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DARK MATTER IN LATE-TYPE GALAXIES

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RESUMEN

Las observaciones de las curvas de rotación en Hα de galaxias de bajo brillo superficial muestran que la pendiente de la densidad de materia oscura en el centro de esas galaxias no concuerda con las predicciones de las simulaciones numéricas cosmológicas. La comparación de nuestros datos con los de otros autores muestra buena concordancia.

ABSTRACT

High resolution Hα rotation curves of Low Surface Brightness galaxies show that the central slopes of the dark matter density in those galaxies do not agree with predictions from cosmological numerical simulations. A comparison of our data with those of other authors shows good agreement.

Key Words: **GALAXIES: DARK MATTER — GALAXIES: ROTATION CURVES**

1. INTRODUCTION

Dwarf and low surface brightness (LSB) galaxies are thought to be dark matter dominated, and thus provide a crucial test for the current cosmological numerical simulations, which are predicting the density profiles of dark-matter halos. Inner power-law slopes for dark halos produced in cosmological simulations of CDM and ΛCDM models come out to be -1.5 (Moore et al. 1999, Fukushige & Makino 2001; denoted “CDM” hereafter) or -1.0 (Navarro et al. 1996; denoted “NFW”). The latter argue that their NFW profile is universal, and thus can be scaled down to the dwarf galaxy scale (even though these scales are not yet fully modelled directly). For warm dark matter models, similar slopes are found (e.g. Knebe et al. 2002).

If one neglects the minor contribution for the stellar and gaseous components in these galaxies, an upper limit can be found for the slope of the density profile of the dark halo directly from inverting the observed rotation curves into a density distribution. It is crucial to get rotation data at the highest spatial resolution possible; some claims in the literature have been made based on HI rotation curves corrected for beam smearing, which are not necessarily correct. Since a clear measurement is better than several arguments, we have collected a large data set using long slit Hα-spectra, and find that we can exclude the cuspy halos predicted by the current cosmological numerical simulations (De Blok et al. 2001a, De Blok et al. 2001b, McGaugh et al. 2001, De Blok & Bosma 2002). In the last paper, we concentrated on nearby dwarf galaxies, so as to have the highest linear resolution possible. Our results (cf. De Blok, this volume) clearly show that the high resolution data favour models with a core, and exclude the steeper slopes required by the NFW and CDM models.

2. REPLY TO CRITICISMS BY PRIMACK

Primack (2001, 2002) severely criticises our work as published in De Blok et al. (2001b). Like e.g. Van den Bosch & Swaters 2001, he orients the discussion towards asking whether the data are still consistent with NFW profiles, rather than towards trying to find which power-law slope fits the data best. I follow here Primack’s arguments, select from our data the galaxies which are well resolved according to his criteria, and see whether his conclusions are justified.

a) Resolution. Though in De Blok et al. (2001b) and De Blok & Bosma (2002) we do discuss the effects of resolution. Let me consider only galaxies with **two** independent points inside 1 kpc, since here is where the discrimination with the NFW model prediction becomes significant.

b) Edge-on galaxies. Contrary to Primack’s assertions, there is nothing mysterious about their kinematics. In Bosma et al. (1992) we show that small edge-on galaxies like NGC 100 are transparent, a conclusion confirmed e.g. by Matthews & Wood (2001). Moreover, our spectra do not show the low radial velocity wings expected for a non solid body rotation in the central parts, which by itself rules out NFW profiles for these edge-on galaxies. So I retain 5 edge-on galaxies in the final sample; even so, the conclusions are not affected by their inclusion.

c) More data. I add new data from the February 2001 run of De Blok & Bosma (2002). Primack

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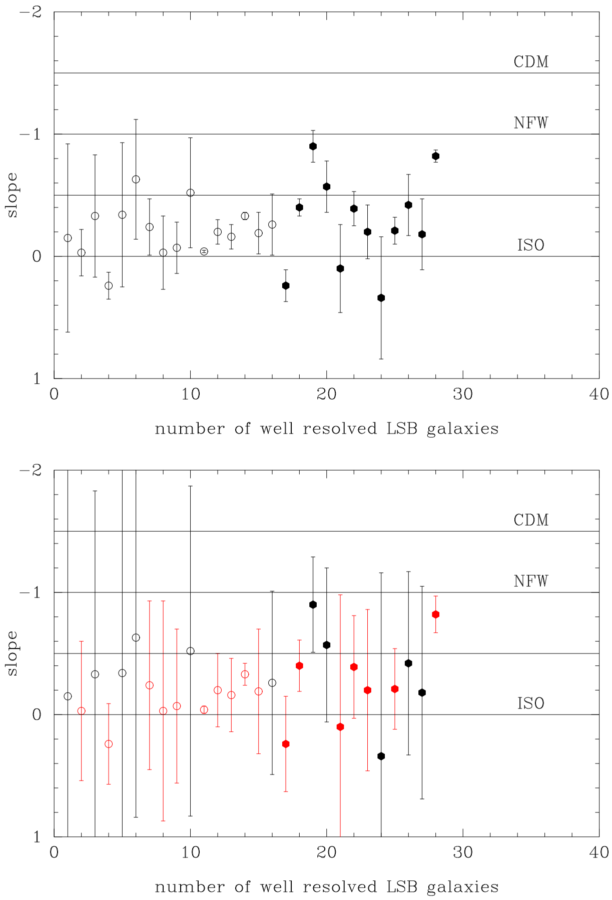

Fig. 1. **Top:** Plots of the slopes for the 16 best resolved galaxies of the De Blok et al. (2001b) sample (open circles) and the additional 12 galaxies in the De Blok & Bosma (2002) sample (filled circles), with 1 σ error bars; **Bottom:** Same, but with 3 σ error bars. 17 points are 3 σ away from the NFW prediction.

(2001) did not have these data at his disposal, but Primack (2002) chose to ignore them.

With these new selection criteria, I rule out NFW slopes at the 3σ-level for 17 galaxies, of which 5 are edge-on (Fig. 1). Primack's statement that of the 12 best cases probed in De Blok et al. (2001b), about half appear consistent with the cuspy NFW profile is incorrect (I find only 2 out of these having slopes $\leq$ -0.5), and his final conclusion that our data set may be consistent with an inner density profile $\alpha \sim$ -1 (in our notation) but probably not steeper, is not warranted, and is not corroborated by the newer data.

In De Blok & Bosma (2002) we already show that data taken by independent observers agree for F561-1, F563-1, F568-3, and UGC 5750. Our results have been corroborated by an independent study by Marchesini et al. (2001, 2002), who did a further comparison of raw data for 2 other galaxies. The Fabry-Perot data from Garrido et al. (2002) for a few galaxies in common are also in good agreement.

During my February 2002 observing run, I checked again several galaxies previously observed by others, and find good agreement between the raw data. Moreover, I experimented for UGC 4325 with deliberate slit offsets of $\pm 5''$, and find very good agreement between the position-velocity curves thus obtained. Such agreement is expected for velocity fields dominated by solid-body rotation.

In conclusion, our results show that the predicted steep slopes in the density profiles of LSB galaxies are not observed. Along with evidence for brighter spirals this implies that also there dark matter may not be dominant in the central parts of galaxies, this means that the current description by cosmological numerical models is incomplete, if not incorrect.

REFERENCES

Bosma, A., Byun, Y., Freeman, K.C., Athanassoula, E. 1992, ApJ, 400, L21
de Blok, W. J. G., Bosma, A. 2001, A&A, 385, 816
de Blok, W. J. G., McGaugh, S. S., Rubin, V. C. 2001a, AJ, 122, 2396
de Blok, W. J. G., McGaugh, S. S., Bosma, A., Rubin, V. C. 2001b, ApJ, 552, L23
Fukushige, T., Makino, J. 2001, ApJ, 557, 533
Garrido, O., Marcelin, M., Amram, P., Boulesteix, J. 2002, A&A, 387, 821
Knebe, A., Devriendt, J. E. G., Mahmood, A., Silk, J. 2002, MNRAS, 329, 813
Marchesini, D., D'Onghia, E., Chincarini, G., Firmani, C., Conconi, P., Molinari, E., Zaachei, A. 2001, astro-ph/0107424
Marchesini, D., D'Onghia, E., Chincarini, G., Firmani, C., Conconi, P., Molinari, E., Zaachei, A. 2002, astro-ph/0202075
Matthews, L. D., Wood, K. 2001, ApJ, 548, 150
McGaugh, S. S., Rubin, V. C., de Blok, W. J. G. 2001, AJ, 122, 2381
Moore, B., Quinn, T., Governato, F., Stadel, J., Lake, G. 1999, MNRAS, 310, 1147
Navarro, J. F., Frenk, C. S., White, S. D. M., 1996, ApJ, 462, 563
Primack, J. 2001, astro-ph/0112255
Primack, J. 2002, astro-ph/0205391
van den Bosch, F., Swaters, R. A. 2001, MNRAS, 325, 1017

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