# Inappropriate Application of Kepler's Empirical Laws of Planetary Motion to Spiral Galaxies Created the Perceived Galaxy Rotation Problem – Thereby Establishing a Galactic Presence for the Elusive, Inferred Dark Matter

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**Abstract**

Astronomers using new, improved spectrographic equipment to study galactic rotation during the 1970s initially presumed that spiral galaxies were 'standard' orbital systems, just like the Solar system, and that the laws of planetary motion should apply. As a result, when the rotational velocities of disk objects were found to be generally flat at all peripheral radii, conflicting with characteristic Keplerian rotation curves, it was concluded that either classical mechanics had been falsified at large scales, or that some enormous, undetected form of matter must be present to extend the distribution of galactic mass to very large radii. The procedural assessment conducted here shows that very large scale aggregations of massive objects cannot be expected to rotate like the highly centralized mass of the Solar system. Newton proved long ago that Keplerian relations specifically apply only to the mass distribution inherent in the Solar system. As a result, no galactic dark matter need be inferred from any discrepancy with Keplerian rotation curves.

## Introduction

Recovering from an illness in 2008, the television captured my attention as I heard Vera Rubin explain the 'discovery' of inferred dark matter in the BBC documentary "Most of Our Universe is Missing" (transcribed):

> *If we observe the velocities of stars orbiting in the galaxy we find that their velocities remain flat all the way to the edge of our observations - that's not what was expected. By correspondence with the Solar system and in fact just from Newton's law it was expected that the velocities of the stars would fall off. So it was clear that our ideas about galaxies were incorrect.*

Knowing only that gravitation's effects were proportional to mass and diminished with distance, I could not comprehend how the centralized mass Solar system and the exceedingly distributed mass of spiral galaxies could possibly be expected to rotate identically. It seemed that there must be some fundamental misconception involved in this galaxy rotation problem, since relatively sparse planets within the Solar system each independently orbit the exceedingly massive Sun, whereas galactic disk objects must continuously interact with perhaps many millions of neighboring objects, often of greater mass.

**Establishing Requirements for Galactic Dark Matter**

The perceived requirement for an enormous dark matter halo surrounding especially spiral galaxies first became widely established among astrophysicists during the 1980s. For nearly a decade, overwhelming observational evidence had been rigorously collected indicating that the rotational characteristics of spiral galaxies did not comply with Keplerian rotation curves, that is, that the rotational velocities of discrete objects within galactic disks did not diminish as a function of their radial distance from their common rotational axis. The observed rotational characteristics could be fit back into the Keplerian mold if the observed galactic discs were merely the inner portion of a much larger, more massive disk. Most of its area and up to 90% of its mass must be composed of some unidentified form of 'dark matter' that only interacts with other matter gravitationally, and essentially does not interact with light at all.

The principal evidence supporting the inferred dark matter in galaxies is the discrepancy between observed orbital velocities and the characteristic Keplerian rotational curves derived from the laws of planetary motion, developed solely from empirical observations of planets in our Solar system. As stated in the seminal report concluding more than ten years of observations and analyses, Rubin, *et al*, (1980), "Rotational properties of 21 SC galaxies with a large range of luminosities and radii, from NGC 4605 /R = 4kpc/ to UGC 2885 /R = 122 kpc/", Section VIII. "DISCUSSION AND CONCLUSIONS" (page 485):

> *1. Most galaxies exhibit rising rotational velocities at the last measured velocity; only for the very largest galaxies are the rotation curves flat. Thus the smallest Sc's (i.e., lowest luminosity) exhibit the same lack of a Keplerian velocity decrease at large R as do the high-luminosity spirals. This form for the rotation curves implies that the mass is not centrally condensed, but that significant mass is located at large R. The integral mass is increasing at least as fast as R. The mass is not converging to a limiting mass at the edge of the optical image. The conclusion is inescapable that non-luminous matter exists beyond the optical galaxy.*

Because Kepler's laws of planetary motion have been traditionally considered a well-proven standard component of classical mechanics, it was thought by many that this Galaxy Rotation Problem represented a fundamental falsification of Newton's law of universal gravitation. However, while astronomers very precisely reported their kinematic observations of galactic rotation, it was *never* formally established that there was any basis for the expectation that galaxy rotation should comply with Keplerian rotation curves and the laws of planetary motion. Newton had actually proved the opposite case (see Notes section).

Kepler's equations strictly apply only to an orbital system consisting of two bodies – they do not consider any perturbations or other effects that might be imparted by any other planets or masses within the orbital system. This simplistic approach conveniently provides generally useful approximations for planetary motions within the Solar system, primarily because 99.86% of total system mass is contained within the Sun, so that perturbances from other planets and masses are generally relatively insignificant.

However, in spiral galaxies the majority of system mass is distributed throughout the disk in a complex configuration of mostly stars and obscuring clouds of dust and gas. In galaxies, up to hundreds of billions of stellar and other masses continuously interact with and perturb the motions of each other. Unlike the relatively independent orbits of planets in the Solar System, the motions of discrete galactic disk object cannot be reasonably evaluated in isolation. For this fundamental reason, the simplistic laws of planetary motion cannot be properly applied to any discrete galactic object to usefully approximate its motions.

The apparent presence of galactic dark matter, generally in proportions inferred by the galaxy rotation problem, also provided resolution to difficulties with cosmological models. Likewise, discrepancies between statistically inferred weak gravitational lensing in thousands of background galaxies and the estimated mass of galaxy clusters seemed to provide compelling evidence of dark matter's existence. However, if the existence of galactic dark matter had not been so widely accepted years ago, one can only wonder if cosmological and gravitational lensing support for dark matter would still seem so convincing.

**Conclusion**

**As Newton proved long ago, Keplerian relations do not generally apply to vast distributions of massive objects**. Regardless of any other evidence for the existence of dark matter, it is now quite clear that the invalid discrepancy between predictions of the empirically derived laws of planetary motion and the rotational characteristics of spiral galaxies cannot infer the existence of any galactic dark matter.

Falsification of the foundational conclusions of earlier researchers regarding galactic dark matter does not entirely preclude its existence elsewhere, but since all other analyses inferring the existence of dark matter are derived from conflicts between very complex derivations of gravitational effects and those expected from the estimated mass of very large scale aggregations of massive objects, all inferences of dark matter should be critically reviewed for potential misinterpretations. Either overestimating gravitational effects or underestimating the mass of compound objects results in the erroneous identification of dark matter.

**Notes** Wikipedia – Kepler's Laws of Planetary Motion (History):

> *Some eight decades later, Isaac Newton proved that relationships like Kepler's would apply exactly under certain ideal conditions that are to a good approximation fulfilled in the solar system, as consequences of Newton's own laws of motion and law of universal gravitation.[1][2] Because of the nonzero planetary masses and resulting perturbations, Kepler's laws apply only approximately and not exactly to the motions in the solar system.[1]*

1. See also G E Smith, "Newton's Philosophiae Naturalis Principia Mathematica", especially the section *Historical context ...* in *The Stanford Encyclopedia of Philosophy* (Winter 2008 Edition), Edward N. Zalta (ed.).

2. Newton's showing, in the 'Principia', that the two-body problem with centripetal forces results in motion in one of the conic sections, is concluded at Book 1, Proposition 13, Corollary 1. His consideration of the effects of perturbations in a multi-body situation starts at Book 1, Proposition 65, including a limit argument that the error in the (Keplerian) approximation of ellipses and equal areas would tend to zero if the relevant planetary masses would tend to zero and with them the planetary mutual perturbations (Proposition 65, Case 1). He discusses the extent of the perturbations in the real solar system in Book 3, Proposition 13.

These limitations and restrictions invalidate Kepler's relations for any gravitational system except those dominated by a single, discrete massive object like the Solar System. As Newton proved more than 300 years ago, Keplerian relations cannot properly apply to very large scale aggregations of massive objects whose distribution significantly diverges from the Solar system's highly centralized mass configuration.

## Supplemental Information

While Jan Oort and Fritz Zwicky each postulated the existence of some missing mass to account for their anomalous observations of stellar and galactic cluster velocities, respectively, in the early 1930s, those reports were effectively disregarded for 40 years. Only after the Galaxy Rotation Problem was identified by Vera Rubin and many collaborators in the 1980s did the requirement for some dark matter become generally established within the astrophysical community.

**Describing Spiral Galaxy rotation without dark matter or modified gravity**

Early in this century, in a series of research reports, a retired aeronautical engineer developed proper Newtonian methods of evaluating the gravitational effects of spiral galaxies - please see: Kenneth F. Nicholson, (2003), "Galactic mass distribution without dark matter or modified Newtonian mechanics," arXiv:astro-ph/0309762v2.

A few researchers further developed those gravitational evaluation methods, summarized in: Dilip G. Banhatti, (2008), "Newtonian mechanics & gravity fully model disk galaxy rotation curves without dark matter," arXiv:0806.1131v4.

Others have independently developed relativistic gravitational evaluation methods: Carrick and Cooperstock, (2010), "General relativistic dynamics applied to the rotation curves of galaxies," arXiv:1101.3224v1.

Another team of researchers independently developed similar methods of evaluating thin disk structures in spiral galaxies: Jalocha *et al*, (2008), "Is dark matter present in NGC4736? An iterative spectral method for finding mass distribution in spiral galaxies," doi:10.1086/533511, arXiv:astro-ph/0611113v3.

In more recent years more 'efficient and robust' computational methods of rotation curve analysis of thin disk galaxies using Newtonian dynamics and the universal law of gravitation have been developed. See: Feng & Gallo, (2011), "Modeling the Newtonian dynamics for rotation curve analysis of thin-disk galaxies," doi:10.1088/1674-4527/11/12/005, arXiv:1104.3236v4.

**Dimensional constraints for any possible galactic Dark Matter halo**

While the presence of dark matter within the galactic disc cannot be precluded, it would not meet the intended requirements to produce the observed relatively flat rotation curves of galactic disks. It is currently estimated that the amount of mass provided by dark matter configured within the Milky Way's peripheral dark matter halo (extending to distances between 100,000 and 300,000 light years from the galactic center) is about 10 times the mass provided by ordinary galactic matter. Please see Battaglia *et al*, (2005), "The radial velocity dispersion profile of the Galactic halo: constraining the density profile of the dark halo of the Milky Way," doi:10.1111/j.1365-2966.2005.09367.x, arXiv:astro-ph/0506102v2.

Some researchers have recently employed microlensing within the Milky Way to reportedly preclude the presence of any significant amounts of dark matter within specific areas of the galactic disc region. See: Sikora *et al*, (2011), "Gravitational microlensing as a test of a finite-width disk model of the Galaxy," arXiv:1103.5056v2.

**Supplemental Information**

(continued)

Analyses of the vertical gradients in rotational velocity of the Galaxy using a simplified framework of global thin disk model approximation indicates that, excluding the galactic bulge and halo, the general mass distribution of the Galaxy forms a thin disk rather than spheroidal object. This result conflicts with disperse dark matter halo model representing the majority of galactic mass. See: Jalocha *et al*, (2010), "Transverse gradients of azimuthal velocity in a global disk model of the Milky Way," doi:10.1111/j.1365-2966.2010.16987.x, arXiv:1003.5936v3.

**Rotational characteristics of Milky Way galactic halo objects**

The above research by Battaglia et al identifies more than 200 objects comprised of ordinary matter that orbit the Milky Way within its distant visible matter halo. These observed halo objects include satellite galaxies, globular clusters and old stars – discrete objects that were crucially found to **comply with characteristic Keplerian diminishing rotation curves.** This suggests that these objects in effect each independently orbit the distant, enormous collective mass of the galactic bulge and disk, similarly to the sparsely distributed, discrete planets orbiting the Sun, which contains 99.86% of total Solar system mass.

Please see: Bratek *et al*, (2011), "Keplerian Ensemble Approximation. The issue of motions of Galactic halo compact objects," arXiv:1108.1629v2.

Recently researchers analyzing the disks of satellite galaxies orbiting the Milky Way and have determined that their overall structural characteristics indicate that they were stripped from other galaxies as groups during close interactions. They conclude that this argues against the presence of a large halo of dark matter surrounding the galaxy: Pawlowski *et al*, (2012), "The VPOS: a vast polar structure of satellite galaxies, globular clusters and streams around the Milky Way," doi:10.1111/j.1365-2966.2012.20937.x, arXiv:1204.5176v1.

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