Can the Standard Model Predict a Minimum Acceleration that Gets Rid of Dark Matter?

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Abstract

The standard model is considered to be very bad at predicting galaxy rotation, and this is why the hypothesis of dark matter was introduced in physics in the 20th century. However, in this paper we show that the standard model may not be as far off as previously believed. By taking into account that gravity has an infinite extent in space and assessing the assumed mass in the observable universe, we get a minimum acceleration that gives a much closer match to observed galaxy rotations than would be expected. We will discuss whether or not this is enough to overturn the long-standing perspective on the standard model and if it could indeed provide a possible and adequate explanation of galaxy rotations.

Key Words: Galaxy rotation, dark energy, observable universe, minimum acceleration.

1 Introduction

The standard gravity model of Newton [1] and Einstein [2], when based on baryonic matter, gives galaxy predictions very different than those actually observed. This is why the hypothesis of dark matter was introduced. As early as the 1880s, Lord Kelvin was describing dark bodies in relation to the Milky Way; Henri Poincare picked up the theme in 1906, actually using the term dark matter in his comments on Kelvin?s work. By the 1920s and '30s, the term was gaining interest and a number of astronomers and astrophysicists were exploring its potential. The debate continues today: Dark matter could exist, or it could simply be a fudge factor that enables an incomplete model to fit observations. Modified Newton Dynamics introduced by Milgrom [3] in 1983 suggests a minimum gravity that is calibrated to the observational data, and the model then fits very well, although from baryonic matter only. However, MOND is more of a curve fitting model since it does not provide a good explanation for why there should be such a minimum acceleration. Here we will also introduce a minimum acceleration, though not by modifying the standard gravity model, but rather by building on its assumption on the mass of the observable universe and the radius of the observable universe.

The radius of the observable universe, as suggested by standard physics, is approximately 4.4×10^{26} meters. The age of the universe is considered to be about 13.77 billion years. In this time period, light can travel $13.77 \times 10^9 \times c \times 365 \times 24 \times 60 \times 60 \approx 1.3 \times 10^{26}$ meter. The reason the radius of the universe is assumed to be considerably larger than this is due to the assumption of expanding space. In this paper, we will take that for granted, although that too is a subject of considerable debate. Further, the mass of the observable universe is assumed to be approximately 1.5×10^{53} kg. Based on the assumed radius of the universe and the mass of the universe, the minimum gravitational acceleration of the universe must then be

$$g_{min} = \frac{GM_u}{r_u^2} \approx \frac{G \times 1.5 \times 10^{53}}{(4.4 \times 10^{26})^2} \approx 5.18 \times 10^{-11}\ m/s^2 \tag{1}$$

This is considerably smaller than the MOND optimized minimum acceleration of approximately $1.2 \times 10^{-10}\ m/s^2$, but the mathematical form of the MOND theory is different than what we are suggesting here, so they are not directly comparable without comparing to observational data. First of all, our minimum acceleration is at the very edge of the observable universe. If the observations are concerning objects, such as galaxies, that are not at the edge of the universe then the minimum acceleration could be higher. We will suggest the acceleration in the galaxy arms should be

$$a = \frac{GM}{r^2} + g_{min} = \frac{GM}{r^2} + \frac{GM_u}{r_u^2} \tag{2}$$

where M is the baryonic matter in the galaxy, and M_u is the mass of the universe, as before. In the next section, we will compare the prediction of this model with observed data.

2 Comparison of Our Model with Observational Data

To test out the model, we have used 2,793 individual data points from 153 galaxies in the Spitzer Photometry and Accurate Rotation Curves (SPARC) database, see also [4]. Figure 1 shows the observations as black dots. The green line is the predicted galaxy rotation from only baryonic matter in the galaxy. As we see, the Green line gives predictions far from the observed data, and is why, as noted before, the idea of dark matter had been introduced originally in order to make this model work. The MOND best fit model is represented by the yellow line. The red line is our model when using radius $4.4 \times 10^{26}\ m$. As we can see, this gives a strong improvement over the standard model, e.g., the green line. At least this would dramatically reduce the amount of dark matter required to push the model to fit observations. However, even under the standard model there is uncertainty in what the radius of the universe is, so we could, of course, suggest a slightly different radius, which would give an even better fit. In the case of the orange line, we have inputted a radius of 1.3 times the commonly assumed radius of $4.4 \times 10^{26}\ m$. The blue line shows the results when using only $1.3 \times 10^{26} m$ as radius; that is the radius one gets by taking the assumed life of the universe times the speed of light; in other words, by ignoring the assumed expansion. This last value of r we see gives predictions very off from observations.

As we can clearly see, taking the mass of the observable universe into account, in addition to that of the galaxy, gives much better predictions than can be produced without doing so. However, we do have several issues with the method just described. For example, if a Galaxy is lying at the edge of the observable universe, then the observable universe gravitational acceleration field should increase the acceleration in galaxy arms that are turned away from the center of the observable universe, but should slow the acceleration in the galaxy arms on the opposite side. This should lead to different redshifts on different sides of the galaxy. We do not believe this has been observed yet, but it could even be more complicated than this. Naturally, different galaxies will have different radii to the center of the observable universe, so if we are taking this into account, we would likely get a much better fit than what we have shown here. Or, counterintuitively, the fit could be worse; this can only be determined by further studies.

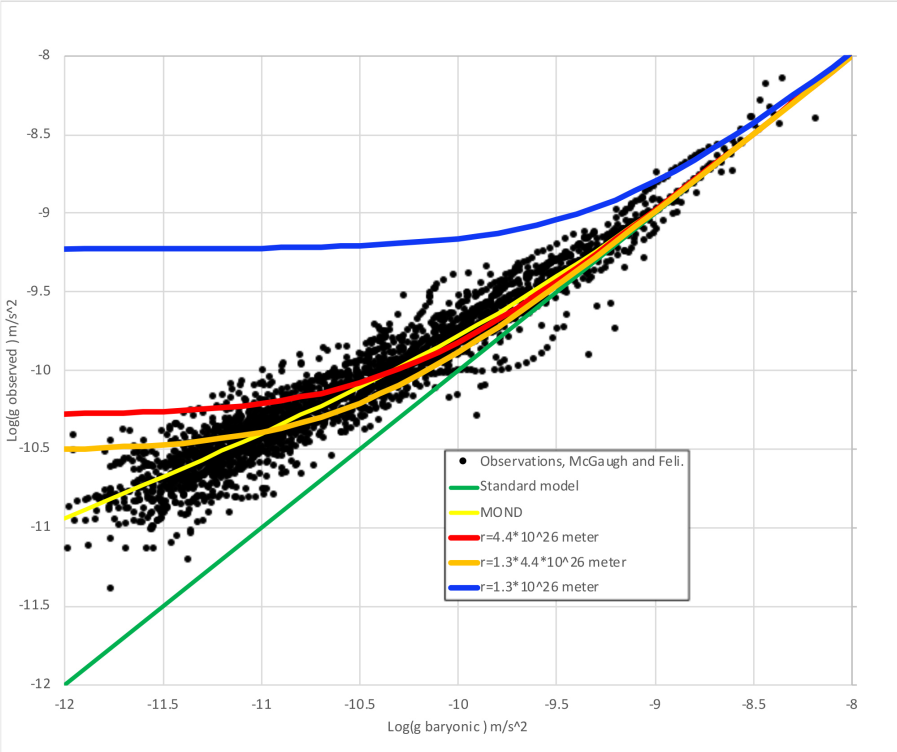

Figure 1: Galactic accelerations from 2,793 individual data points for 153 SPARC galaxies are shown in black dots. Predictions by standard physics are shown in green. The yellow line is MOND, which fits the observations very well. The red line includes the minimum acceleration from the mass in the observable universe with the standard assumed radius of approximately 4.4×10^{26} meters and the orange line shows the results when we have multiplied this radius by 1.3. The blue line depicts the predictions when we use a radius equal to the assumed time since the Big Bang multiplied by the speed of light. (Note: Log stands for Logarithm with base 10.)

3 Conclusion

We have looked at galaxy rotation predictions when taking the gravity acceleration field from the observable universe into account. This seems to give predictions quite close to observations. However, there may be several issues with this method and the approach requires additional rigorous study. Still, we think the idea is interesting and merits further investigation by the physics community.

References

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