

*The Direct Contradiction Between Two Popular Hypotheses --  
Cosmic Acceleration / Quintessence and Dark Matter,  
and Its Implications*

*Roger Ellman*

Abstract

Recent distance determinations to Type Ia supernovae [ SNe Ia ] by new means exceed the Hubble distance by 10 - 15%.<sup>1,2</sup> The explanation that has been offered is an "anti-gravity effect" accelerating the universe' expansion. The effect is attributed to some unknown substance pervading cosmological space, a modern variant on the Ancients' fifth essence, "quintessence".

In other research<sup>3</sup>, the study of galaxies and the larger cosmic structures of groups of galaxies as rotating systems, with their concomitant balance of gravitational attraction [ $G \cdot M \cdot m / R^2$ ] and centripetal force [ $m \cdot V^2 / R$ ], has disclosed a component of the gravitational attraction that cannot be accounted for. It is inferred that a halo of "dark matter" pervades the galaxies and supplies the unaccounted for gravitation.

Therefore, we are confronted with the contradiction:

[1] the SNe Ia data with its hypothesis that the cosmos is operated on by an "anti-gravity effect", and

[2] the rotation curves data which indicates that an additional gravitational effect is operating, not an anti-gravitational one.

The two hypotheses are mutually exclusive. At least one is completely incorrect [the hypothesis, not the data] and quite possibly both hypotheses are wrong.

That being the case, it is essential that alternative explanations for the SNe Ia data and the rotation curves data be sought. The status of such alternatives is reviewed and a new alternative, based on NASA reported observations of long-term satellite behavior, is suggested.

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*The Problem - The Contradictory Hypotheses*

[1] *New Data From Type Ia Supernovae*

The, for years generally accepted, Hubble astronomical model of the universe is of a uniformly expanding cosmos in which all galaxies are moving apart so that their speed away from us is proportional to their distance from us, the constant of proportionality being called the Hubble Constant,  $H$ . Until recently the distance to far distant such bodies has been determined by measuring the redshift, deemed a Doppler effect. From that one obtains the speed of recession,  $v$ , and then the distance  $v/H$ .

Recently it has become possible to determine the distance to far distant galaxies by an alternative independent means based on observations of Type Ia supernovae [SNe Ia] in those galaxies.<sup>1,2</sup> It has been found that the intrinsic brightness [luminosity] of such supernovae is related to the pattern [light curve] of their flare up and back down, a process taking weeks overall. By comparing the intrinsic brightness, as determined from that pattern, to the observed brightness the distance can be determined from the inverse square law.

Those new distance determinations indicate distances exceeding the Hubble model distance by 10% - 15%. The interpretation of that result as proposed by the researchers who developed the data and others is that some "anti-gravity effect" is accelerating the universe's expansion, which expansion had hitherto been thought to be slowing down because of gravitation.

Because such an effect requires a cause, the effect is attributed to some unknown substance pervading cosmological space, a modern variant on the Ancients' fifth essence, or "quintessence". That "anti-gravity effect", by default, would have to be a property of the empty space, the vacuum, of the universe since it is certainly not a property of the matter.

The line of thought has led to the reinstatement of Einstein's "cosmological constant" a term in his equations that he introduced to account for the universe not promptly collapsing due to gravitation and which he later disavowed upon Hubble's discovery of the expansion of the universe.

Those implications are so unsettling to theory and to reasonableness that the data had been initially deemed in error. As a result there have been extensive analyses of sources of error and measurements have been taken on a large enough number of Type Ia supernovae to be statistically significant all with the conclusion that the new distance measurements are valid and that theory must be adjusted accordingly.

The new SNe Ia distance determinations do not state that the expansion of the universe is accelerating, nor that there is some kind of "antigravity" effect, nor that there is some new substance, quintessence. The data only forces the conclusion that there is a problem in the purely Hubble conception of the cosmos or at least in the Hubble-based method of determining the distance to distant objects.

## [2] New Data From Galactic Rotation Curves

In other research<sup>3</sup>, the study of galaxies and the larger cosmic structures of groups of galaxies as rotating systems, with their concomitant balance of gravitational attraction [ $G \cdot M \cdot m / R^2$ ] and centripetal force [ $m \cdot v^2 / R$ ], has disclosed a component of gravitational attraction that cannot be accounted for. When the rotating system's central mass is far greater than the orbiting masses [e.g. our solar system], the dynamics, which are referred to as Keplerian for that case, are such that the orbiting bodies' orbital velocities are inversely proportional to the square root of the radial distance from the central mass [ $v = (G \cdot M / R)^{1/2}$ ]. A curve or plot of orbital velocities vs. their path radii is termed a Rotation Curve.

For galaxies that we view as the thin disk not the spiral or globular spread in space, we see one end moving toward us relative to the center and the other end moving away. The rotational velocities are measured by observing the variations in redshift along the galactic diameter represented by the disk. Galactic rotation curves so obtained are not of the expected Keplerian form, an inverse square root; rather, [beyond the radius of the dense galactic central core] the curves are essentially flat.

In a solid sphere, where the density is uniform throughout, all parts move at rotational velocities directly proportional to radius. Since the observed flat galactic rotation curves fall between the Keplerian inverse square root of radius and the uniform density's direct proportion to radius, it is inferred that matter that we have not observed must be dispersed throughout the galaxy, a halo of "dark matter" that causes the rotation to take the form that the rotation curve exhibits -- thus the "dark matter" hypothesis.

The rotation curves and the data on which they are based do not state that the galaxies have the hypothesized "dark matter" halo. The curves and the data only indicate that the rotating bodies are experiencing greater gravitational attraction toward the center of rotation than can be accounted for by the observable galactic structure. The halo of "dark matter" is hypothesized as the cause of that additional gravitation.

Therefore, we are confronted with the contradiction:

[1] the SNe Ia data with its hypothesis that the cosmos is operated on by an "anti-gravity effect", and

[2] the rotation curves data which indicates that an additional gravitational effect is operating, not an anti-gravitational one.

The two hypotheses are mutually exclusive. At least one is completely incorrect [the hypothesis, not the data] and quite possibly both hypotheses are wrong.

That being the case, it is essential that alternative explanations for the SNe Ia data and the rotation curves data be sought and alternative, more viable, hypotheses for them be developed and tested.

## Current Results Related to Alternative Hypotheses

The only research involving data from new measurements that might be deemed an intended investigation of alternative hypotheses is that of measurements intended to explore the constancy or long term variation in the value of the fine structure constant,  $\alpha$ .<sup>4</sup> The researchers report stability of  $\alpha$  to 1 part in  $10^5$  back to  $4.8 \cdot 10^9$  years ago. Inasmuch as  $\alpha$  is dimensionless its constancy should be little more a surprise than the constancy of  $\pi$  or of  $e$ , the natural logarithmic base. And, inasmuch as  $\alpha$  is defined as

a function of the fundamental constants:  $c$ ,  $g$ ,  $h$  or  $h/2\pi$  and  $\mu_0$  or  $\epsilon_0$  investigation of the stability of those would be more to the point.

An alternative hypothesis for the rotation curves anomalous gravitation and implied mass discrepancy has been proposed and theoretically analyzed.<sup>5, 6</sup> Referred to as MOND, Modification of Newtonian Dynamics, the hypothesis suggests that the gravitational anomaly stems not from additional ["dark"] matter but from a variation in the Newtonian dynamics of gravitation at small accelerations. That is, the theorists, having noted that the gravitational anomaly is only noticeable in the regions of the rotation curves where the acceleration is well below  $10^{-8} \text{ cm/sec}^2$  propose that gravity and or inertia may behave in a modified manner when  $g$  or  $a < 10^{-8} \text{ cm/sec}^2$ .

However, an alternative reason for the anomaly so being not noticeable could be the presence of a constant gravitational type acceleration present at a value somewhat above  $10^{-8} \text{ cm/sec}^2$ . That is, the effect of such a constant acceleration would not be noticeable when the ambient, or "natural" acceleration is much larger; rather it would only start to be noticeable when that otherwise acceleration had become sufficiently smaller. Is there evidence of such an unusual constant acceleration ?

Yes, there is. Exactly such an acceleration has been extensively observed and reported in the behavior of the Pioneer 10 and 11 satellites [and to a lesser extent the Galileo, and Ulysses] over a number of years.<sup>7, 8</sup> An acceleration towards the Sun has acted on those satellites consistently over the period. The effect is believed to be general; however, it is so small [as is the rotation curves' anomalous acceleration used to justify "dark matter"] that it has only been measurable in the case of those satellites because of their not having had course corrections over an extended number of years. The acceleration is independent of distance from the Sun, appears to be constant and continuous, and is observed to have a value of about  $8.5 \cdot 10^{-8} \text{ cm/s}^2$ .

We have, then, an apparently present but unexplained gravitational type acceleration operating in the rotation curves, and at the same time an observed and measured equivalent acceleration operating in the path behavior of the Pioneer 10 and 11 satellites as they travel far out from the Sun.

Numerous suggested explanations of this acceleration have been investigated and rejected for various valid reasons to the effect that they don't fit the actual observed behavior. But, even without having to hand an explanation of how the Pioneer anomalous acceleration comes about we do have to hand in it an actual behavior that corresponds to and explains the rotation curves problem. We have to hand an explanation that does not require inventing unseen matter. We have to hand an explanation that does not require changing Newton's law of gravitation and / or his laws of motion. Surely such a situation merits investigation and analysis.

Of course, one cannot be content with the situation until a satisfactory explanation of the Pioneers' anomalous acceleration has been developed. Has there been any progress in that regard ? Yes, there has, an analysis that correlates precisely with the Pioneer observations.<sup>9</sup> Not only that, the same analytical explanation also resolves the Type Ia Supernovae distance discrepancies and does so without requiring the invention of some kind of "anti-gravity" effect and of a new kind of substance, or "quintessence", to explain it.<sup>10</sup>

Surely, it is not merely of interest, but rather, it is urgent that this hypothesis, which can be validated or disproved by two experiments as proposed in the cited papers, <sup>9, 10</sup> be investigated.

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[N.B. The first three references themselves further reference many of the large and significant number of papers on their topics.]

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