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Low Surface Brighness galaxies: $V_{circ} - \sigma_c$ relation and halo central density radial profile from stellar kinematics measurements

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Major and minor axis kinematics of the stellar and gaseous component of a sample of 11 Low Surface Brightness galaxies is presented. The data, together with broad band imaging, will be used to construct detailed mass models aimed at deriving the central density radial profile of the dark matter component. The same data are used to study the V_{circ} - σ_c relation for LSBs. We find that LSBs have a higher V_{circ} at a given σ_c(or lower σ_c at a given V_{circ}) when compared to HSB and Ellipticals. This argues against the relevance of baryon collapse in the radial density profile of the dark matter haloes of LSB galaxies.

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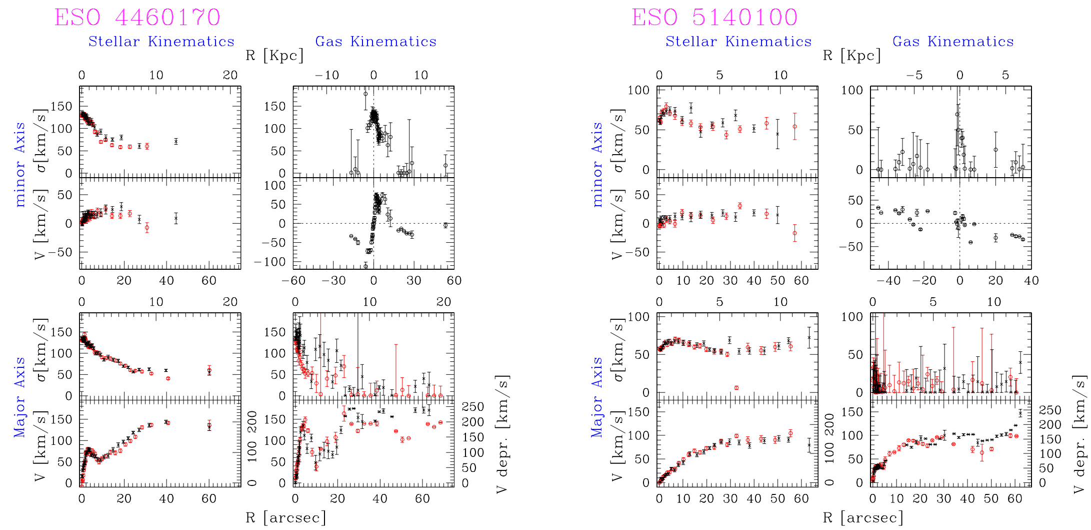

Figure 1: Kinematics derived for 2 LSB. Left and right windows represents the stellar and gas kinematics respectively. Lower and upper windows represents the Major and minor axis respectively. All data have been folded around the center, with the exception of the gas minor axis. Stellar kinematics, although is generally less extended, is more regular and symmetric than the gaseous one.

1. Introduction

The H I rotation curves of Low Surface Brightness galaxies (LSB) have received a great deal of attention, because they represent an ideal test-bed to check the density profiles of dark matter produced by N-body simulations in cold dark matter (CDM) universes [1]. In fact their shape can not be reproduced by scaling the stellar disk contribution to the rotation curve, thus indicating that LSB galaxies are dark matter dominated, even in their innermost regions [2].

A lively debate has recently taken place in the astronomical community. Indeed, there are observations, all based on the ionized gas and HI kinematics, which are in contrast with the CDM predictions finding constant density cores in the center of galaxies (e.g. [3]) and others than seems to be in favor of cuspy density profiles (e.g. [4]).

The high collecting power of VLT offers us the opportunity to measure the stellar kinematics of LSBs, and therefore to constrain for the first time the dark matter content of these galaxies independently from the ionized gas tracer.

In this work we present the results of the kinematical observation of 11 LSB galaxies. We give a brief description of the detailed mass models that we are building. Models are aimed at deriving the dark matter radial central density distribution. Finally, we use the acquired kinematical data to study the properties of LSBs concerning the circular velocity and the central stellar velocity dispersion plane.

2. The data: observations and results

We obtained long-slit major and minor axis stellar and ionized gas kinematics for a sample of

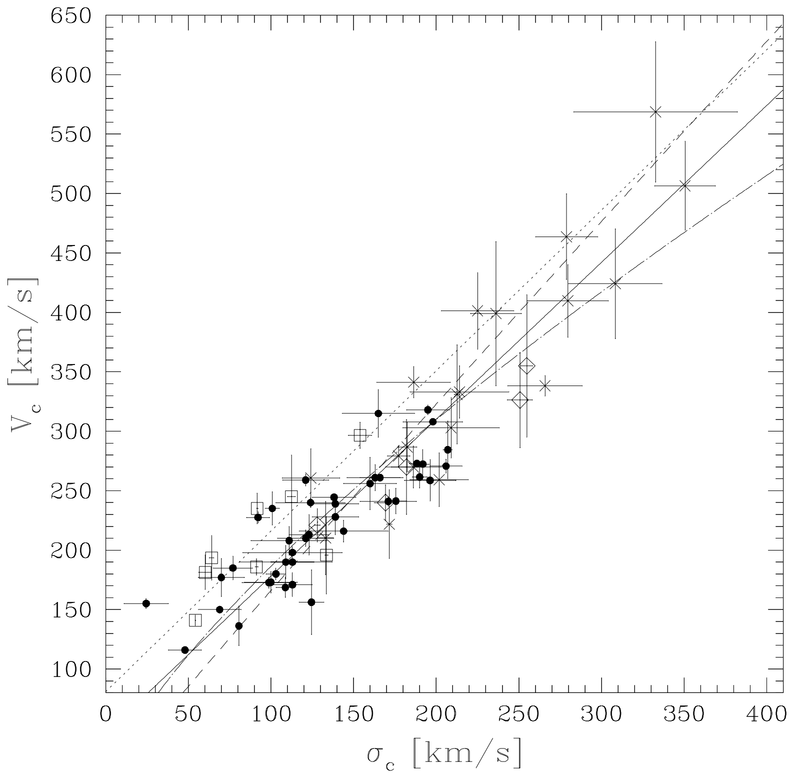

Figure 2: V_{circ} - σ_c relation for HSB galaxies (*filled circles*), elliptical galaxies (*diamonds* and *crosses*) LSB (*squares*). The *continuous* and *dash-dotted line* represent the linear and power-law fit to HSB+E. The *dotted line* represents the linear-law fit to LSB galaxies. LSBs all lie above the HSB+E relation.

11 LSBs. Galaxies have been selected from the ESO-LV catalog following the criteria described by [5] and are characterized by a low surface brightness disk and a bulge that in the center may have a surface brightness brighter than the canonical 22.6 mag·arcsec^{-2} value.

Observations have been curried out at ESO-Paranal with FORS2, *grism_V*1400 and 1" slit. The wavelength range was 4750—5800Å and the slit length 7' and typical exposure time was 2×45min for minor axis and 3×45min for major axis. We derived the kinematics of the stellar component (radial velocity, velocity dispersion, Gauss-Hermite h_3 and h_4 parameters) and and of the ionized gas component (radial velocity and velocity dispersion from H_β and [OIII]5007Å emission lines). In Fig.1 we show, as an example, the kinematics of two sample galaxies.

From the observational point of view the main results are that i) non-zero velocities along the minor axis are present in the majority of LSBs ii) the stellar component traces the kinematics with greater regularity than the ionized gas one. Stellar velocity and velocity dispersion curves are very symmetric and points are characterized by a small scatter.

3. Mass models

Dynamical modeling is still in progress. Here we briefly describe the method.

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Models are Jeans based. Galaxy is assumed to be axisymmetric (and this is probably the biggest assumption in the whole process). The stellar light distribution j(R,z) is derived by de-projecting the galaxy z-band image. The stellar mass distribution is derived from the stellar light distribution considering a constant M/L. DM halo is taken of the form $\rho \propto (r/r_d)^{-a}(r_d^2 + r^2)^{a/2-1}$. With this potential (DM+M/L×j(R,z)) we use the Jeans equation to calculate galaxy's internal moments. Velocity ellipsoid may be non spherical. Finally we project moments along the line of sight and we use χ^2 to derive ρ_0, a, r_d and M/L.

4. V_{circ}- σ_c relation

Recently a tight correlation between the bulge velocity dispersion σ_c and the galaxy asymptotic circular velocity V_{circ} has been found for a sample of elliptical and spiral galaxies [6]. The validity of this relation has been also confirmed by [7] who enlarged the spiral galaxy sample. The fact that such a tight relation exists between two velocity scales that probe very different spatial regions (the bulge and the dark matter halo), is a strong indication of a fundamental correlation in the structure not only of spirals but also of ellipticals. On the other hand, it may be interesting to investigate whether the V_{circ}- σ_c relation holds also for less dense objects characterized by a shallow potential well in their core. This is the case of LSB galaxies. Eight LSBs of our sample show a flat gas rotation curve in the outer region and we extracted V_{circ} and σ_c for these subsample. The V_{circ} - σ_c relation for HSB+E and LSB is shown in fig.2. LSB all lie above the HSB+E relation, having at a given V_{circ}, a lower σ_c. A detailed description of this work can be found in [8].

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