IS THERE A SPIRAL GALAXY ROTATION CURVE CONUNDRUM?

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Abstract:
Here we show that a simple model using Newtonian Gravitation is sufficient to explain observations on spiral galaxies. The model allows for the prediction of the extra hydrogen gas mass that travels together with galaxies, thus rendering Dark Matter Halos unnecessary. The ability to predict the amount of "Dunkle Materie" traveling together with a galaxy based on its rotation curve should be useful in explaining results from the "Dark Matter Survey".

keywords: Cosmology, Astrophysics, Relativity, Spacetime, Hypergeometrical Universe Theory, Dark Matter, Dark Energy, L-CDM, Big Bang, Big Pop

1. INTRODUCTION

This brief note is part of a series addressing the Spiral Galaxy Rotation Curve Conundrum. It is claimed that the observation of "flat tops" on rotation curves is not consistent with Newton's Law of Gravitation.

This conclusion is specious and the result of a poor understanding of Physics. Scientists subconsciously use Newton's Shell theorem which states that the gravitational field outside a spherical shell having total mass M is the same as if the entire mass M is concentrated at its center (center of mass).

This means that to conclude that the gravitational acceleration decreases with distance, they are rejecting the obvious: that a spiral galaxy resembles a disk instead of a sphere.

Below we see both the observed data for the M33 galaxy and the "expected" Newtonian Gravitation predictions.

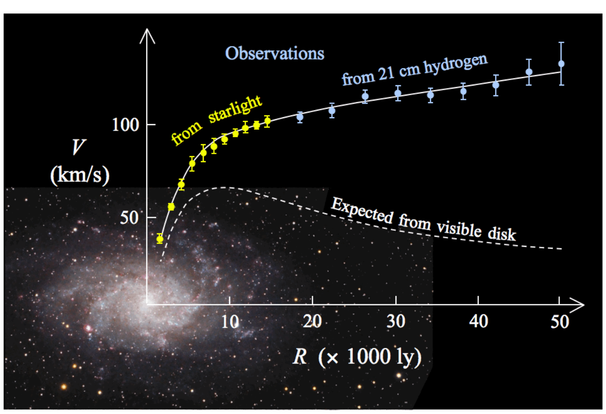

Figure 1. M33 is a galaxy with a radius of 50,000 light-years and a luminous mass of 5E10 Solar Masses. The picture shows both the observation and what we would expect if all the mass were located in the core. Galaxy rotation curve. (2022, August 21). In *Wikipedia*. https://en.wikipedia.org/wiki/Galaxy_rotation_curve

2. METHODS

The Gaussian Formulation of Newtonian Gravitation[1,2]

This formulation is due to Carl Friedrich Gauss.

Our work models spiral galaxies as cylinders with two exponentially decaying mass densities. The two densities represent the central bulge and the extended gas cloud associated with the galaxy. Notice that both densities extend equally over the galaxy. The difference between them is contained in the different densities and different exponential coefficients.

The gravitational acceleration g at any given distance (on the surface of the cylinder) is given by:

$$\oint \vec{g}\,.d\vec{A} = \oint \vec{g}\,.\vec{\eta}\,dA = -\,4\pi G m \quad (1)$$

$$\oint \vec{g}\,.d\vec{A} = -\,2\pi r h g = -\,4\pi G M \quad (2)$$

$$g = \frac{v^2}{r} = \frac{2GM}{rh} \quad (3)$$

$$v = \sqrt{\frac{2GM}{h}} \quad (4)$$

Where the integral is a surface integral on the surface of the cylinder. Notice that vertical accelerations cancel each other at the galaxy plane.
Hence the mass to be used is the mass corresponding to the narrower cylinder

$$M(x) = M_0(x) + M_1(x) = \int_0^x 2\pi y\, h_0 \rho_0\, e^{-\alpha_0 y}\, dy + \int_0^x 2\pi y\, h_0 \rho_1\, e^{-\alpha_1 y}\, dy =$$

$$\frac{2\pi h_0 \rho_0}{\alpha_0^2}\left(1 - e^{-\alpha_0 x} - a_0 x e^{-\alpha_0 x}\right) + \frac{2\pi h_0 \rho_1}{\alpha_1^2}\left(1 - e^{-\alpha_1 x} - \alpha_1 x e^{-\alpha_1 x}\right) \quad (5)$$

$$M_{0Total} = \frac{2\pi h_0 \rho_0}{\alpha_0^2} \quad (6)$$

$$M_{1Total} = \frac{2\pi h_0 \rho_1}{\alpha_1^2} \quad (7)$$

$$v = \sqrt{4\pi G\left[\frac{\rho_0}{\alpha_0^2}\left(1 - e^{-\alpha_0 x} - a_0 x e^{-\alpha_0 x}\right) + \frac{\rho_1}{\alpha_1^2}\left(1 - e^{-\alpha_1 x} - \alpha_1 x e^{-\alpha_1 x}\right)\right]} \quad (8)$$

LIMITING VALUES

$$M(\infty) = 2\pi h_0 \left(\frac{\rho_0}{\alpha_0^2} + \frac{\rho_1}{\alpha_1^2} \right) \tag{9}$$

The limiting value of the acceleration is given by:

$$g\left(2\pi x h_0\right) = 8\pi^2 G h_0 \left(\frac{\rho_0}{\alpha_0^2} + \frac{\rho_1}{\alpha_1^2} \right) \tag{10}$$

$$g = \frac{4\pi G}{x} \left(\frac{\rho_0}{\alpha_0^2} + \frac{\rho_1}{\alpha_1^2} \right) = \frac{v^2}{x} \tag{11}$$

$$v_{flat} = \sqrt{4\pi G \left(\frac{\rho_0}{\alpha_0^2} + \frac{\rho_1}{\alpha_1^2} \right)} \tag{12}$$

3. RESULTS

A minimization protocol was implemented to extract the fitting parameters. The Jupyter Notebook used to create all plots and perform minimization was made available.

Below are the fitting results where one can see that even the oscillations could be easily explained by density fluctuations

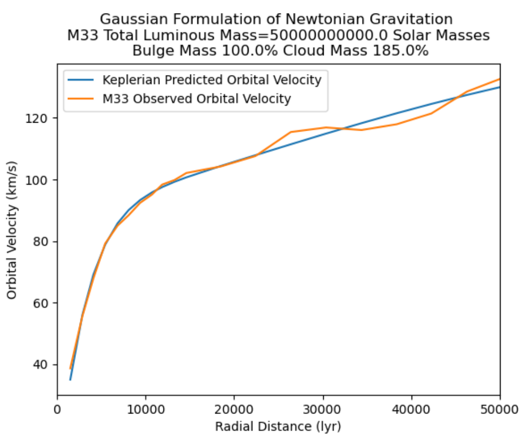

Figure 2. M33 observed the rotation curve in orange and the model fitting results in blue. One can see that there is no flat top on this spiral galaxy. The reason is that the hydrogen cloud density is slowly decaying with distance. Notice that the profile is idiosyncratic. There is no natural law that would impose a given decay rate. At least, we didn't model it in this article.

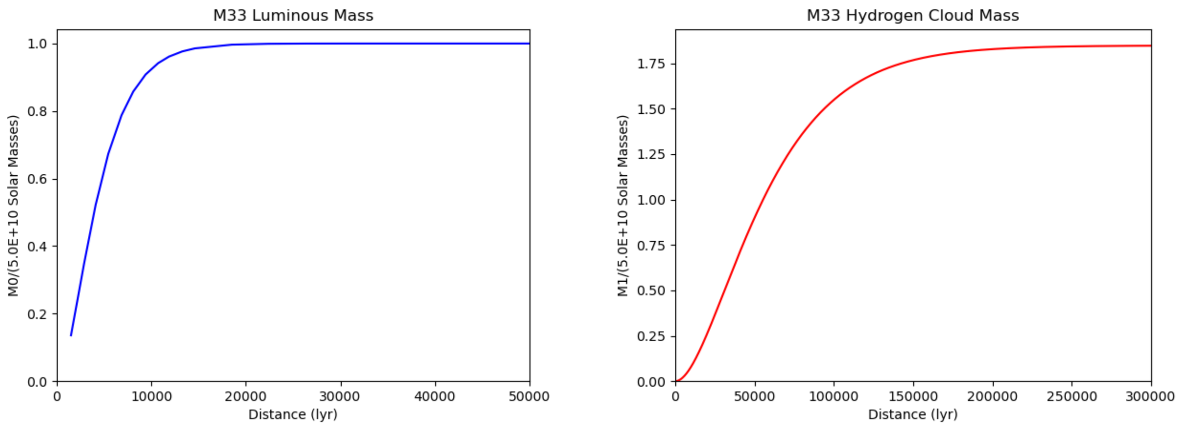

Figure 3. These figures show the mass functions for both luminous mass and hydrogen gas cloud. The fitting process forced the luminous mass to be 5E10 Solar Mass. M33 is not a "Flat Top" rotation curve galaxy. The slope in the curve is due to the longer decaying hydrogen cloud mass distribution. So, from estimating that decaying rate, one can estimate the hidden gas cloud mass. This extra mass is the "Dunklen Materie" that Dr. Fritz Zwicky referred to in his study of the Coma Cluster.

Notice that the amount of hydrogen that is gravitationally attached to the galaxy is 184% of the Luminous Mass. That is an invisible mass and because of that, it has been perplexing scientists for 90 years.

M33 Fitting Parameters	
α_0	4.25314512E-04/lyr
ρ_0	1.28007958E+01 atoms/cm^3
α_1	3.27397280E-05/lyr
ρ_1	1.40132411E-01atoms/cm^3
h_0	1.57787001E+05 lyr

Table 1 contains the fitting parameters for M33.

4. CONCLUSIONS

This work is based on the Gaussian Model for Gravitation (created by Carl Friedrich Gauss). Spiral Galaxies are modeled as cylinders. A cylinder has three surfaces and thus three accelerations according to Gauss. At the plane of the galaxy, the vertical accelerations cancel each other and can be disregarded. My work considers just the acceleration on the cylinder side surface. It is simple and the full derivation was presented.

I showed that once one considers that the mass distribution in a spiral galaxy is disk-like (as opposed to being a spherical distribution), the observed rotation curve is readily recovered.

This means that the mass distribution in any galaxy is idiosyncratic but that is also the assumption used in L-CDM. There, one assumes that there is an idiosyncratic Dark Matter Halo.

So, my theory is showing that standard gravitation plus an observed and observable idiosyncratic distribution (both Luminous mass and gas cloud density decays with radial distance) replicated the rotation curve observation. **It shows that when most of the mass is accounted for, the remaining gas presents a flat-top rotation curve.**

Compare that with the non-observed L-CDM distribution with a tremendously large and undefined size halo of Dark Matter.

This article clearly and simply challenges what scientists have been telling you: "Newton's Law of Gravitation requires the rotation curve to be smaller at longer distances which is clearly not the case.

That is only the case if all mass is located in a core or if the distribution is spherical in nature.

The results in this article challenge the idea that Dark Matter is required to explain the Universe. The Hypergeometrical Universe Theory (HU)**[3-5]** already showed that the Supernova Cosmology Project SN1a measurements are not only better explained with an epoch-dependent G, but they are actually predicted by HU.

This simple model allows for the understanding of how is it possible for gas clouds to be "gravitationally connected in a Non-Newtonian Fashion". Of course, considering it Non-Newtonian is an error.

The model also allows for the prediction of how large the attached gas cloud is. This is relevant because currently, an extensive "Dark Matter Survey" is mapping extensive intergalactic masses. The current article provides guidance to understand how these gas masses are attached to clusters and galaxies.

Notice that the height of the cylinder h_0 doesn't affect the velocity fitting. It affects the masses allocated. The fitted height is to be understood as the thickness of the initial rotating gas cloud that resulted in the M33 galaxy.

As gases coalesced into stars and the gas cloud cooled, the thickness decreased.

This points to a distinct model for star and planet formation.

5. DEDICATION

I would like to dedicate this article to my parents, a long overdue thank you for their love and guidance.

6. REFERENCES

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