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Footprints of the dark matter halo: from pattern speed to disk vertical structure

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Abstract. Dwarf irregular (dIrr) and low surface brightness (LSB) galaxies constitute the ideal sites for studying the density distribution of the dark matter halo, which strongly regulates the structure and dynamics in these galaxies even in the innermost regions of the stellar disk. In the first part of this paper, we present our detection of a slowly rotating gaseous bar in the dIrr NGC 3741 using the Tremaine-Weinberg method. In the second part, we show that the superthin nature of the stellar disk in the LSB galaxy UGC 7321 can be attributed to the presence of a dense and compact dark matter halo.

Keywords : galaxies: dwarf - galaxies: irregular - galaxies: individual: NGC 3741 - galaxies: haloes - galaxies: structure - galaxies: individual: UGC 7321

1. Introduction

A slow bar in the dwarf irregular galaxy NGC 3741: Using the Tremaine-Weinberg method, we measure the speed of the HI bar seen in the disk of NGC 3741 using the HI 21cm radio synthesis images from the VLA-ANGST survey. NGC 3741 is an extremely gas rich galaxy with an HI disk which extends to about 8.3 times its Holmberg radius. It is also highly dark matter-dominated. Our calculated value of the pattern speed Ω_p is 17.1 ± 3.4 kms^{-1}kpc^{-}. We also find the ratio of the co-rotation radius to the bar semi-major axis to be (1.6 ± 0.3)r_b, indicating a slow bar, r_b being

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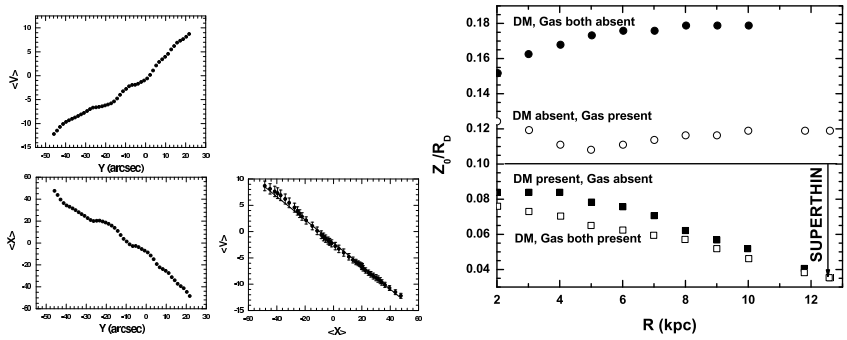

Figure 1. Left: On the left are shown $< V >$ (the integral of surface brightness-weighed radial velocity along the slit) as a function of slit offset y (distance of the slit from the line of nodes) and $< X >$ (the integral of surface brightness-weighed position vector along a slit) as a function of y. On the right, $< V >$ is plotted against $< X >$ overlaid with the best straight line fit to it within -50" $< < X > <$ 50". The slope (viz. 0.22 kms^{-1}arcsec^{-1}) of the $< V >$ versus $< X >$ plot gives Ω_p sin(i) where Ω_p is the pattern speed and "i" the inclination of the disk. **Right:** Plot of the ratio z_0/R_D (where z_0 is the stellar vertical scale height and R_D the exponential disk scalelength) with galactocentric radius R for UGC 7321 for different realizations of the two-component galaxy model. The figure clearly shows that it is the dark matter halo and not the gas-rich disk that is responsible for the superthin stellar disc observed in UGC 7321.

the bar radius. This is consistent with bar models in which dynamical friction results in a slow bar in dark matter dominated galaxies (Banerjee et al. 2013).

Why are some galaxy disks extremely thin? Some low-surface-brightness galaxies are known to have extremely thin stellar discs with the vertical-to-planar axes ratio 0.1 or less, often referred to as superthin galaxies. Although their existence is now known for over three decades, the physical origin of the superthin disks is still not understood. We model the vertical thickness of the stellar disk using our model of a two-component (gravitationally coupled stars and gas) disc embedded in a dark matter halo, for a bulgeless, superthin galaxy UGC 7321 which has a dense, compact halo. We show that that it is the compact dark matter halo which plays the decisive role in determining the mean distribution of stars in the vertical direction in low-luminosity bulgeless galaxies like UGC 7321, and causes the stellar disk to be superthin (Banerjee & Jog 2013).

2. Results

References

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