Mem. S.A.It. Vol. 78, 769

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Kinematics of low surface-brightness galaxies

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Abstract. In order to verify the correlation between the disk circular velocity V_c and the central velocity dispersion of the spheroidal component σ_c, we analyzed a sample of 12 low surface-brightness galaxies (LSBs). In previous works LSBs have been claimed to follow either a different linear (Pizzella et al. 2005) or the same power-law relation (Buyle et al. 2006) with respect to high surface-brightness galaxies (HSBs). The galaxies studied in this work enable us to confirm that LSBs and HSBs follow two different linear V_c-σ_c relations.

Key words. galaxies: fundamental parameters, galaxies: kinematics and dynamics

1. Introduction

Ferrarese (2002) found a relation between the disk circular velocity, V_c, and the central velocity dispersion of the spheroidal component, σ_c, in high surface brightness disk galaxies (HSBs) and elliptical galaxies. This relation was interpreted as a correlation between the spheroidal component and the dark matter (DM) halo. It was found that the V_c-σ_c relation follows a power-law for $\sigma_c > 80$ km s^{-1}. These conclusions were confirmed by Baes et al. (2003) and Buyle et al. (2006) who studied larger samples of HSBs. Pizzella et al. (2005, hereafter P05) investigated the V_c-σ_c relation for a small sample of less-dense objects, namely low surface brightness galaxies (LSBs). These are disk galaxies with a central face-on surface brightness lower than 22.6 B-mag arcsec^{-2}. They found that this type of galaxies followed a different V_c-σ_c relation. Moreover, they suggested that a linear relation was a better description of the V_c-σ_c relation also for $\sigma_c < 80$ km s^{-1}. The aim of this work is to confirm that LSBs follow a different V_c-σ_c relation with respect to HSBs.

2. Sample selection and observations

We analyzed a sample of 12 galaxies classified as LSBs by Impey et al. (1996). They have been selected to have different bulge-to-total luminosity ratios on the basis of the photometric decomposition by Galaz et al. (2002).

The spectroscopic data were acquired with UT1 of the ESO VLT in March 2006. The FOcal Reducer Spectrograph 2 (FORS2) was used in the 4560-5860 Å interval with instrumental velocity dispersion of 59 km s^{-1}. The selected spectral range covered the Hβ and [OIII]5007 Å emission lines as well as the MgI-triplet absorption lines at 5200 Å. For each galaxy 3 different major-axis spectra were obtained. The total exposure time was 7200 s. A number of stellar spectra was obtained to be used as templates in measuring the stellar kinematics.

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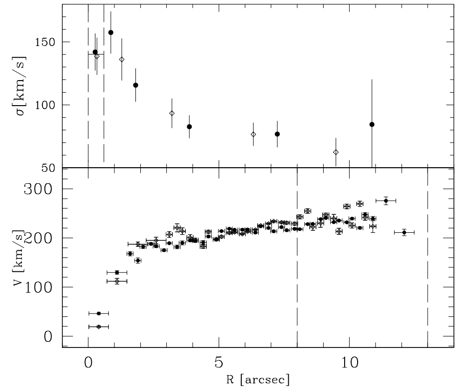

Fig. 1. The folded and deprojected gas rotation curve (bottom) and stellar velocity dispersion profile (top) of PGC 46798. Vertical dashed lines mark the radial regions where V_c and σ_c are measured.

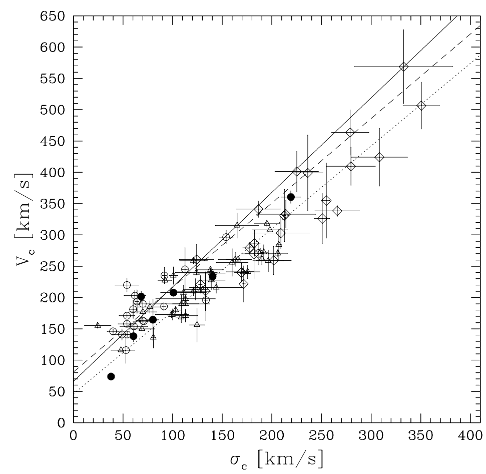

Fig. 2. Correlation between V_c and σ_c for LSBs and HSBs. Filled circles represent the LSBs studied in this work. Open circles are the LSB of P05 and Buyle et al. (2006). Triangles and diamonds correspond to HSBs and elliptical studied by P05. The dashed line represent the linear fit for the LSBs found by P05 while the solid represent the improved linear fit for LSBs we found. Dotted line represent the linear fit for the HSBs as found by P05.

3. Ionized gas and stellar kinematics

Data reduction and wavelength calibration were performed with purposely written pipelines in IRAF language. The ionized-gas rotation curve and velocity dispersion profile were obtained by fitting two Gaussians with the same width to the Hβ and [OIII] emission lines. The position and width of the Gaussians give the line-of-sight velocity and velocity dispersion respectively. The stellar rotation curve and velocity dispersion profile were obtained by fitting the absorption lines with the Fourier Correlation Quotient method. Errors on ionized-gas and stellar kinematics were estimated by means of Monte Carlo simulations taking into account photon and readout noise. For each galaxies V_c was estimated from the flat portion of the gas rotation curve after correcting for galaxy inclination, σ_c was derived from the inner portion of the stellar velocity dispersion radial profile 1. Galaxies with either an irregular or asymmetric rotation curve were rejected.

4. Results

By combining these new data with the previously available ones (P05, Buyle et al. 2006) we built a sample of 26 LSBs. The new dataset covers a large range of σ_c on both the lower (40 km s^{-1}) and upper (220 km s^{-1}) ends. This is very important in order to demonstrate that the LSBs and HSBs follow two different V_c-σ_c relations. We plotted all the values in the V_c-σ_c plane (Fig. 2) and we compared the distribution of LSBs and HSBs with the linear and power-law fits by P05 for HSBs. For a given σ_c LSBs are characterized by a higher value of V_c with respect to HSBs. We performed a regression analysis of the data and we found an improved V_c-σ_c relation for the LSBs:

$$V_c = (1.51 \pm 0.19)\sigma_c + (66 \pm 15)\text{km s}^{-1} \qquad (1)$$

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