Anatomy of giant spiral galaxies

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1. Introduction

The progress made in last years in numerical modeling allows to study the internal structure of galaxies with great detail. This is of particular interest for stellar systems composed by several components, such as spiral galaxies. In the recent years, we produced a self-consistent, 3-D model of disk galaxy made by an exponential disk and a $r^{1/4}$ bulge (Pignatelli & Galletta, 1999).

The model fit simultaneously the photometric data (surface brightness, ellipticities and PAs of isophote major axis) and the kinematic data (rotation curves and velocity dispersion curves along various PAs). In such a way, the structure of the luminous matter derived from the photometric analysis is compared with the total matter deduced from the dynamical data and the presence of dark matter may be studied.

To test the model, we selected five galaxies with morphological types spanning from S0/a to Sc and absolute magnitudes from -20.6 to -22.5. They have been selected from HI observations looking for objects with a line width $W_{20} > 350$ km/sec.

Figure 1. B images of two galaxies of the sample: the SBcd galaxy NGC 3263 and the Sbc galaxy NGC 6925.
For all these galaxies we obtained images at B and I photometric wave bands using the ESO telescopes at La Silla. The used telescopes were the Danish 1.5m, the NTT+EMMI and the ESO-MPI 2.2m+EFOSC2. The spectra have been collected with the spectrographs Boller& Chivens and EFOSC2 of the 2.2m ESO-MPI telescope.

We used the model to evaluate the intrinsic properties of these galaxies, such as the disk/bulge mass ratio and the scale length of the galaxy components.

2. The results from the model

The galaxies can be described by superposition of different components. For each component, we separately assume that: (a) the density distribution is oblate, without strongly triaxial structures; (b) the isodensity surfaces are similar concentric spheroids; (c) the surface density profile follows a simple $R^{1/4}$ or exponential law; (d) the velocity distribution is locally Gaussian; (e) the velocity dispersion is isotropic $\sigma_r = \sigma_\theta = \sigma_z$.

The model has $4n + 1$ free parameters, where $n$ is the number of adopted components: namely the luminosity $L_{\text{tot}}$, the effective radius $R_e$, the mass-luminosity ratio $M/L$ and the flattening $b/a$ of each component plus the inclination angle $i$ of the galaxy.

Photometry can be used to constrain all these parameters except the M/L ratio, which must be derived by kinematics. In Fig. 2 we show an example of the application of the model to the rotation curve of NGC 6925: in this case, we found that the stellar velocity can be fitted by a model without dark matter with a $M/L = 3.9$ solar units and a total mass of $2.7 \cdot 10^{11} M_\odot$.

Figure 2. Stellar rotation velocities for NGC 6925, compared with the results of the dynamical model (see text).

Since these galaxies have high value for the HI line width $W_{20}$, it has been suggested (Buson et al., 1991) that they could have in general an unusually high content of dark matter in the inner regions or, perhaps, an unusual stellar population. None of this hypothesis is confirmed by our analysis.

References

Buson, L. M., Galletta, G., Saglia, R. P., Zeilinger, W. W., 1991, Msngr 63, 50
Pignatelli, E., & Galletta, G., 1999, A&A 349, 369