Cosmic duologue
Federico Lelli & Azadeh Fattahi-Savadjani
Dark Matter vs. Modified Newtonian Dynamics

See also: 2010 Dark Matter debate between Pavel Kroupa and Simon White (Bethe Kolloqium @ Bonn University):
http://astroweb.case.edu/ssm/mond/20101125_BE_DarkMatter.mp4
Cosmic duologue:
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Zwicky 1933:
The redshift of extragalactic nebulae
(1242 ADS citations as of 24/04/2020)
Cosmic duologue:
Dark Matter vs. Modified Newtonian Dynamics

Rubin, V. et al. (1980): (960 ADS citations)
Cosmic duologue:
Dark Matter vs. Modified Newtonian Dynamics

Milgrom (1983):
(1974 ADS citations)

A MODIFICATION OF THE NEWTONIAN DYNAMICS: IMPLICATIONS FOR GALAXIES

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Received 1982 February 4; accepted 1982 December 28

ABSTRACT

I use a modified form of the Newtonian dynamics (inertia and/or gravity) to describe the motion of bodies in the gravitational fields of galaxies, assuming that galaxies contain no hidden mass, with the following main results.

1. The Keplerian, circular velocity around a finite galaxy becomes independent of r at large radii, thus resulting in asymptotically flat velocity curves.

2. The asymptotic circular velocity ($V_c$) is determined only by the total mass of the galaxy (M): $V_c^2 = a_G M$, where $a_G$ is an acceleration constant appearing in the modified dynamics. This relation is consistent with the observed Tully-Fisher relation if one uses a luminosity parameter which is proportional to the observable mass.

3. The discrepancy between the dynamically determined Oort density in the solar neighborhood and the density of observed matter disappears.

4. The rotation curve of a galaxy can remain flat down to very small radii, as observed, only if the galaxy's average surface density $\Sigma$ falls in some narrow range of values which agrees with the Fish and Freeman laws. For smaller values of $\Sigma$, the velocity rises more slowly to the asymptotic value.

5. The value of the acceleration constant, $a_G$, determined in a few independent ways is approximately $2 \times 10^{-10} (H_0/50 \, \text{km s}^{-1} \, \text{Mpc}^{-1})^2 \, \text{cm s}^{-2}$, which is of the order of $C_H = 5 \times 10^{-8} H_0/50 \, \text{km s}^{-1} \, \text{Mpc}^{-1}$ cm s$^{-2}$.

The main predictions are:

1. Rotation curves calculated on the basis of the observed mass distribution and the modified dynamics should agree with the observed velocity curves.

2. The $V_c^2 = a_G M$ relation should hold exactly.

3. An analog of the Oort discrepancy should exist in all galaxies and become more severe with increasing r in a predictable way.

Subject headings: galaxies: internal motions — galaxies: stellar content — galaxies: structure — stars: stellar dynamics
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ABSTRACT

I use a modified form of the Newtonian dynamics (inertia and/or gravity) to describe the motion of bodies in the gravitational fields of galaxies, assuming that galaxies contain no hidden mass, with the following main results.

1. The Keplerian, circular velocity around a finite galaxy becomes independent of r at large radii, thus resulting in asymptotically flat velocity curves.

2. The asymptotic circular velocity \( V_\infty \) is determined only by the total mass of the galaxy \( M \):
   \[ V_\infty^2 = a_0 \xi M, \]
   where \( a_0 \) is an acceleration constant appearing in the modified dynamics. This relation is consistent with the observed Tully-Fisher relation if one uses a luminosity parameter which is proportional to the observable mass.

3. The discrepancy between the dynamically determined Oort density in the solar neighborhood and the density of observed matter disappears.

4. The rotation curve of a galaxy can remain flat down to very small radii, as observed, only if the galaxy’s average surface density \( \Sigma \) falls in some narrow range of values which agrees with the Fish and Freeman laws. For smaller values of \( \Sigma \), the velocity rises more slowly to the asymptotic value.

5. The value of the acceleration constant, \( a_0 \), determined in a few independent ways is approximately \( 2 \times 10^{-8} (H_0/50 \text{ km s}^{-1} \text{ Mpc}^{-1})^2 \text{ cm s}^{-2} \), which is of the order of \( CH_0 = 5 \times 10^{-8} H_0/50 \text{ km s}^{-1} \text{ Mpc}^{-1} \text{ cm s}^{-2} \).

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