1 INTRODUCTION

Recent advances in the modelling of the Milky Way indicate that, contrary to the predictions of cold dark matter (CDM) cosmology (Diemand, Moore & Stadel 2004, and references therein), the inner Galaxy is completely dominated by baryons. We ask whether current Galaxy models are more compatible with modified Newtonian dynamics (MOND).

The evidence for accelerating cosmic expansion can be interpreted either as signalling the presence of a large amount of dark energy (quintessence), or as an indication that Einstein’s minimal theory of gravity must be modified by adding a cosmological constant. Similarly, the evidence for flat galactic rotation curves is conventionally interpreted as evidence for massive haloes of cold dark matter (CDM), but twenty years ago Milgrom (1983) suggested that flat rotation curves might signal the need to modify Newtonian dynamics in regions where the acceleration is smaller than a critical value \(a_0\). This proposal, dubbed MOND, was then refined by the introduction of a non-relativistic field equation for the modified gravitational potential (Bekenstein & Milgrom 1984). There is now a significant body of evidence that, for whatever reason, there is a characteristic acceleration \(a_0 \sim cH_0\) associated with galaxies (Sanders & McGaugh 2002). Furthermore, MOND has a remarkable ability to account for features in the phenomenology of galaxies that were unknown when Milgrom introduced the theory.

Recent developments in the theory of gravity have added plausibility to the case for modification of gravity rather than addition of exotic matter. First, Bekenstein (2004) has presented a Lorentz-covariant theory of gravity that has a MONDian behaviour in the appropriate limit. Secondly, it has become recognized (e.g. Gripaios 2004) that spontaneous symmetry breaking in an effective field theory of gravity might well lead to loss of Lorentz invariance of the type required by Bekenstein. A great deal of work needs to be done to determine whether a theory such as that of Bekenstein is compatible with observations of the cosmic microwave background and large-scale structure (e.g. Skordis et al. 2005). But knowledge that it is possible to embed MOND within a physically acceptable dynamical framework, and that this framework is not unattractive from the point of view of mathematical physics, must make us take more seriously the phenomenological successes of MOND.

On the other hand, there is growing evidence that the dark haloes of galaxies do not conform to CDM simulations: they are cuspy in neither low-surface-brightness (e.g. Bosma 2004) nor high-surface-brightness galaxies, the centers of which are completely baryon-dominated (Gerhard et al. 2001; Gentile et al. 2004; Cappellari et al. 2005). Moreover the shapes of the rotation curves are intimately connected to the underlying stellar-light profile, just as modified gravity predicts. In this paper, we study the particular case of our own Milky Way galaxy, which is the best example of a baryon-dominated high-surface-brightness galaxy.

In Section 2 we review the evidence that the inner Galaxy is dominated by baryons. In Section 3 we investigate the predictions of MOND for the Galactic circular-speed curve and the vertical equilibrium of the solar neighbourhood. Section 4 sums up.

2 THE BASEL MODEL OF THE MILKY WAY

Bissantz & Gerhard (2002, hereafter BG) present a model of the luminosity density interior to the Sun. Like its predecessor (Binney,
Gerhard & Spergel 1997), this model is based on the Cosmic Background Explorer (COBE) L-band photometry, but it incorporates constraints from the slight difference in the mean apparent magnitude of red-clump stars on either side of the Galactic centre, and from tracers of spiral arms in the disc. Its bar is thinner than that in the model of Binney et al. (1997).

Bissantz, Englmaier & Gerhard (2003, hereafter BEG) determine the pattern speeds of the bar and the spiral structure, and upgrade the BG model to a mass model by simulating the flow of gas in potentials obtained by assigning spatially constant mass-to-light ratios to the BG model. Maps of the density of CO and H1 in the longitude-velocity plane (l, v) plane are derived and compared with the corresponding observational plots. BEG find that they can reproduce the observed (l, v) plots by assigning to the bar a pattern speed that agrees with an independent determination from the kinematics of the solar neighbourhood (Dehnen 2000), while assigning a significantly lower pattern speed to the spiral structure. The spiral structure is four-armed and its amplitude in the mass density is larger by a factor of ~1.5 than its amplitude in the near-infrared luminosity density. This standard model explains the entire rotation curve inside a galactocentric radius of ~0.6R⊙ (where R⊙ is the galactocentric radius of the Sun) without any dark matter. However, at the solar radius R⊙, the model yields a circular speed that is ~40 km s⁻¹ too low. To make up the balance, an axisymmetric quasi-isothermal dark halo with a large core radius (r_c = 1.34R⊙) and a small central density is added, and the mass-to-light ratio of the luminous component is lowered by less than 10 per cent compared to the standard model.

The model introduced by BEG is not cuspy like the haloes predicted by CDM cosmology (Diemand et al. 2004, and references therein). A cuspy halo could not have been added: indeed, what drives BEG to assign to baryons essentially all matter within the corotation radius of the bar, and to enhance the amplitude of the spiral structure outside the bar, is the size of the non-circular velocities that are apparent in the observed (l, v) plots: the dark halo is assumed to be axisymmetric, so if much mass is shifted from the baryons to the halo, the non-axisymmetric component of the overall potential is weakened, and the non-circular velocities are predicted to be too small. Given that the structure of the BEG halo is unexpected in the CDM theory, we now ask whether it can be eliminated by assuming that MOND is the correct theory of gravity. A full answer to this question requires extensive numerical work to solve the non-linear field equation (Bekenstein & Milgrom 1984) for the modified potential generated by the Galaxy, including contributions from the bar and spiral structure. However, the non-axisymmetry is important only at R ≲ 1/2R⊙, where the effects of MOND are small, which guarantees that the problem arising in the dark matter framework will not arise in MOND. Therefore, as in standard Newtonian theory, the first step is to study the circular-speed curve that follows from the axisymmetric component of the density distribution.

3 THE MILKY WAY IN MOND

The halo introduced by BEG is not cuspy like the haloes predicted by CDM cosmology (Diemand et al. 2004, and references therein). A cuspy halo could not have been added: indeed, what drives BEG to assign to baryons essentially all matter within the corotation radius of the bar, and to enhance the amplitude of the spiral structure outside the bar, is the size of the non-circular velocities that are apparent in the observed (l, v) plots: the dark halo is assumed to be axisymmetric, so if much mass is shifted from the baryons to the halo, the non-axisymmetric component of the overall potential is weakened, and the non-circular velocities are predicted to be too small. Given that the structure of the BEG halo is unexpected in the CDM theory, we now ask whether it can be eliminated by assuming that MOND is the correct theory of gravity. A full answer to this question requires extensive numerical work to solve the non-linear field equation (Bekenstein & Milgrom 1984) for the modified potential generated by the Galaxy, including contributions from the bar and spiral structure. However, the non-axisymmetry is important only at R ≲ 1/2R⊙, where the effects of MOND are small, which guarantees that the problem arising in the dark matter framework will not arise in MOND. Therefore, as in standard Newtonian theory, the first step is to study the circular-speed curve that follows from the axisymmetric component of the density distribution.

3.1 The rotation curve

In cylindrical or spherical symmetry the gravitational force per unit mass KMOND predicted by MOND in the Galactic plane is related to the corresponding Newtonian force per unit mass KNewton by Milgrom’s formula (Milgrom 1983):

$$\mu (K_{\text{MOND}}/a_0) = K_{\text{MOND}} = K_{\text{Newton}}$$

where the interpolating function µ runs smoothly from µ(x) = x at x ≪ 1 to µ(x) = 1 at x ≫ 1. In a flat axisymmetric disc, Milgrom’s
formula is only exact if MOND is viewed as a modification of inertia (Milgrom 1994) rather than a modification of gravity. However, using the field equation for the modified gravitational potential, Brada & Milgrom (1995) have shown that equation (1) holds everywhere outside Kuzmin discs and disc-plus-bulge generalizations of them, while it provides a very good approximation for exponential discs. As a consequence, this formula has been used to fit the rotation curves of an impressive list of external galaxies (Sanders & McGaugh 2002). It is thus worthwhile to test the ability of this formula to fit the rotation curve of the Milky Way.

Once the values of $a_0$ and of the mass-to-light ratio $\Upsilon$ are known, equation (1) predicts the force field for each choice of interpolating function. From a sample of external galaxies with high quality rotation curves Begeman, Broeils & Sanders (1991) derived $a_0 = 1.2 \pm 0.27 \times 10^{-8}$ cm s$^{-2}$ using the ‘standard’ interpolating function $\mu(x) = x/\sqrt{1 + x^2}$. Retaining the mass-to-light ratio of the Basel model without dark matter, and using the standard interpolating function yields the long-dashed circular-speed curve shown on Fig. 1 (Model I). The circular speed is then 207 km s$^{-1}$ at $R = 1/2R_0$, exactly as in the Basel model with dark halo, and 200 km s$^{-1}$ at $R_0$. Thus making gravity MONDian with the standard interpolating function reduces the deficit in $v_c(R_0)$ from 40 km s$^{-1}$ to 20 km s$^{-1}$, but does not eliminate it.

However, the value of $v_c(R_0)$ is hard to determine and a lower value than 220 km s$^{-1}$ is not excluded (e.g. Olling & Merrifield 1998). The primary observable is the terminal velocity $v(t)$ at each longitude $l$:

$$v_t(l) = \text{sign}(l)v_c(R_0 \sin l) - v_c(R_0 \sin l).$$

From $v_t(l)$ it is easy to determine $v_c(R)$ if one knows $R_0$ and $v_c(R_0)$, but neither parameter is known with precision. Given this uncertainty, it is important to understand the predictions of each model for the run of $v_t(l)$ (see Fig. 2). When $v_c(R_0) = 220$ km s$^{-1}$ is assumed, as it was by the Basel group, the baryonic Basel model yields an excellent fit to the data at $|l| \leq 40^\circ$, but the curve is not self-consistent because it does not pass through zero at $|l| = 90^\circ$.

The short-dashed curve in Fig. 2 shows that when we self-consistently adopt $v_c(R_0) = 180$ km s$^{-1}$ (see Table 1), in the fourth quadrant the terminal velocities near $l = -20^\circ$ become marginally too negative and from there rise too steeply as $l \rightarrow -90^\circ$. However, this self-consistent baryonic Newtonian model is not clearly incompatible with the measured terminal velocities.

Our MONDian Model I (long-dashed curve in Fig. 2) reduces the discrepancy with the terminal velocity data, but still fits the data less well than the Basel model with dark matter (dotted curve in Fig. 2) because $v_c(R_0) = 200$ km s$^{-1}$ is low. If we enforce $v_c(R_1) = 220$ km s$^{-1}$ simply by increasing $\Upsilon$, we make $v_c$ too large at $R \approx 1/2R_0$. A better fit can be obtained by adjusting both $a_0$ and $\Upsilon$.

To increase $v_c(R_0)$ we increase $a_0$ and thus trigger a MONDian correction at smaller radii. This in turn obliges us to decrease $\Upsilon$ in order to keep a velocity of 207 km s$^{-1}$ at $R = 1/2R_0$, exactly as in the Basel model with dark matter. This decrease in $\Upsilon$ requires a further increase in $a_0$ to retain $v_c(R_0) = 220$ km s$^{-1}$, with the result that by the time we have achieved a satisfactory fit to the rotation curve at $R = 1/2R_0$ and $R = R_0$, $a_0$ has increased significantly. The dot-dashed curves in Figs 1 and 2 show the fits obtained when $a_0 = 3.4 \times 10^{-8}$ cm s$^{-2}$ and $\Upsilon_L = 0.91 M_\odot/L_\odot$ (Model II). This model predicts an asymptotic circular speed of 210 km s$^{-1}$ that is higher than those predicted by the conventional value of $a_0$ (see Table 1).

The asymptotic circular speed of the Galaxy is not well determined (Binney & Dehnen 1997; Wilkinson & Evans 1999). By contrast, in external galaxies with extended HI, the behaviour of $v_c$ at large $R$ is strongly constrained by observations. Extended rotation curves have been obtained for many galaxies with the aim of probing dark haloes (e.g. Begeman et al. 1991; Broeils & van Woerden 1994; Gentile et al. 2004). To be specific, we focus here on the case of NGC 3198, which was carefully studied by Begeman et al. (1991); this system is the textbook example of a galaxy with an extended flat rotation curve because it has a large apparent diameter and a velocity field that shows the gas to be confined to a plane and following accurately circular orbits. Fig. 3 shows that when one fits the rotation curve of NGC 3198 with $a_0 = 3.4 \times 10^{-8}$ cm s$^{-2}$, the decrease in $\Upsilon$ that is required to match the measured asymptotic velocity results in $v_c$ being too low at small radii.

Consequently, the data for NGC 3198 rule out the large value of $a_0$ required by Model II. In principle we can make Model II compatible with the standard value $a_0 = 1.2 \times 10^{-8}$ cm s$^{-2}$ by rescaling it: the rotation curves of the models listed in Table 1 are invariant if we change the value of $R_0$ from 8 kpc and then multiply $\Upsilon$ by $R_0/(8 \text{kpc})$ and $a_0$ by $(8 \text{kpc})/R_0$.

However, to obtain $a_0 = 1.2 \times 10^{-8}$ cm s$^{-2}$ by rescaling $R_0$ we would have to set $R_0 \simeq 15$ kpc, which is excluded by a wealth of data on the scale size of the Milky Way.

### Table 1.

For the Basel model with and without dark matter, and our 4 MONDian models, the columns display respectively the form of the interpolating function $\mu$, the value of $a_0$ in units of $10^{-8}$ cm s$^{-2}$, the value of the L-band mass-to-light ratio $\Upsilon_L$ in $M_\odot/L_\odot$ ($\Upsilon_L = \xi^2$, where $\xi$ is the scaling constant for the rotation curve in BEG), the circular speed at the solar radius $R_0$ and at infinity in km s$^{-1}$, and finally the value $\mu(x_0)$ where $x_0 = v_c(R_0)/(R_0 a_0)$. The values are displayed for models with $R_0 = 8$ kpc.

<table>
<thead>
<tr>
<th>$\mu(x)$</th>
<th>$a_0$</th>
<th>$\Upsilon_L$</th>
<th>$v_c(R_0)$</th>
<th>$v_\infty$</th>
<th>$\mu(x_0)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>1</td>
<td>0</td>
<td>1.08</td>
<td>220</td>
<td>235</td>
</tr>
<tr>
<td>no-DM</td>
<td>1</td>
<td>0</td>
<td>1.21</td>
<td>180</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>$x/\sqrt{1 + x^2}$</td>
<td>1.2</td>
<td>1.21</td>
<td>200</td>
<td>175</td>
</tr>
<tr>
<td>II</td>
<td>$x/\sqrt{1 + x^2}$</td>
<td>3.4</td>
<td>0.91</td>
<td>220</td>
<td>210</td>
</tr>
<tr>
<td>III</td>
<td>$x/(1 + x)$</td>
<td>1.2</td>
<td>0.95</td>
<td>208</td>
<td>165</td>
</tr>
<tr>
<td>IV</td>
<td>fit</td>
<td>1.2</td>
<td>1.08</td>
<td>220</td>
<td>170</td>
</tr>
</tbody>
</table>

**Figure 2.** Terminal velocity curves in the fourth quadrant for the same models as in Fig. 1, compared with the data of Kerr et al. (1986). The terminal line-of-sight velocities are defined by $v_t(l) = \text{sign}(l)v_c(R_0 \sin l) - v_c(R_0 \sin l)$. 

---


---

**MOND in the Milky Way** 605

---

Downloaded from https://academic.oup.com/mnras/article-abstract/363/2/603/1129944 by guest on 19 January 2019
We therefore consider an alternative ‘simple’ interpolating function, namely
\[ \mu(x) = \sqrt{x/1 + x}. \]  
This function provides a less sudden transition from the Newtonian to the MONDian regime than does the standard function. The continuous curve in Fig. 3 shows that the simple interpolating function together with the conventional value \( a_0 = 1.2 \times 10^{-8} \text{ cm s}^{-2} \) yield a very good fit to the rotation curve of NGC 3198.

The full curves in Figs 1 and 2 show the corresponding fits to the Basel model (Model III). We now have \( v_c(R_0) = 208 \text{ km s}^{-1} \). Although this value lies very close to the conventional value, we find it is impossible to push \( v_c(R_0) \) up to 220 km s\(^{-1}\) by increasing \( a_0 \), because we then have to decrease the mass-to-light ratio radically in order to fit the inner rotation curve \( v_c(0.5 R_0) = 207 \text{ km s}^{-1} \), making \( v_c(R_0) \) too low again. The transition from Newtonian to MONDian physics provided by the simple interpolating function is insufficiently abrupt. Slightly changing the value of \( R_0 \) does not eliminate the problem. However, Fig. 2 shows that the fit of Model III to the terminal-velocity curve is extremely satisfactory. This simple interpolating function thus fits the data for both NGC 3198 and the Milky Way. However, it does not exactly reproduce the run of \( v_c(R) \) of the Basel model; to achieve this, one needs a more complex form of the interpolating function.

### 3.2 The interpolating function

In low-surface-brightness (LSB) galaxies, \( x < 1 \) at all radii, with the consequence that the measured acceleration \( v_c^2/R \) is approximately equal to \([a_0/\mu GL(R)/R^2]^{1/2}\). It follows that these galaxies constrain only the product \( a_0 \mu \) and leave the interpolating function unconstrained. In high-surface-brightness (HSB) galaxies such as NGC 3198, \( x \) ranges from values greater than unity down to small values. Hence with these objects we can break the degeneracy between \( a_0 \) and \( \mu \), but, as Fig. 3 illustrates, the large gradients in rotation curves at small radii, combined with the poor spatial resolution of observations in the 21-cm line, leave considerable degeneracy between \( a_0 \) and \( \mu \), and constrain the interpolating function only weakly. The Basel model is strongly constrained at small radii, and it is pertinent to probe the extent to which it constrains the interpolating function in equation (1).

Imagine an ideal galaxy in which both the asymptotically flat rotation curve and the luminosity distribution are known with precision. Then with \( x = v_c^2/(R a_0) \) we can write
\[
\mu(x) = \frac{\sqrt{2} f(a_0 x)}{a_0 x},
\]
where \( f(v_c^2/R) \) is obtained from the Newtonian equation for the force per unit mass with the mass–density \( \rho(x) \) replaced by the luminosity–density \( j(x) \). From data at large \( x \) (corresponding to the central parts of the galaxy), where \( \mu(x) \simeq 1 \) and \( f(y) \propto y \), we can read off \( \mu \). At large radii (small \( x \)) we have \( \mu(x) \simeq x \) and \( f(y) \propto y^2 \), so we can determine \( a_0 \). Once \( \mu \) and \( a_0 \) are known, we can completely determine \( \mu(x) \) from equation (4).

As an example, we treat the circular-speed curve of the Basel model plus dark halo as a perfect set of data. From the centre we find \( \Upsilon_L = 1.08 M_\odot/L_\odot \), while the asymptotic velocity \( v_\infty = 235 \text{ km s}^{-1} \) implies \( a_0 = 4.47 \times 10^{-8} \text{ cm s}^{-2} \). This large value of \( a_0 \) suggests that the model’s asymptotic velocity is too high. If one could show that the Milky Way’s asymptotic circular speed really is this high, MOND would have been falsified.

However, if we combine \( \Upsilon_L = 1.08 M_\odot/L_\odot \) with the conventional value \( a_0 = 1.2 \times 10^{-8} \text{ cm s}^{-2} \), we infer an asymptotic velocity \( 170 \text{ km s}^{-1} \), and can read off the form of the interpolating function that perfectly fits the Basel model at \( R \leq R_0 \) (Model IV). The dotted curve in Fig. 4 shows this function, which transitions smoothly from \( x/(1 + x) \) at \( x \leq 1 \) to \( x/\sqrt{1 + x^2} \) at \( x \geq 10 \).

Any successful underlying theory for MOND must predict an interpolating function that lies between the curves labelled I and III in Fig. 4. Bekenstein (1973) introduced the TeVeS theory of gravitation, in which the physical metric depends on the Einstein metric, a vector field, and a scalar field. The dynamics of the scalar field is controlled by a Lagrangian density involving an undetermined function \( F \) that yields a MONDian behaviour for the potential in the non-relativistic limit. Adopting a computationally tractable form for \( F \), Bekenstein shows for the case of spherical symmetry that equation (1) holds with \( \mu \) replaced by a function that depends on both the Newtonian acceleration and the gradient of the scalar field. For accelerations that are not large compared to \( a_0 \), the MONDian and Newtonian accelerations are then related by equation (1) with the interpolating function
\[
\mu(x) = \frac{\sqrt{1 + 4x} - 1}{\sqrt{1 + 4x} + 1},
\]
which is shown as the dashed curve in Fig. 4. Because this curve lies far below the dotted curve at all values of \( x \), the correction to Newtonian gravity to which this function gives rise is much too big to be compatible with the dynamics of the Milky Way (see Table 1). Of course, since the Galaxy is not spherical, the approximations used above do not apply to it, and we have no guarantee that the concept of an interpolating function can be used for the Galaxy in TeVeS.
4 DISCUSSION

By combining near-infrared photometry and simulations of gas flow in the plane, and without invoking dark matter in the inner 5 kpc, the Basel group has developed an extremely successful model of the Milky Way that accounts for the structure of $(l, v)$ plots for CO and H I, for the proper motions of bulge stars, for the microclensing optical depth towards bulge fields, and for the observed distribution of the durations of microlensing events. Given the number of these checks, there can be little doubt that we now really do know the distribution of baryons inside the solar radius. For no other galaxy do we have information of comparable quality.

It is far from clear that the Basel model is compatible with the predictions of CDM. In the light of early indications that baryons dominate the inner Galaxy, an attempt was made to build models that minimize the dark halo consistent with constraints from simulations of clustering CDM (Klypin, Zhao & Somerville 2002). In all these models, however, CDM contributes significantly to the density at $\sim 3$ kpc from the Galactic centre where the Basel model requires the density to be almost entirely invested in stars. To investigate this matter further, we need a CDM-inspired model that includes a stellar bar and reproduces the photometry of the Galaxy. It would be of great interest to calculate the predictions of such a model for microlensing surveys and the $(l, v)$ diagrams of CO and H I. If these predictions disagree with observations, the CDM paradigm would be strongly weakened. Gentile et al. (2004) have shown that the paradigm encounters similar difficulties reproducing the rotation curves of a sample of five external galaxies.

In MOND, there are two free parameters ($\Upsilon$ and $a_0$, the latter a constant of nature) and one free function ($\mu$, to be fixed by an underlying theory of MOND). Once those quantities are known, the gravitational force field is completely determined by the baryon distribution. We have investigated what circular-speed curves MOND predicts from the distribution of baryons in the Basel model. A full answer to this question requires extensive numerical work, but a good approximation to the truth can be obtained from Milgrom’s formula (1). For the value of $a_0$ that has been determined from observations of external galaxies, we encounter difficulty making $v_s(R_0)$ as large as the value, $220$ km s$^{-1}$, assumed by the Basel model. When the standard interpolating function $\mu(x)$ is used, satisfaction of this condition requires $a_0 = 3.4 \times 10^{-8}$ cm s$^{-2}$ (Model II), a value which is incompatible with observations of NGC 3198. Keeping the conventional value $a_0 = 1.2 \times 10^{-8}$ cm s$^{-2}$ (Model I) yields $v_s(R_0) = 200$ km s$^{-1}$ implying slightly too low values for the terminal velocities. Interestingly, Gentile et al. (2004) have also found that MOND cannot account for the rotation curves of their sample of spiral galaxies, at least with that value of $a_0$ and that choice of interpolating function. However, in the Milky Way, a very good fit to the terminal velocity curve (Model III) can be obtained if the interpolating function (3) is used. It would be of great interest to test the ability of this interpolating function to fit the rotation curves of external galaxies in the sample of Gentile et al. (2004). We then showed how a perfect set of data could determine $\Upsilon$, $a_0$ and the interpolating function $\mu(x)$, and displayed the results (Model IV) that would follow if data were precisely those predicted by the Basel model at $R \leq R_0$. 

In the absence of dark matter, we conclude that the Galaxy’s asymptotic velocity must be smaller than the value, 235 km s$^{-1}$, implied by the dark halo of the Basel model (see Table 1); MOND predicts it to be $\sim 170 \pm 5$ km s$^{-1}$. The fitted, numerically specified interpolating function of Model IV produces a local circular speed of 220 km s$^{-1}$, but lower values are obtained for the standard and simple interpolating functions of Models I and III, which suggests that 220 km s$^{-1}$ is an upper limit for $v_c(R_0)$. We have also shown that it is unlikely that the interpolating function explored by Bekenstein (2004) as a toy model can account for the dynamics of the Milky Way. We finally showed that the three models with $a_0 = 1.2 \times 10^{-8}$ cm s$^{-2}$ (Models I, III and IV) are compatible with what is known about the vertical force at $R_0 = 8$ kpc.

It can thus be argued that, with a suitable choice of MOND’s interpolating function, and a realistic choice of mass-to-light ratio, the Milky Way can be added to the long list of galaxies for which Milgrom’s formula (1) is successful in predicting the rotation curve from the baryon distribution. The next step towards exploring the agreement between the data and the predictions MONDian gravity makes from the Basel model involves using a potential solver (e.g. Brada & Milgrom 1999) for the non-linear Bekenstein–Milgrom equation to determine the MOND force generated by the non-axisymmetric components of the Basel model with the parameters and interpolating functions of our Models I, III and IV. Another test for the relevance of MOND as an alternative to dark matter in the Milky Way will be provided by the measurement of the velocity dispersions in distant globular clusters orbiting the Galaxy in the outer halo, well into the deep-MOND regime (Baumgardt, Grebel & Kroupa 2005).

ACKNOWLEDGMENTS

We thank P. Englmaier and O. Gerhard for kindly providing us the circular-speed curves on which this paper is based. We also thank the Fondation Wiener-Anspach (Belgium) for its financial support.

REFERENCES


This paper has been typeset from a \TeX/\LaTeX\ file prepared by the author.