Mem. S.A.It. Suppl. Vol. 3, 151
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Memorie della
Supplementi

CDM or PSEUDO-ISOTHERMAL HALOS in GALAXIES

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Abstract. We present preliminary results of the spectroscopic observations of a sample of 12 bulge-dominated low surface brightness galaxies (LSB). We measured the stellar and gaseous kinematics along their major and minor axes. Such combined information will allow us to accurately investigate the dark matter (DM) content within their optical regions, providing further constraints on cosmological models. In particular we are going to test the consistency of the observed DM density radial profiles with the predictions of standard CDM models. Preliminary constant M/L modeling indicates the presence of dark matter at all radii. In order to derive the DM density radial profiles we need to construct dynamical mass models with a dark matter halo (work in progress).

Key words. LSB – ionized gas kinematics – stellar kinematics – mass dark matter

1. Introduction

Low surface brightness (LSB) galaxies (defined as disk galaxies with a central face-on μ_B fainter than 22.6 mag·arcsec^{-2}) have been found in large numbers only in recent years (e.g. Schombert et al. 1992; Impey et al. 1996). They are believed to be dark matter dominated and it is straightforward to compare the observed rotation curves of these galaxies with those derived from numerical cosmological simulations where the dark matter is the dominant component (Navarro et al. 1997). However, this approach turned out to give ambiguous results. In fact, disentangling between the contributions of the luminous disk and the dark halo to the observed rotation curve is complicated by the fact that such components are individually responsible for rotation curves very similar in shape, so that for instance it is never very clear up to which point the disk is responsible for the inner part of the rotation curve (de Blok, McGaugh & Rubin, 2001). It can be very difficult to use gas kinematics to measure even the total central mass profiles: the gas can have an intrinsic velocity dispersion and so need not to move on perfectly ballistic orbits; the emissivity distribution of the gas is often clumpy (Kormendy & Westpfahl 1989; van den Bosch & Swaters 2001). More mundanely, imperfect centering of the slit on the galaxy nucleus (not al-

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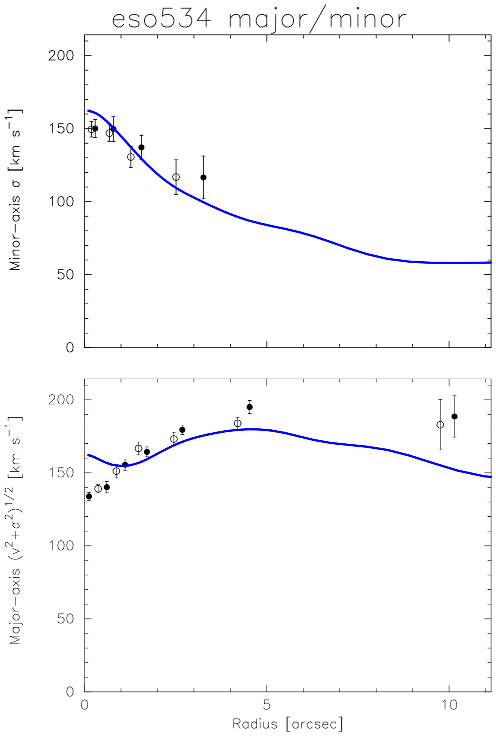

Fig. 1. ESO 5340200. Stellar kinematics of the minor (upper panel) and major axis (lower panel). *Dots* are the data points (open and closed symbols refer to the two side of the galaxy). For semplicity, we show the value of $\sqrt{V^2+\sigma^2}$. The *full line* represents the kinematical profile of the best mass model without dark matter. The model can not reproduce the high $\sqrt{V^2+\sigma^2}$ value in the external region.

ways a straightforward task on LSB galaxies) and uncertainties on the major-axis position angle also contribute to the total uncertainties on the kinematics.

A way to solve some of this problem is to use the stellar kinematics in addition to the ionized gas one. In this poster we show the preliminary results of a VLT+FORS2 observation aimed at measuring accurately the velocities, velocity dispersions of the stellar component.

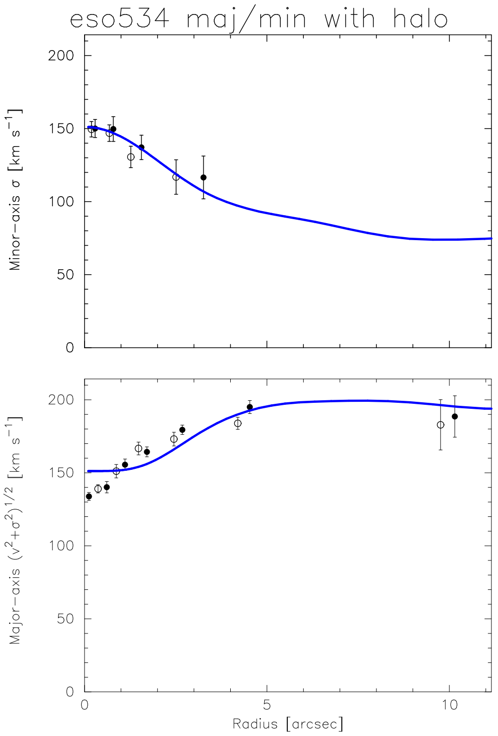

Fig. 2. As Fig.1 but fitting the data with a model considering the presence of a dark matter halo.

2. Observations and Results

In three different observing run we obtained data with the VLT+FORS2+grism_V1400+1.0”. We observed 12 galaxies along their major and minor axis and derived the stellar and ionized gas kinematics. In this paper we present the observed kinematics of the stellar and ionized gas components and the preliminary (constant M/L and with dark matter halo) mass models only for ESO 5340200. We observed the galaxy along 4 position angles, and in particoular along the major (PA=167°) and minor (PA=77°) axis. In Fig.1 we show the kinematics observed for the stellar component along the major and minor axis while in Fig.3 we show the velocity curve measured for the ionized gas component. The system velocity is

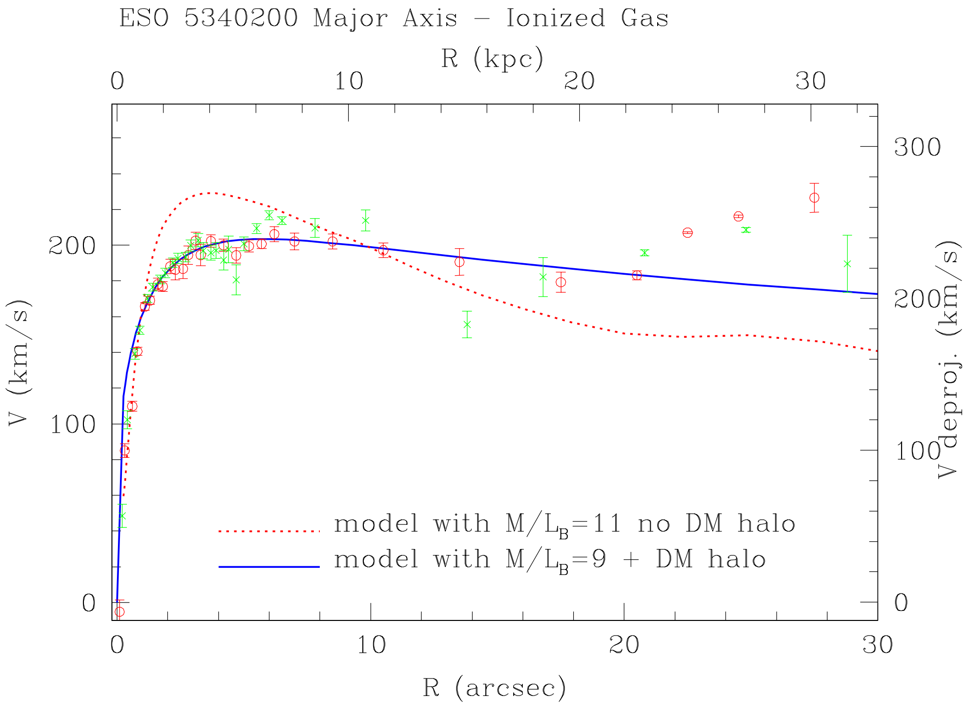

Fig. 3. ESO 5340200. Major axis ionized gas velocity curve. *Dots* represents the observed velocities after folding, *full line* is the velocity predicted for the gas according to the mass model based on photometry and stellar kinematics without (*dotted line*) and with (*full line*) dark matter

17282 km/s which, after correction to the 3K background reference system, yields a distance of 226 Mpc ($H_0 = 75\,km/s/Mpc$). At this distance $1''$ corresponds to 1.1 kpc. The measured total gunn-z magnitude is 13.9 (B_T=16.08 in the ESO-LV catalog).

Using the gunn-z photometry and stellar kinematics we constructed a preliminary constant M/L dynamical mass model. We deprojected the light distribution assuming that the galaxy is axisymmetric with an inclination angle of 58°. Then we make the further assumption that it has an isotropic velocity distribution and use the Jeans equations (Binney, Davies & Illingworth 1990; Magorrian & Binney 1994) to calculate the model's projected velocity moments for a range of assumed mass density profiles. In Fig.1 we plot the predicted kinematics for a model in which mass follows light, with a high M/L of 11 (B-band). It is clear that a constant M/L ratio can not fit the whole observed radial range. It predicts too much mass in the inner region and not enough mass in the outer region. Moreover, the best fit model

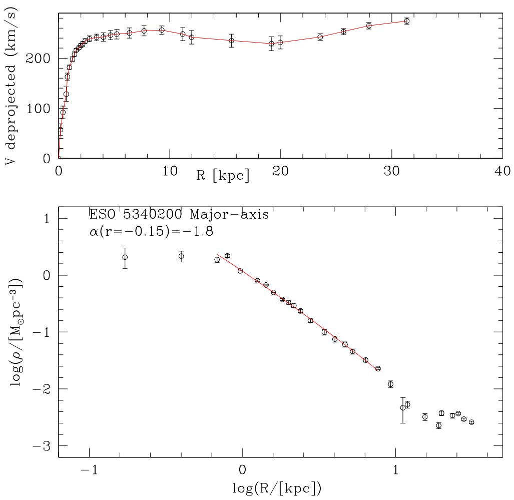

Fig. 4. ESO 5340200. Stellar kinematics of the minor (upper panel) and major axis (lower panel). *Dots* are the data points (open and closed symbols refer to the two side of the galaxy) while the *full line* represents the kinematical profile of the best model

have an M/L_B=11 which is definitively too high. In Fig.3 we plot the circular velocity derived from the constant M/L dynamical model and compare it with the observed ionized gas kinematics. Again, the model overestimate the mass in the central region and underestimate the mass in the outer region. In addition, we derived the central mass density radial profile as done by de Blok et al (2001). We folded the ionized gas along the Major axis, deprojected, smoothed and derived the density $\rho(r)$(Fig.8):

$$4\pi G\rho(r) = 2\frac{v}{r}\frac{\partial v}{\partial r} + \left(\frac{v}{r}\right)^2$$

The resulting density profile is shown in Fig.4. The cuspyness we find in the innermost radius not affected by seeing smearing ($r = 0.8'' = 900\,pc$, $\alpha = -1.8$ where $\rho \propto r^\alpha$) seems to indicate the presence of a CDM halo. We started to construct mass models with constant stellar M/L and a dark halo. In Fig. 2 we present a very preliminary model and it is possible to test how the fit may improve with respect the model without dark matter. In this preliminary mass model we included a dark matter halo with density

$$\rho(r) = constant \times r^{-a} \times (r0 + r)^{(b-a)}$$

with a=1.5, b=2.5 and r0=3kpc . The fit seems to improve. Also the comparison of the predicted circular velocity and the ionized gas velocity curve show now a better agreement (Fig.3).

Finally, we have a VIMOS+IFU program aimed at measuring the 2D ionized gas kinematics in the central $13'' \times 13''$ of the sample galaxies. When the data will be available we will have a powerful tool to test the real kinematical behavior of the ionized gas in the nuclei of these objects and to further constrain the central radial density distribution.

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