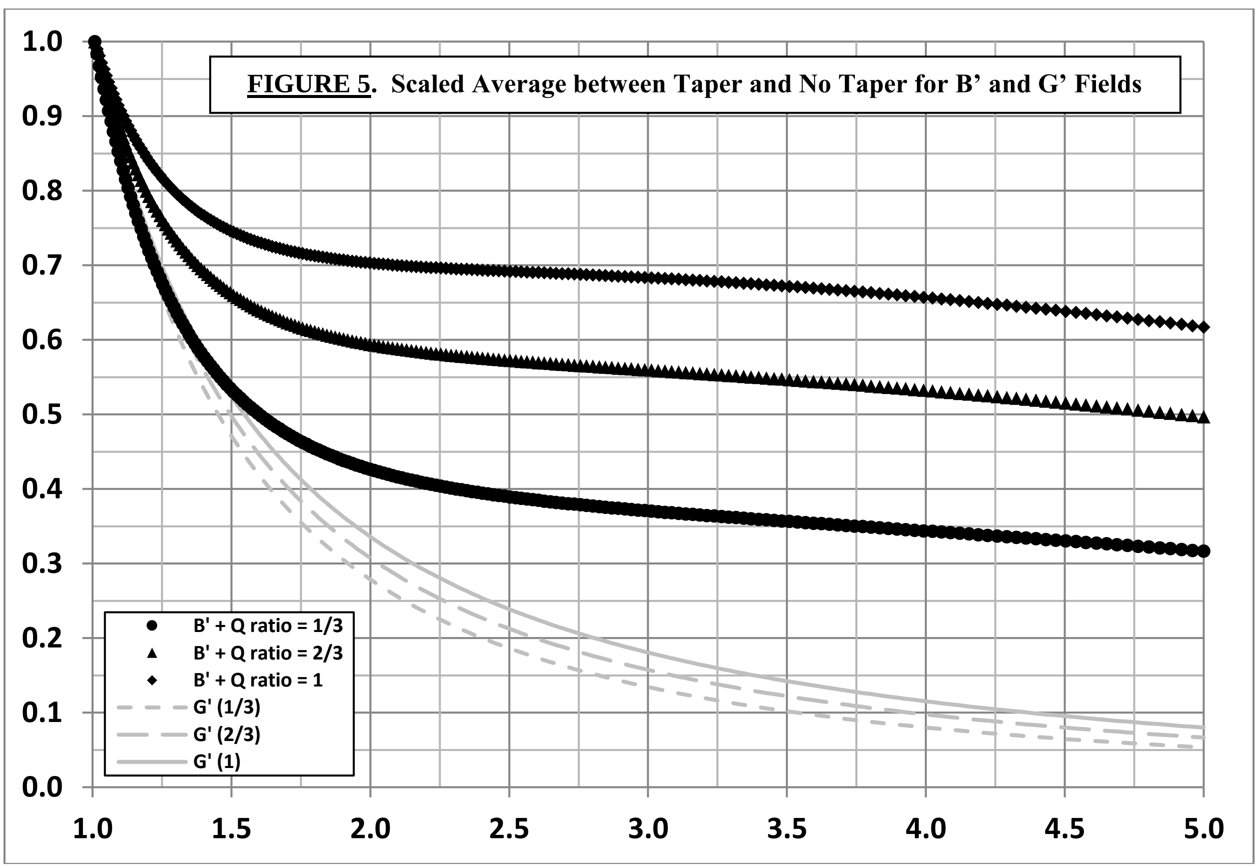


FIGURE 5. Scaled Average between Taper and No Taper for B' and G' Fields
B' + Q ratio = 1/3
B' + Q ratio = 2/3
B' + Q ratio = 1
G' (1/3)
G' (2/3)
G' (1)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

Appendix: Possible Effect from a Globular Cluster Halo

As discussed in "Globular cluster" [11]:

"A globular cluster is a spherical collection of stars that orbits a galactic core as a satellite. Globular clusters are very tightly bound by gravity, which gives them their spherical shapes and relatively high stellar densities toward their centers ... Globular clusters are fairly common; there are about 150 to 158 currently known globular clusters in the Milky Way, with perhaps 10 to 20 more still undiscovered Large galaxies can have more: … Some giant elliptical galaxies … have as many as 13,000 globular clusters ... Globular clusters are generally composed of hundreds of thousands of low-metal, old stars, … similar to those in the bulge of a spiral galaxy but confined to a volume of only a few million cubic parsecs ... Globular clusters can contain a high density of stars … Some globular clusters … are extraordinarily massive, with several million solar masses and multiple stellar populations."

To gauge the possible contribution from any magnetic field generated by a halo of globular clusters surrounding my representative spiral galaxy, I assume there is such a halo at a distance of $5R_d/2$ (i.e., $r = 25/2$), rotating with the galaxy at the same rotational speed ω as the disk so as to form a spherical shell of charge in which the galaxy resides. (This very crude approximation is based loosely on the estimated radius of the Milky Way galaxy [~50,000-60,000 light-years] and the estimate that its halo of globular clusters is located at a radius of ~131,000 light years.) From Vagner [9], the B field inside such a sphere within the ecliptic plane is

$B_h = \mu_0 Q_h \omega / 6\pi r$ [11]

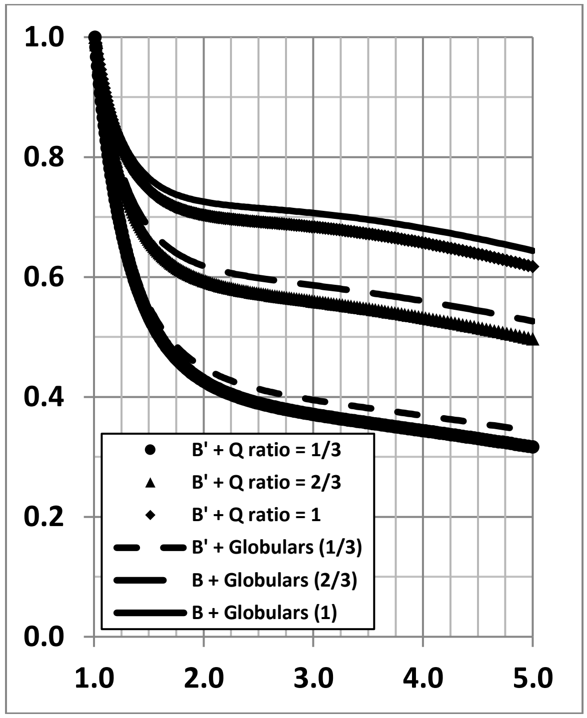
where Q_h = charge on the spherical shell i.e., the total charge of the halo).

As before, we can define $B_h' = B_h/(\mu_0\omega/2\pi) = Q_h/3r$ [12]

Considering the same range on Q_h as for Q_d (i.e., from $Q_s/3$ to Q_s), and setting $Q_s = 1$ and $r = 5R_d/2 = 25/2$, we obtain

$B_h' = 2f/75$, where $1/3 \leq f \leq 1$. [13]

When this is added to the combined B field from the rotating sphere and disk, the total B field rises as much as ~8%, as shown in Figure 6 (plotted against the scaled averages as in Figure 5 for convenience of viewing).



<u>FIGURE 6</u>. Scaled Average B' Fields between Taper and No Taper (with Halo of Globular Clusters)