Is Molecular Hydrogen (H_2) the 'Dark Matter' that Explains the Galactic Rotation Anomaly?

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

Molecular hydrogen (H_2), virtually undetectable from space, has long been a viable candidate for the alleged 'dark matter' supposedly accountable for the 'flattening' of the galactic (tangential) rotation curves. Presented here is a simplified analysis, assuming such molecular hydrogen is uniformly distributed throughout the Milky Way Galaxy's disk, that examines the plausibility of such 'dark matter' providing a definitive gravitational explanation for the observed rotational behavior.

1. Introduction

As discussed in [1]: "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 [see Figure 1] … 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."

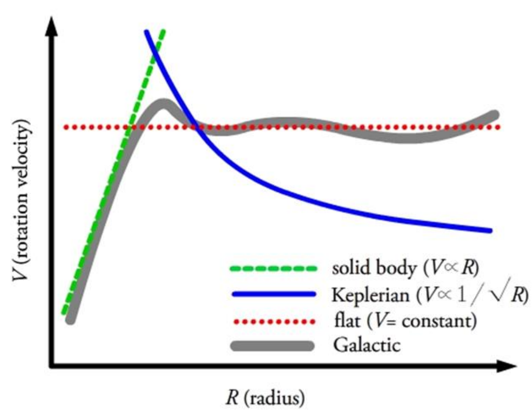

FIGURE 1. Galactic (Tangential) Rotational Curves [2]

In 1966, Varsavsky observed that "… the appearance of the rotation curve of the [Milky Way] Galaxy implies that molecular hydrogen could have an abundance comparable, or actually higher by a factor of about four, to that of atomic hydrogen … Molecular hydrogen, if present, would have a considerable influence on many astronomical problems … [If] a large fraction of the unseen mass is gas distributed near the plane of the Galaxy, [and] this gas … can be molecular hydrogen, we could postulate an abundance of molecular hydrogen up to five times larger than the abundance of atomic hydrogen and still satisfy all the observations of the motions of the stars." [3]

In 1989, P. Marmet and Reber commented that "[t]he largest fraction of gases in space cannot be atomic hydrogen, but possibly can be H_2 [molecular hydrogen]. Such a large amount of H_2 would be undetectable in the 21-cm radio receivers of radio astronomers [i.e., the wavelength at which atomic hydrogen absorbs and emits radiation] … H_2, having no dipole moment, cannot emit any measurable amount of radio-frequency signal … it is extremely difficult to detect. Therefore, H_2 is a serious candidate that might form the important component of invisible matter in space." [4]

In 1995, Marmet offered an alternative explanation for the Cosmic Microwave Background (CMB) instead of the Big Bang. "Astronomical observations show that there is a very large quantity of atomic hydrogen (H) in the universe … It is well known in basic physics and chemistry that atomic hydrogen H is quite unstable. Spectroscopy reveals that when one has a given quantity of atomic hydrogen in a given volume, these atoms react between themselves to form molecular hydrogen (H_2) … Molecular H_2 is extremely stable at normal pressure down to the most extreme vacuum. One can expect that, after billions of years, an important fraction of atomic hydrogen H in the universe is already combined to form the extremely stable molecular hydrogen (H_2) … Molecular H_2 is among the most transparent gases in the universe. Consequently, one cannot hope to detect free H_2 in space by usual spectroscopic means.

"Since we are fully surrounded by the matter of the universe, it is well known that Planck's radiation observed from inside our local volume of space at 3 K (during the last billion years) must be perfectly isotropic. This is in perfect agreement with observational data. It is inconceivable that the matter in space around us (a billion light years around us) would not emit Planck's radiation … [If] the region of the heavens around the earth [is] filled with molecular H_2 at 3K, [and] such a gas emits 3 K Planck's radiation in all directions, this leads to the 3 K isotropic radiation as observed in space. However, on the contrary, the primeval radiation [from the Big Bang] has been calculated to be non-isotropic." [5]

Molecular hydrogen has been a leading candidate for 'dark matter,' at least within a galaxy, for 50 years or more, not to mention Marmet's conjecture that it could be an explanation for the CMB. At least traces of it have been identified in ours and other galaxies, fairly remarkable given its extreme difficulty to detect. [6,7] If molecular hydrogen is indeed the majority of the alleged 'dark matter' that permeates throughout our Milky Way Galaxy and causes its anomalous rotation, an analysis of its gravitational effects might lend some evidence to the validity of this postulate.

2. Estimating Gravity and Rotational Speed within the Milky Way Galaxy

Figure 2 is a view looking down on the Milky Way Galaxy from above, assuming it is circular of uniform density (due to presence of molecular hydrogen [H_2] as 'dark matter'), with the galactic core at the center (not shown).[1] Assume a star with the sun's mass is located in the disk a distance 'r' from the center, as shown by the solid red circle. The net force of gravity from the symmetric disk segments around the star will be zero, leaving the remaining volume of the disk, with center of mass shown by the open green circle, to exert a radially inward gravitational force on the star. If the disk has a uniform thickness 'h' and the galactic radius is 'R', the volume of the part of the disk exerting a net gravitational force is $V = \pi h R^2 - hr^2(2\cos^{-1}\frac{r}{R} - \sin[2\cos^{-1}\frac{r}{R}])$. [8] If the mass of the galaxy is M and the star has the sun's mass 'm,' the gravitational force on the star will be $F_{disk} = {VGMm}/{\pi h R^2 (r+x)^2}$, where 'x' is the distance from the galactic center to the exerting volume's center of mass. Since the disk is of uniform density, $x = {r\gamma}/{V}$, where γ is the volume of the symmetric portion of the disk with no net gravitational effect, i.e., the term after the minus sign in the equation above for V.

Now including the gravitational force from the galactic core, $F_{core} = {G\mu m}/{r^2}$, where 'μ' is the mass of the core, the total gravitational force on the star as a function of r is just the sum, as shown in Figure 3 (constants are M = 2.29E+42 kg, μ = 8.55E+36 kg, m = 1.99E+30 kg, h = 1.89E+13 km, R = 6.62E+17 km, G = 6.67E-20 $km^3/kg\text{-}s^2$ [9]). From this, equating the total gravitational force to the centripetal force at r, we obtain $F(r)_{total} = {mv(r)^2}/{r}$, which implies $v(r) = \sqrt{rF(r)/m}$, where v(r) is the tangential speed at r. As indicated by Figure 4, the tangential speed continues to rise, leveling off only near the edge of the galaxy, despite the fact that the gravitational force levels off much closer to the galactic center. However, after a quick initial drop, the angular speed $\omega(r) = v(r)/r$ levels off, declining gradually with distance.

The tangential speed across the galactic disk in Figure 4, if anything, most nearly resembles that of the 'solid body' in Figure 1, if that line had a much more gradual slope. This is reinforced by the tendency for the angular speed to level off with radial distance, although still showing some gradual decrease. Thus, it appears that, from this highly simplified analysis, assuming uniformly distributed 'dark matter' throughout the galactic disk falls somewhat short of explaining the galactic rotation anomaly by itself.

2.1 Alternate or Supplemental Considerations

As an alternative or supplement to the 'dark matter' explanation, electromagnetic phenomena have been proposed as mechanisms that account for the flattening of the galactic (tangential) rotation curve. Among these are ones that exclusively invoke Electric/Plasma Universe Theory and even one of the author's own. [10-12] Another that, while providing a strictly gravitational explanation still leaves room for the possibility of electromagnetic effects, is that from L. Marmet: "Given the rotation curve, the intrinsic angular momentum, the maximum radius and a smooth mass distributions as boundary conditions, a unique mass distribution is obtained. The mass distribution is finite and does not have to fit a simple analytical function. The additional mass needed to obtain an agreement with the observed mass-to-luminosity ratio is provided by baryonic matter most likely to be molecular hydrogen and condensed matter … Also, calculations with plasmas also produce matter distributions which explain galaxy dynamics. It would be important to know which fraction of interstellar matter is a plasma and contributes as such." [13]

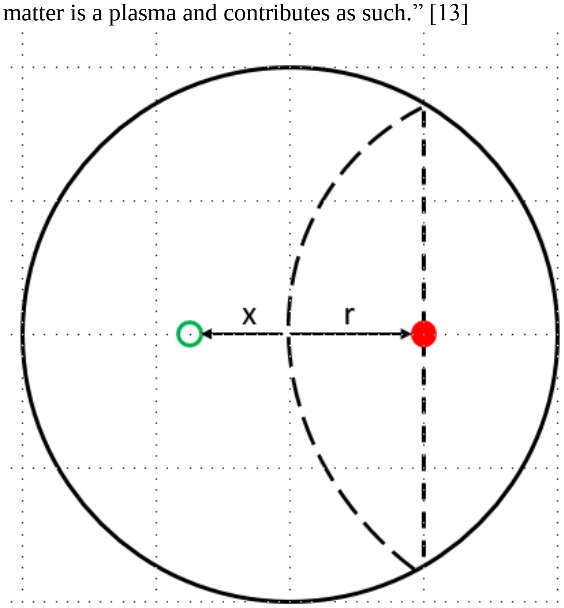

FIGURE 2. Schematic Idealized View of Milky Way Galaxy from Above

3. Conclusion

While molecular hydrogen appears as a plausible candidate for 'dark matter,' at least within galaxies, if such actually exists, the simple analysis here suggests that it alone may not be sufficient to explain the galactic rotation anomaly of the 'flattening' of the tangential speed curve with radial distance. If distributed uniformly throughout the disk of a galaxy, 'dark matter' does not produce the observed flattening, but suggests more of a 'solid body' (pinwheel) rotational behavior, also suggested by the angular speed variation. At least one alternative that assumes a 'double mass' distribution of molecular hydrogen as the 'dark matter' within a galactic disk has been proposed by Marmet to rectify the 'failure to flatten,' although it does not dismiss the possibility of electromagnetic effects contributing as well.

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1 In the Appendix, this same geometric configuration and analysis for the disk is used to examine the potential behavior of the gravitational force inside the earth, but there considering Figure 2 as a projection of a three-dimensional spherical Earth in two dimensions.

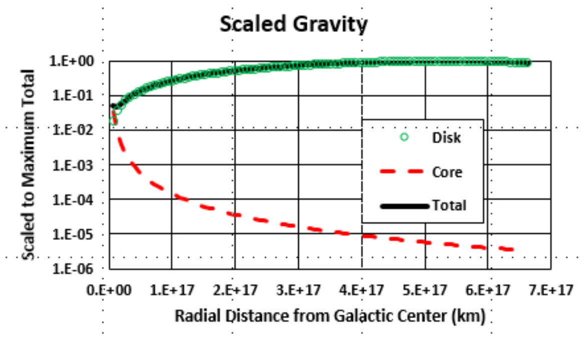

FIGURE 3. **Gravitational Force on Star vs. Radial Distance from Galactic Center**

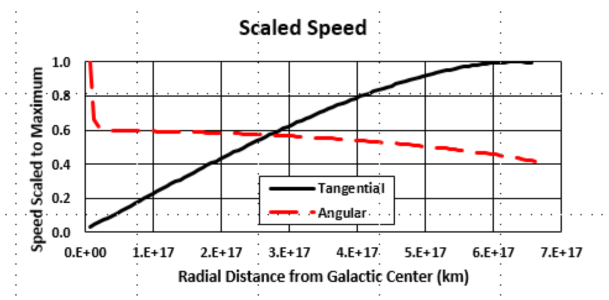

FIGURE 4. **Tangential and Angular Speed of Star vs. Radial Distance from Galactic Center**

4. References

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APPENDIX
Gravitational Force within the Earth

The preceding analysis for the gravitational effects from the galactic disk are readily extended to the earth, with modification to account for a three-dimensional sphere instead of a galactic disk. [14] That is, using a parallel approach as for the gravitational effect on an object (now a 1-kg mass) located within the sphere, Figure 5 showing the variation of the earth's gravity with distance from center results (Earth Mass = 5.97E+24 kg, Earth Radius = 6370 km [density assumed uniform]). Note it peaks around 14 nt at a depth of ~2400 km, or ~40% deep into the earth. The interesting initial increase as one descends from the surface was observed during a descent into a 2-km borehole in Greenland (Figure 6), albeit to a depth negligible compared to that of the earth (0.03%). [15]

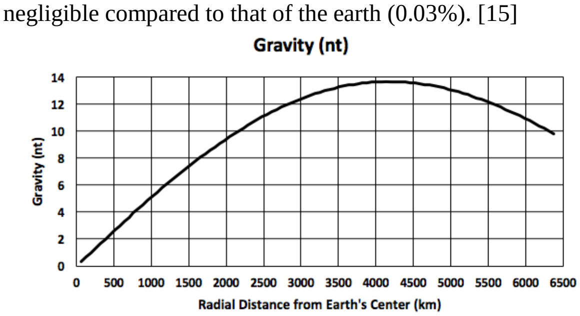

FIGURE 5. **Earth Gravity vs. Radial Distance from Center**

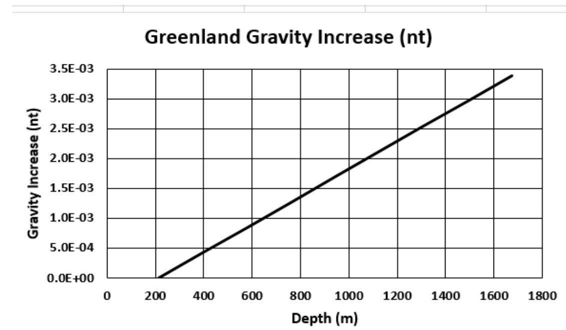

FIGURE 6. **Gravitational Increase vs. Depth from Greenland Borehole Measurements**