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Rotation curves of luminous spiral galaxies

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We study the rotation curves profiles of high-luminosity spiral galaxies. The sample contains 30 high-quality rotation curves. The outer rotation curves for individual systems in the sample divide among slightly rising, flat, and declining profiles.

Keywords: Spiral galaxies; Kinematics and dynamics

1 Introduction

Rotation curves (RCs) yield crucial information on the mass structure of spiral galaxies (e.g. [1]). It is assumed that a galaxy's RC reflects its circular velocity profile $V(R) = (Rd\Phi/dR)^{1/2}$, where Φ is the Newtonian gravitational potential and the disc and halo velocity components add quadratically: $V^2(R) = V_D^2(R) + V_H^2(R)$. More specifically a RC, in combination with surface photometry, provides us with the galaxy mass distribution. It is well known that the distribution of stellar light in a spiral with characteristic radius $R_{\rm opt} \equiv 3.2R_{\rm D}$, where $R_{\rm D}$ is the exponential disc scale-length, does not match the distribution of its gravitating mass ([1, 2]). RCs imply that spiral galaxies contain a large amount of dark matter or, alternatively, the existence of exotic physics on galactic scales. The detailed study of RC *shapes* provides crucial information both on the fractional amount of dark matter and on its spatial distribution, helping to investigate its very nature.

The concept of the *Universal Rotation Curve* (URC), implicit in [3], was pioneered by Persic and Salucci [4] and set in Persic, Salucci & Stel ([5], hereafter PSS). According to this paradigm, the RCs of disc galaxies can be generally represented by $V_{URC}(R/R_D; P_i)$, i.e. by a *universal* function of normalized radius, tuned by one or more galaxy observational quantities P_i (e.g. the I-band luminosity as in PSS, or the virial mass as in [6]). Remarkably, just one global quantity takes into account for more than 90% of the RC variance.

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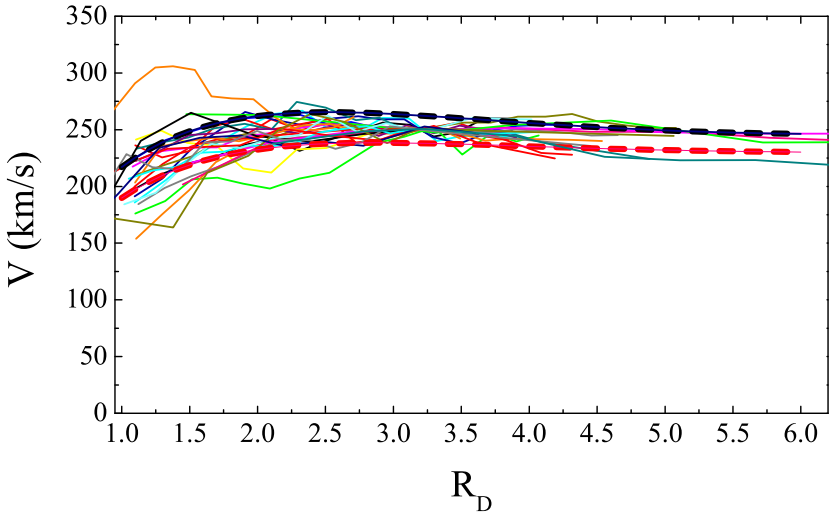


Figure 1 The RCs of the sample normalized to the same $V(R_{\rm opt})$. The dashed red and black lines indicate the URC predictions for $V(R_{\rm opt}) = 220$ km/s and $V(R_{\rm opt}) = 350$ km/s correspondingly.

Catinella et al. ([7], hereafter C+06) studied 2200 RCs of disc galaxies and constructed the template RCs for objects of different luminosities. The [6] and C+06 template functions coincide for low and intermediate luminosities, but are discrepant at the high-luminosity end. In [6] the URC for the highest luminosity bin slightly declines, while in PSS this decline was more marked. In C+06, instead, the template curve shows a slight but clear rise.

The aim of this work is to investigate the individual RC profiles of high-luminosity spirals and clarify the nature of the URC behaviour. The advantage of this work is that we will consider only the *high-quality* RCs.

2 Data selection and RCs profiles

We select high-quality RCs of high luminosity late-type spirals (Sb or later) with available photometry that satisfy the following criteria:

1. 200 km/s $< V_{\rm opt} <$ 350 km/s (corresponding to $-22.4 < M_B < -20.6$);
2. good spatial resolution B across the RC: B $< 0.5\ R_{\rm D}$;
3. at least 4 independent RC points in the region of interest $2 < R/R_{\rm D} < 3.5$;
4. the RC does not exhibit features indicative of prominent spiral structure nor warps;
5. the RC has small observational errors in its amplitude and derivative: $\delta V/V < 0.04$, $\delta\nabla < 0.05$;
6. the inclination is $53^\circ < i < 90^\circ$.

We build a sample of 30 *high-quality* RCs (see Fig. 1). For each galaxy the raw kinematical data are smoothed as in [8] and the distance from the galaxy center is measured in units of $R_{\rm D}$. Because the rotation curves are not always flat, or linear, in the region where the slope is measured, the adopted value of $R_{\rm D}$ will have a significant effect on the results. An error of $\sim 30\%$ in R_D would, e.g. take us from the target radius $2R_{\rm D}$ to $1.4R_{\rm D}$ or $2.6R_{\rm D}$, a range of radii where the rotation curve necessarily changes slope. Adopting literature values obtained from different bands, particularly from optical bands which are more sensitive to younger stellar populations, by different methods (the region where the disc fit is performed), and by different authors would introduce a significant scatter in our measurements. Therefore for most of the galaxies of our sample we opt to obtain the disc scale-lengths from near-infrared images, using a two-dimensional disc-bulge decomposition code GALFIT [9]. All the images are taken from the K_s-band 2MASS All Sky Release Atlas. The images are photometrically calibrated, and the typical FWHM for the point-spread function (PSF) is ~ 3 arcsec. Two components are used in the fits: an exponential disc and a Sersic bulge or a PSF for unresolved central sources. Then the RCs were binned as in [10]. We consider radial bins of sizes of $0.2R_{\rm D}$ and $0.6R_{\rm D}$ for $H\alpha$ and HI RCs, respectively. We analyzed the individual RCs profiles in the region of $2.7 < R/R_{\rm D} < 3.5$. The RCs divide between mildly rising, flat and mildly declining profiles: 3 are mildly rising, 12 are flat and 15 RCs are declining.

3 Conclusions

We studied the individual RCs profiles of the 30 luminous spirals $-22.4 < M_B < -20.6$, using the high-quality data. The disc scale-length $R_{\rm D}$ is a crucial parameter, since an error of $\sim 30\%$ in $R_{\rm D}$ would change the total profile of the RC. In our sample we find that the RCs profiles divided between mildly rising, flat and mildly declining profiles.

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