On the variation of the energy scale 34

A Note on Galaxy Rotation Curves from Weak Lensing Data

by

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Summary

Galaxy rotation curves have been published recently derived from weak gravitational lensing data; these curves remain flat for many hundreds of kiloparsecs, well beyond the distances for optical & radio data. We demonstrate that this result is fully consistent with our conjecture of a weighting function that determines the dynamical mass from the baryonic mass, and that dark matter is not needed for galaxy rotation curves.

1 Introduction

1.1 The rotation curve of a disk galaxy is the plot of the orbital speed of the stars & gas as a function of distance from the galaxy centre. Figure 1 shows the rotation curve for spiral galaxy NGC 2403 (Lelli et al, 2016). This is typical of rotation curves for disk galaxies: it rises steadily from the centre before levelling off in the outer regions where it remains essentially constant. Galaxy rotation curves rarely extend out to more than a few tens of kiloparsecs (kpc).

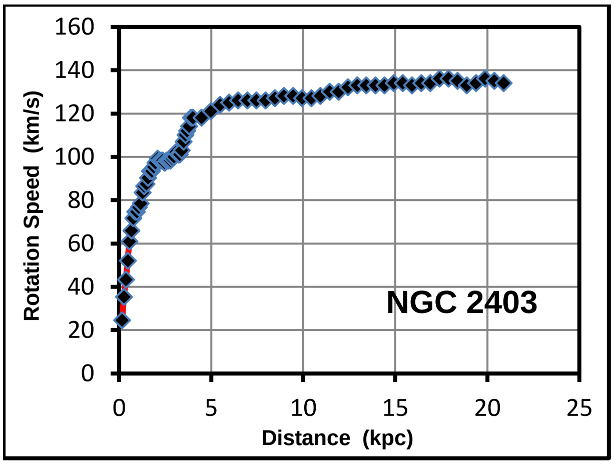

Figure 1. The rotation curve for spiral galaxy NGC 2403 (Lelli et al, 2016). The diamonds are the observed data values. The curve shows a rise from the galaxy centre before levelling off to a near-constant value in the outer regions.

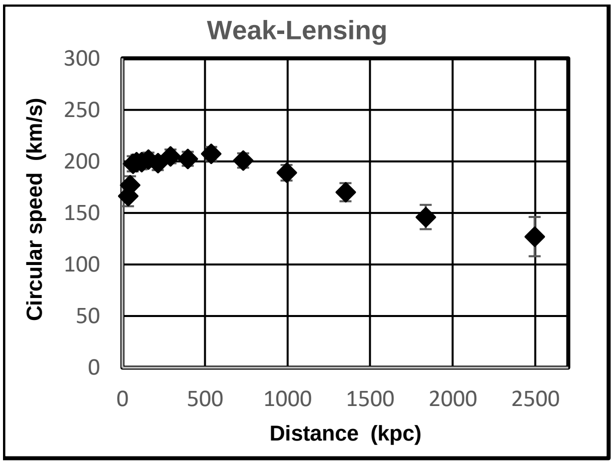

Figure 2. The rotation curve for an aggregation of disk galaxies derived from weak lensing data (Mistele et al, 2024). The curve is essentially flat out to over 500 kpc before showing a decline. Note the huge increase in distance compared to Figure 1.

1.2 Mistele et al (2024) have used weak lensing data to derive the gravitational field around a large number of isolated disk galaxies. The gravitational field then determines the circular orbital speeds, which constitute the rotation curve shown in Figure 2 above. After the initial rise the curve remains flat to well over 500 kpc, after which it begins a gradual decline. This curve extends out to almost ten times the distance of NGC 2403 in Figure 1.

1.3 In previous ViXra papers (JoKe 2023b; JoKe 2023a; JoKe 2020; JoKe 2019) we put forward the conjecture that there is no dark matter and that the rotation curves of disk galaxies can be explained by the existence of a simple weighting function that links the dynamical mass to the baryonic mass. It is the dynamical mass, rather than the baryonic mass, which is to be used in Newton's law of gravity (which is the appropriate law of gravity for disk galaxies). ViXra papers (JoKe 2024, JoKe 2023b) show how this weighting function can explain not just disk galaxies but all those scenarios where dark matter is invoked.

1.4 In this paper we show that our conjecture holds good and is fully capable of explaining the new observations of Mistele et al (2024). In fact, it confirms our prediction that the flat rotation curves of disk galaxies would eventually start to decline and follow Newton's $1/\sqrt{r}$ law as expected for a central mass.

2 Analysis

2.1 Our conjecture is that there exists a weighting function that determines the dynamical mass from the baryonic mass. This is fully explained in JoKe (2023b) where equation (14) that defines the rotational velocity, $v(r)$, at distance r is

$$v(r)^2 \;=\; \frac{G}{r\;\xi(r)}\int_0^r \xi(x)\, dM_{\text{bar}}(x) \tag{1}$$

where $\xi(r)$ is the value of our weighting function at r ; $\xi(x)$ is the value of our ξ-function at X; $dM_{\text{bar}}(x)$ is the baryonic mass of the incremental shell at X. So each incremental shell is weighted by the local value of ξ, and the whole integral is then divided by the value of ξ at r .

2.2 If we know the rotational velocity and the baryonic mass distribution, then we can solve equation (1) for the $\xi(r)$ function. Lelli et al (2016) provide the velocity and mass data for many galaxies, including NGC 2403, and Figure 3 below shows the resulting plot for our $\xi(r)$ weighting function. The vertical axis is the logarithm of our weighting function $\xi(r)$; the horizontal axis is the logarithm of the distance in kpc. There is a clear linear relationship and this is seen for all the galaxies in Lelli et al (2016) that have sufficiently good data.

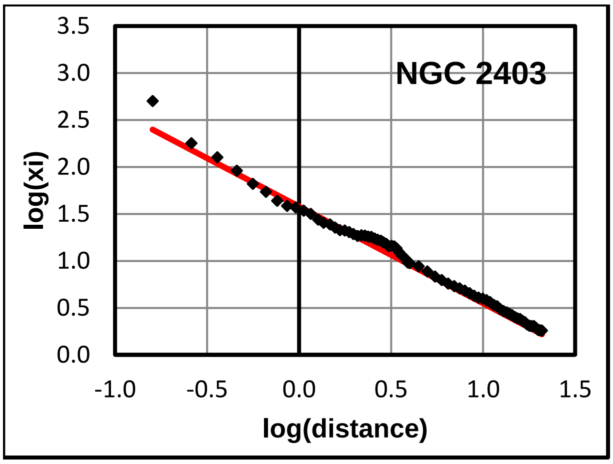

Figure 3. Graph of our $\xi(r)$ weighting function against distance for spiral galaxy NGC 2403, based on data from Lelli et al (2016). There is a clear linear relationship. The red line is a straight line that approximates the data values.

2.3 If the rotation curve extends to a large distance from the galaxy centre, then the baryonic mass will have converged to a fixed value and equation (1) can be replaced by a central point mass rather than an extended mass distribution

$$v(r)^2 \;=\; \frac{G\, M_{\mathrm{bar}}\, \xi_{bar}}{r\;\xi(r)} \;=\; \frac{K}{r\,\xi(r)} \qquad (2)$$

where M_{bar} is the total baryonic mass; ξ_{bar} is the effective value of our weighting function for the total baryonic mass; K is a constant. So, equation (2) should hold beyond around 50 kpc by which distance the baryonic mass of the galaxy should have converged.

2.4 So, without knowing the exact baryonic mass distribution, we can use equation (2) on the weak lensing data shown in Figure 2 and solve for our $\xi(r)$ weighting function. The result is shown in Figure 4 below and, once again, we have a clear linear relationship. The line turns over at very large distances and becomes essentially constant. This exact behaviour was predicted in JoKe (2023b) and illustrated in Figure 6 of that paper.

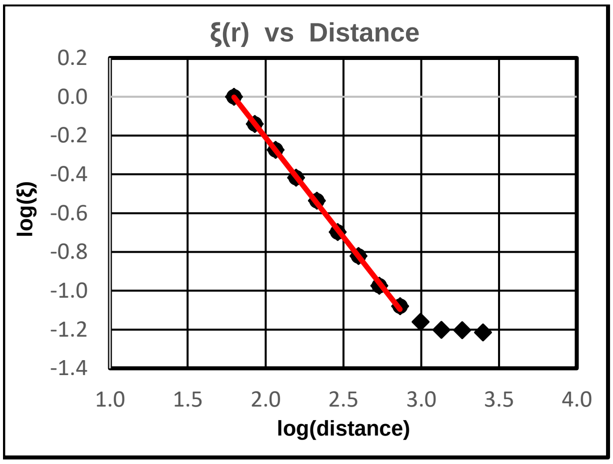

Figure 4. Plot of our $\xi(r)$ weighting function against distance for the weak lensing data of Mistele et al (2024). There is a clear linear relationship that turns over to a constant value at very large distances.

2.5 The observed linear relationship shown in Figure 4 means that our $\xi(r)$ weighting function is given by

$$\log(\xi) \;=\; \alpha\,\log(r) \;+\; \mathrm{constant} \qquad (3)$$

where α is the slope of the linear relationship. This slope is very close to -1.0 for Figure 4, but is known to vary from -0.5 to -1.5 for disk galaxies.

2.6 If we assume that equation (3) holds, then we can choose a suitable value for the slope α and use equation (2) to predict the shape of the rotation curve. When we do this, we get Figure 5 below, which is the same as Figure 2 but with our predicted curve superimposed. We find that a value of α=-1.03 for the slope of our weighting function $\xi(r)$ gives a good fit to the data. This is then fed into equation (2) to calculate the circular speed, which is the red curve shown in Figure 5 below . The curve is normalised at the third data point which fixes the value of the constant K. The green curve shows the expected 1/√r Newtonian fall-off for a central mass, adjusted to fit the outermost data points.

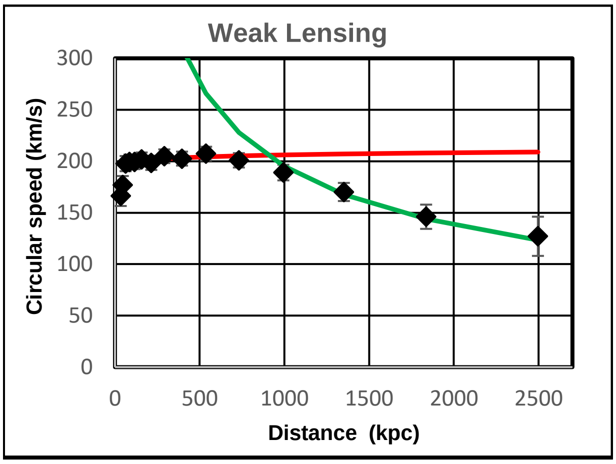

Figure 5. The rotation curve for the weak lensing data (Mistele et al, 2024); the data are the same as in Figure 2. The red curve is our predicted rotation curve using equation (2) with a slope of α=-1.03 for our weighting function. The green curve is the 1/√r Newtonian decline that fits the outermost points.

2.7 Figure 5 demonstrates that our conjecture of a weighting function is fully consistent with the observations. The red curve passes through the data points out to distance of around 750 kpc. At this point the value of our weighting function drops to the fixed value of intergalactic space, and beyond this point the data points follow the expected Newtonian decline.

2.8 Mistele et al split their observations into four groupings, separated out by galactic mass. So, they actually end up with four diagrams similar to Figure 5, one for each mass grouping. These are shown in the four panels that make up Figure 6 below. Our conjecture still holds for these four panels, but it not quite so convincing as the aggregated data of Figure 5.

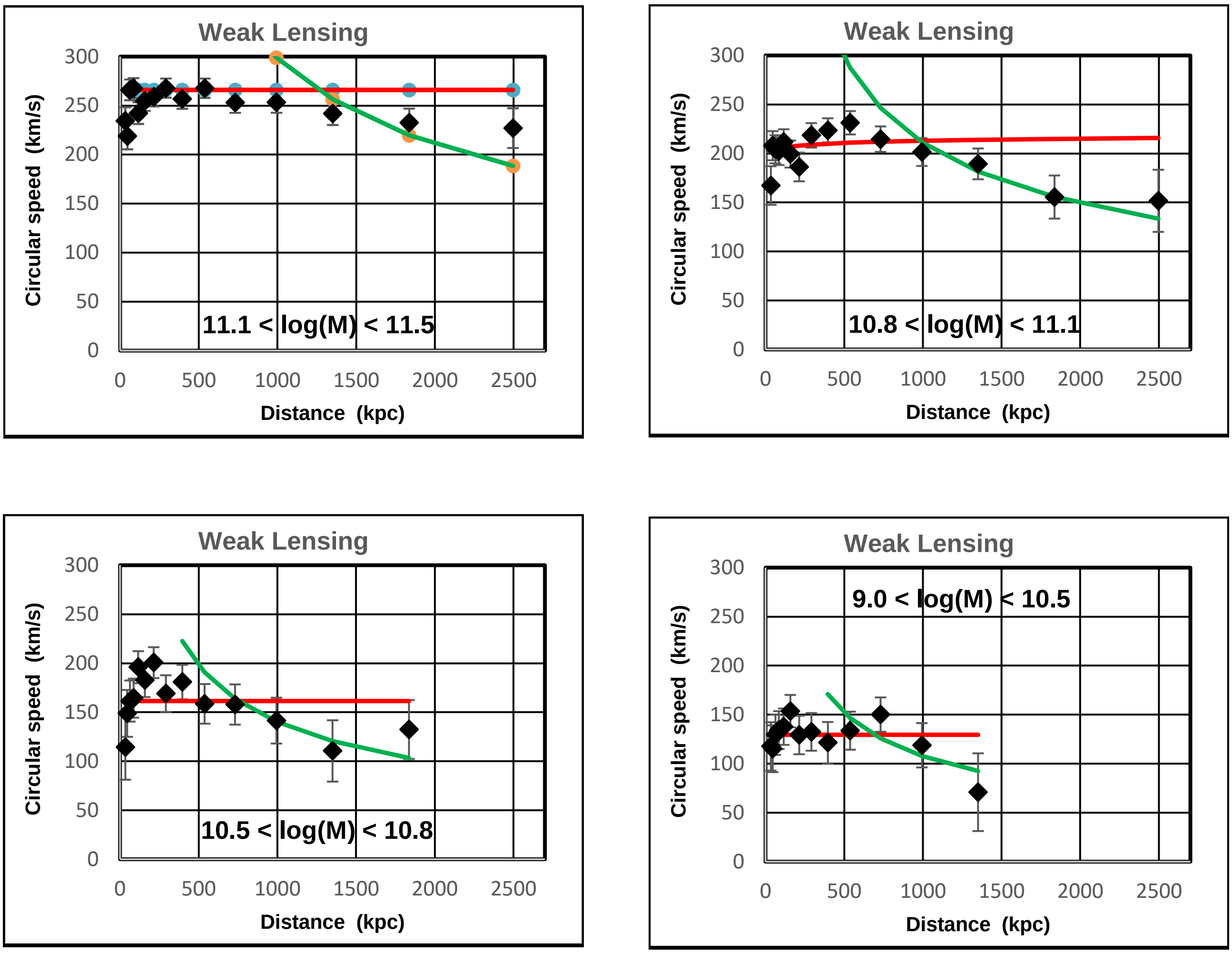

Figure 6. Circular speed plots for the four individual mass ranges that when combined give Figure 5. The heaviest galaxies are in the top left panel; the lightest galaxies in the bottom right panel. In each panel the red line is the curve for our conjecture based on equation (2); the green curve is the 1/√r Newtonian decline that matches the outmost points.

2.9 The error bars shown in Figures 5 & 6 are the statistical errors. There are also systematic errors which are somewhat larger and mean that, despite the downward trend in the circular speeds towards large distances, the data are still consistent with flat rotation curves out to at least 400 kpc or well over one million light years.

3 Discussion

3.1 There are two main ways of explaining the mass discrepancies that occur in many astronomical scenarios:

a) dark matter, where the mass discrepancy is resolved by assuming the existence of large amounts of a non-baryonic form of matter (Sanders, 2010).

b) a modification of the law of gravity (Newton, Einstein), such as MOND (Sanders, 2010).

We offer a third option that is completely different in nature to the other two:

c) the existence of a weighting function that means the dynamical mass, as used in the law of gravity, is different from the baryonic mass (JoKe, 2023b).

Our third option is capable of explaining all the astronomical scenarios where dark matter is invoked (JoKe 2024, Joke 2023b).

3.2 Figure 5 shows how our conjecture of a weighting function is consistent with the rotation curve (circular speed) derived from weak gravitational lensing. The red curve is the curve predicted by our conjecture; the green curve is the Newtonian decline that fits the outermost points. The plot implies our weighting function merges into the value for intergalactic space around 750 kpc from the galaxy centre. That is a long way out considering few galaxies extend beyond 50 kpc. So, this new data from weak lensing does not cause any problems for our conjecture, but it is causing trouble for the ΛCDM theory and its requirement for dark matter.

3.3 No artificial intelligence (AI) has been used in this work.

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