Who Needs Dark Matter? Is the Galactic Rotation Anomaly an Optical Illusion?

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In an earlier paper, "Who Needs Dark Matter? An Alternative Explanation for the Galactic Rotation Anomaly," this author examined a possible electromagnetic phenomenon as an explanation for the 'galactic rotation anomaly,' whereby the rotational speeds of stars in a spiral galaxy exhibit a relatively constant value despite increasing radius. There, this author assumed that angular rotation speed remained relatively constant, so as to preserve the stability of the spiral arms as they rotate. Several other authors' theories were presented along with one by this author himself, which cited the magnetic field within the plane of a galaxy resulting from rotation by both the spherical galactic core and flattened 'disk' containing the spiral arms as possibly yielding the constant angular speed. However, many galactic rotation curves exhibit constant tangential rather than angular rotation speed, inconsistent with a 'pinwheel-like' galactic rotation which would preserve spiral arm stability. The possibility that this is really an 'optical illusion' masking the actual pinwheel-like rotation, and corresponding constancy of angular, not tangential, speed is considered here. Finally, speculation as to the phenomenon responsible for this 'illusion' is offered.

1. Introduction

Figure 1 shows typical galactic rotation curves, where the tangential speed remains relatively constant as one proceeds outward from the galactic center. This contrasts with the analysis presented in Ref. [2] where it was assumed that the angular speed is the one which remains relatively constant, such that the integrity of the galactic spiral arms is preserved as they rotate about in a pinwheel fashion. This presents a dilemma, in that relatively constant tangential speed cannot preserve spiral arm stability, at least not without postulating something like 'density waves' where the stability of the spiral arms is really an optical illusion: [3]

Density wave theory or the Lin-Shu density wave theory is a theory proposed by C.C. Lin and Frank Shu in the mid-1960s to explain the spiral arm structure of spiral galaxies. Their theory introduces the idea of long-lived quasistatic density waves (also called heavy sound), which are sections of the galactic disk that have greater mass density (about 10–20% greater). The theory has also been successfully applied to Saturn's rings. Originally, astronomers had the idea that the arms of a spiral galaxy were material. However, if this were the case, then the arms would become more and more tightly wound, since the matter nearer to the center of the galaxy rotates faster than the matter at the edge of the galaxy. The arms would become indistinguishable from the rest of the galaxy after only a few orbits. This is called the winding problem. Lin and Shu proposed in 1964 that the arms were not material in nature, but instead made up of areas of greater density, similar to a traffic jam on a highway. The cars move through the traffic jam: the density of cars increases in the middle of it. The traffic jam itself, however, does not move (or not a great deal, in comparison to the cars). In the galaxy, stars, gas, dust, and other components move through the density waves, are compressed, and then move out of them.[1] More specifically, the density wave theory argues that the 'gravitational attraction between stars at different radii' prevents the so-called winding problem, and actually maintains the spiral pattern.

Figure 2 illustrates the 'unraveling' that would occur for constant tangential speed vs. radius over eight rotations of the galaxy as the spiral arm, modeled as starting as a 'spoke' ('line') becomes more 'tightly wound' and eventually loses any integrity. Furthermore, the equation derived in Ref. [2] that indicated the relatively constant magnetic field with increasing radius would reduce to one similar to that for gravity, decreasing with the inverse of the radius-squared rather than just the inverse of the radius.

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1 There appears to be an inconsistency with this analogy, and therefore perhaps with the 'density wave' theory itself. Cars traveling through different 'densities' of a traffic jam will proceed at different speeds depending upon the density. They travel faster between 'pile-ups' and slower through 'pile-ups.' They do not exhibit constant speed, as suggested by the galactic rotation curves and accepted by 'density wave' theory.

2. Magnetic Field under Constant Tangential Speed

In Ref. [2], it was shown that, for angular speed remaining constant with radius, the magnetic field is derived as follows. 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 $B_s(r) = \mu_0 Q_s \omega R_s^2/12\pi r^3$, where Q_s = total charge on the sphere (galactic core), R_s = radius of galactic core (sphere), 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): $B_d(r) = \mu_0\sigma\omega r/2$, 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).

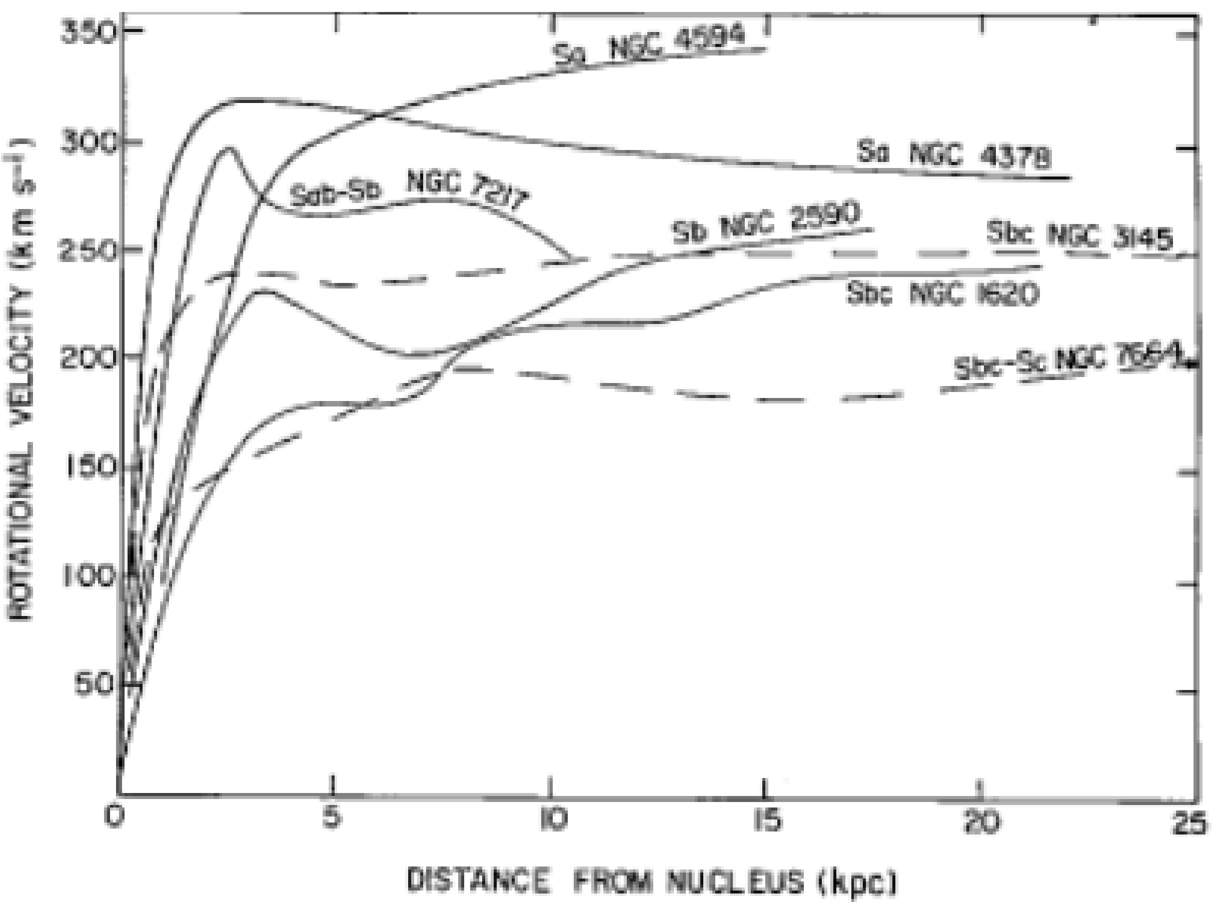


Figure 1. Representative Galactic Rotation Curves [1]

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, $B(r) = (\mu_0\omega Q_s/2\pi)(R_s^2/6r^3 + k[r]r/[r^2 - R_s^2])$. With $Q_s = 1$ and $R_s = 1$ (such that all further calculations were scaled to the sphere's charge and density), this simplified to $B(r) = (\mu_0\omega/2\pi)(1/6r^3 + k[r]r/[r^2 - 1])$, where $R_s < r \leq R_d$, i.e., $1 < r \leq 5$. It was evident that, as one proceeds outward radially along the disk, the contribution from the sphere drops off as $1/r^3$ while that from the portion of the disk between the sphere and r only as 1/r, given the previous constraint on k(r).

3. An 'Optical Illusion?"

In Ref. [2], just such an explanation was cited by Hughes, who "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 … [W]e need to raise the calculated Newton curve so it crosses the observed curve at this position [i.e., at a radius similar to our own position in the Milky Way (for galaxies of similar mass and distribution)]. 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'." [5] Hughes' explanation essentially assumes spiral arm stability and, therefore, pinwheel-like rotation, with the corresponding need for constant angular, not tangential, speed. The constancy of tangential speed is an illusion due to relativity.

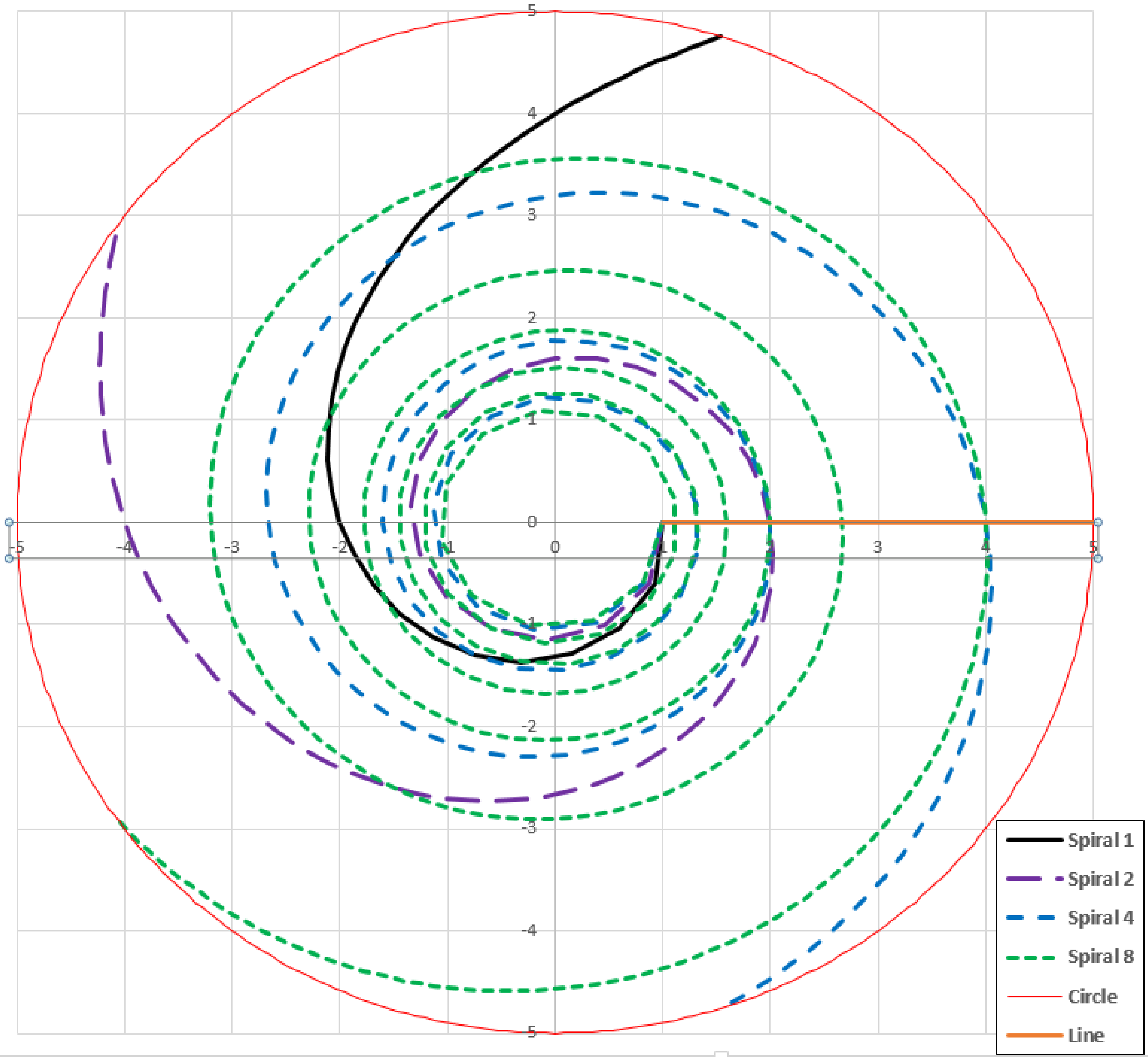
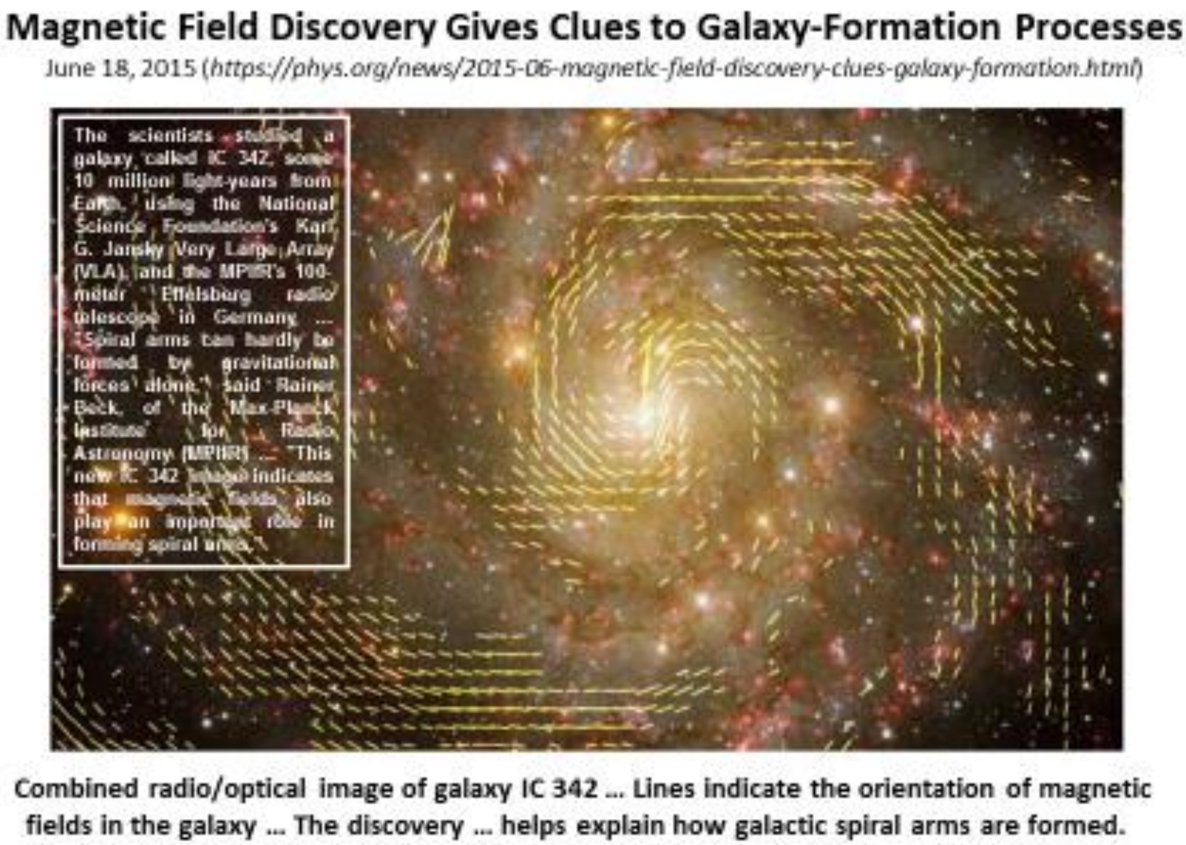


Figure 2. Unraveling of Spiral Arms Starting as 'Spoke' over Eight Galactic Rotations

What explanation for this illusory behavior might be offered if a non-relativistic, magnetic field effect were cited, as in Ref [2]? Assuming pinwheel-like rotation, and the corresponding spiral arm stability, is correct, one returns to the 1/r behavior due to the magnetic field in the galactic plane as being truly representative of the physics for galactic rotational stability. However, for the 'illusion' of a 1/r behavior of angular speed, such that tangential speed appears to remain constant, something must lead to this deceptive observation.

However, if it is the tangential speed, not the angular speed, that remains constant with increasing radius, the magnetic field equations for the sphere and disk would be rewritten as follows. For the sphere, $B_s(r) = \mu_0 Q_s \omega_s R_s^2/12\pi r^3$, which is almost exactly the same as before, except now we represent the angular speed of the sphere as ω_s. With the tangential speed v, not the angular speed, being constant with increasing radius over the disk, $\omega(r) = v/r$. At R_s, $v = \omega_s R_s$, yielding $\omega(r) = \omega_s R_s/r$. Therefore, the previous equation for the magnetic field within the plane of the disk from the disk alone becomes $B_d(r) = \mu_0\sigma\omega(r)r/2 = \mu_0\sigma\omega_s R_s/2 = (\mu_0\omega_s/2\pi)(k[r]Q_s/[r^2 - R_s^2])$, which resembles the previous equation, but now with ω_s in place of ω and a factor of r no longer in the numerator. Now, when the sphere's and disk's magnetic fields are combined, the resulting magnetic field within the plane of the disk becomes $B(r) = (\mu_0\omega_s Q_s/2\pi)(R_s^2/6r^3 + k[r]/[r^2 - R_s^2])$, which simplifies to $B(r) = (\mu_0\omega_s/2\pi)(1/6r^3 + k[r]/[r^2 - 1])$ with $Q_s = 1$ and $R_s = 1$ as before.

The key difference is that the factor of r in the numerator for the term corresponding to the magnetic field from the disk has been removed, such that its influence as r increases is now proportional to $1/r^2$ instead of $1/r$, i.e., analogous to gravity. However, unless one accepts the 'density wave' theory, with or without the 'Dark Matter' speculation, a $1/r^2$ behavior cannot explain the stability of the galactic spiral arms as they rotate about the core. Nor can this stability be consistent with tangential speed remaining relatively constant with increasing r – the arms would have to unravel.



<u>Figure 3</u>. Magnetic Fields across a Spiral Galaxy [4]

Figure 3 strongly suggests that spiral arm stability is related to a galaxy's magnetic field, which suggests that a galaxy rotates more like a pinwheel with angular, not tangential, speed remaining relatively constant with increasing radius, as analyzed in Ref [2]. Therefore, how can the 'observed' relative constancy of tangential speed (vs. angular) be explained? Is it an optical illusion?

Tangential speed is inferred from observing the Doppler shift of the light from stars rotating at different galactic radii. If two stars of the same 'color'[2] but at different radial distances are observed to have the same Doppler shift ('red" if receding, 'blue' if approaching), they are assumed to have the same tangential speeds. However, this leads

[2] 'Color' here is used in the loose sense to represent the entire electromagnetic spectrum for light, e.g., X-rays have a 'color' corresponding to shorter wavelengths and higher frequencies than 'visible' light, while microwaves have a 'color' corresponding to longer wavelengths and lower frequencies.

back to the inconsistency between constant tangential speed and galactic spiral arm stability. This author, as well as others, has speculated on light speed being variable and dependent upon source and/or observer speed (e.g., see Ref. [6-9]). Since light is an electromagnetic phenomenon, might its speed be affected by being in a magnetic field? Might the light emitted from stars rotating at smaller radii, and therefore in a higher galactic magnetic field, travel at a greater speed than light emitted from stars rotating at larger radii, and therefore in a lower galactic magnetic field? If so, and if this speed variation exhibits a similar 1/r behavior as the magnetic field, then effectively what is being 'observed' under the constraint that light always travels with the same speed regardless of source or observer speed, i.e., the 'relativity' constraint, could lead to 'observing' a relatively constant tangential speed at the different radii. However, with a variable light speed dependent upon the strength of the magnetic field, and this dependence being at least approximately 1/r, what is really constant is the angular speed and, therefore, the galactic spiral arms remain stable and rotate like a pinwheel.

Observed at two different galactic radii, r and R, with $r < R$, are two constant tangential speeds v. The assumed corresponding angular speeds are ω and Ω, with $\omega = v/r > \Omega = v/R$ since $r < R$. However, since v is measured via Doppler shift, constrained by the speed of light assumed constant, the observed tangential speed $v_o(r) = v_a(r)/|r|$ for light speed affected by the magnetic field, where $v_a(r)$ is the actual tangential speed at r. (Note, | | indicates magnitude [unitless].) Therefore, obtain the following actual angular speeds at r and R, respectively: $\omega(r) = v_a(r)/r \rightarrow |\omega(r)| = |r|v_o(r)/r = |v_o(r)| = |v_o|$, since the observed tangential speed is constant, and $\Omega(R) = v_a(R)/R \rightarrow |\Omega(r)| = |R|v_o(R)/R = |v_o(R)| = |v_o|$. Therefore, $\omega(r) = \Omega(R)$, i.e., the actual angular speeds, not the actual tangential speeds, are constant, preserving galactic spiral arm stability.

Clearly this is all speculative and perhaps quite a leap of faith. However, is it any more speculative than a 'density wave' hypothesis, requiring the presence of 'Dark Matter' for a gravity-only explanation?

References

1. https://web.njit.edu/~gary/321/rot_curves.gif
2. Gallucci, R. 2016. "Who Needs Dark Matter? An Alternative Explanation for the Galactic Rotation Anomaly," **Proceedings of the Third Annual Chappell Natural Philosophy Society Conference**, July 19-22, 2017, Vancouver, BC, pp. 38-43; presented at **EU2017 – The Electric Universe: Future Science**, August 17-20, 2017, Phoenix, AZ; also http://vixra.org/pdf/1609.0014.pdf.
3. "Density Wave Theory," https://en. wikipedia.org/wiki/Density_wave_theory.
4. "Magnetic Field Discovery Gives Clues to Galaxy-Formation Processes," https://phys. org/news/2015-06-magnetic-field-discovery-clues-galaxy-formation.html.
5. http://www.thenakedscientists.com/forum/ index.php?topic=39624.0 (Ken Hughes).
6. Gallucci, R. 2013. "Time Dilation in Relativity," **Proceedings of the Natural Philosophy Alliance, 20th Annual Conference of the NPA, 10-13 July 2013**, Volume 10, College Park, MD, pp. 84-86 (also http://vixra.org/pdf/1601.0080.pdf [2016]).
7. Gallucci, R. 2016. "Does Light Travel with the Velocity of a Moving Source?" **Proceedings of the Second Annual Chappell Natural Philosophy Society Conference**, July 20-23, 2016, College Park, MD, pp. 94-99 (also http://vixra.org/pdf/1606.0127.pdf).
8. Gallucci, R. 2016. "The Speed of Light: Constant and Non-Constant" **Proceedings of the Second Annual Chappell Natural Philosophy Society Conference**, July 20-23, 2016, College Park, MD, pp. 67-73 (also http://vixra.org/pdf/1606.0128.pdf).
9. Gallucci, R. 2016. "Can Varying Light Speed Explain Photon-Particle Interactions?" **Proceedings of the Third Annual Chappell Natural Philosophy Society Conference**, July 19-22, 2017, Vancouver, BC, pp. 44-48 (also http://vixra.org/pdf/1608.0419.pdf).
10. "Red Face Shift," http://www.everythingselectric.com/red-face-shift/ (February 28, 2015).
11. Gallucci, R. 2017. "Intrinsic Redshift in Quasi-Stellar Objects (QSOs) - Mass Dependence and Quantization?" submitted to *Galilean Electrodynamics*, https://home.comcast.net/~adring/ (also http://vixra.org/pdf/1704.0076.pdf).

Appendix

Halton Arp developed a theory of 'intrinsic redshift' as an alternative explanation for the observed high redshifts in quasi-stellar objects (QSOs): [10]

> *Halton Arp was investigating galaxies and created the famous "Atlas of Peculiar Galaxies." He observed then interpreted there were visually colliding and linked galactic objects* [quasars]. *The red shift of science suggested that although these dust and plasma formations appeared to look like they were connected, they were in theory light years apart. Halton Arp become convinced that red and blueshift was wrong. ... In some photographs a quasar is in the foreground of known galaxies, and in others there appeared to be matter bridging the two objects, implying they are very close in space. If they are, and the redshifts were due to Hubble expansion, then both objects should have similar redshifts. The galaxies had much smaller redshifts than the quasars. Arp argued that the redshift was not due to Hubble expansion or physical movement of the objects, but must have a non-cosmological or 'intrinsic' origin ... As quasars move away from their origins within galactic nuclei, their redshift properties begin to decrease until they reach ... [a] point [where] the quasar resembles a galaxy, albeit a small one.*

Arp also developed a theory of variable particle mass to explain the intrinsic redshift.[3]

Might Arp's conjecture of decreasing redshift with distance way from a galaxy be extended to explain the possible 'optical illusion' that yields a flattening of galactic tangential speed with radius? When nearest a galaxy, the QSO redshift is greatest, which would imply a much higher speed than is actually occurring. As the QSO moves away, i.e., distance increases, the redshift also decreases, implying a slowing of speed. Now, if this QSO behavior were actually occurring <u>within</u> the galactic disk as well, might this not suggest a flattening of a rotational curve by distorting the observed speed at lower radii, where the actual speeds are lower, to seem much higher? And, as one proceeds to higher radii, this distortion decreases, such that combined with the actual increasing tangential speed the rotational curve appears to be 'flattened' when, in actuality, it is the angular speed curve that is flattened while the tangential speed curve shows a linear increase with radius?

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3 Although beyond the scope of this Appendix, at least a summary of Arp's theory of 'variable particle mass' can be found in Ref. [11].