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The disc mass of spiral galaxies

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ABSTRACT

We derive the disc masses of 18 spiral galaxies of different luminosity and Hubble type, both by mass modelling their rotation curves and by fitting their spectral energy distribution with spectrophotometric models. The good agreement of the estimates obtained from these two different methods allows us to quantify the reliability of their performance and to derive very accurate stellar mass-to-light ratio versus colour (and stellar mass) relationships.

Key words: galaxies: kinematics and dynamics – galaxies: spiral – dark matter.

1 INTRODUCTION

The disc mass M_D, together with disc length-scale R_D, is the main physical property of the baryonic component of normal spiral galaxies. In the current framework of galaxy formation theory, in an halo of mass M_{vir}, the present day value of M_D indicates the efficiency with which the stellar formation process acted in protospirals on the large primordial reservoir of $\sim 1/6 M_{vir}$ H I material. It also bears the imprint of the physical processes (supernovae feedback, cooling, previrialization) that have prevented the latter in entirely transforming into a stellar disc (see Shankar et al. 2006). The quantity $(M_D\, R_D)^{1/2}$ is proportional to the angular momentum per unit mass of the disc matter, very likely the same value of that of the dark particles (e.g. Tonini et al. 2006) and it is linked to the tidal torques that dark halo experienced from neighbours at their turnarounds. Finally, we should recall that $M_D R_D^{-2}$ is a measure of the central stellar surface density.

The mass modelling of the rotation curves (hereafter RCs) is a robust and reliable method (hereafter the kinematical method 'kin') to derive the disc mass (e.g. Tonini & Salucci 2004). For illustrative purposes we recall that, inside one disc length-scale the RCs almost entirely match the distribution of the stellar component, a perfect match between gravitating mass and luminous mass is reached by adding just a very small dark matter (DM) component (e.g. Persic, Salucci & Stel 1996; Salucci & Persic 1999). This observational evidence is well understood within the current galaxy formation scenario. Discs form from baryons that, while falling into DM potential wells, unlike the DM component, radiate, lose kinetic energy and contract: their final configuration saturates the gravitational field of the inner regions of galaxies.

A second independent way, pioneered by Tinsley (1981) (hereafter the spectrophotometric method 'pho'), by fitting a galaxy broad-band spectral energy distribution (SED) with stellar population models obtains the disc mass as the resulting best-fitting parameter.

In Salucci, Ashman & Persic (1991) we find the first study in which the combination of these two independent methods was applied to a sample of 38 spirals with available kinematics and photometry; disc masses were estimated from the $B - V$ colours and then compared with the values obtained by modelling their RCs. Similarly, Ratnam & Salucci (2000) used high spatial resolution (<100 pc) RCs of 30 spirals in order to derive the mass distribution in their innermost kpc. They found that, in this region the luminous matter completely accounts for the gravitational potential, so that the kinematics provides a very precise value for the stellar mass-to-light ratio (M/L). These values resulted in a good agreement with that obtained from $B - I$ colours by applying the predictions of population synthesis models. A similar result has been found for a small number of 'laboratory' barred spirals (Weiner et al. 2001; Pérez, Fux & Freeman 2004).

A substantial improvement of the 'pho' method has come from Bell & de Jong (2001); they devised spiral galaxy evolution models that yielded the stellar M/L values dependence on different colours for integrated stellar populations. These results were tested against the 'maximum disc' stellar M/L values of a sample of spiral galaxies.

In a different approach the determination of disc masses was directly implemented in the RC mass modelling itself. Kassin, de Jong & Weiner (2006) studied a sample of 34 bright spiral galaxies whose disc masses were obtained by *BRK* colours, so that the mass model had one less free parameter. However, this promising procedure requires the mass estimate to be very accurate; since an error on the assumed value M_{pho}, with respect to the actual value M_{true}, fatally flaws the entire mass modelling (e.g. Tonini & Salucci 2004). It is useful to give a simplified proof of this. Let us set $V_h \propto R^s$, the halo velocity contribution to the circular velocity around $2.2R_D$, the radius where the disc contribution to the circular velocity (of true value $\beta \simeq V_d^2/V^2$) has a radial maximum. By setting ∇ the (observed) RC slope at $2.2R_D$, we have: $s = \nabla/(1 - \beta\, M_{pho}/M_{true})$ that shows even quite small errors in the pho estimate of M_{true} may trigger very large errors in derived DM halo profiles.

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Advantages and disadvantages are present in both 'pho' and 'kin' methods, though, remarkably, they are almost orthogonal. The photometric method relies on the not trivial caveat that, given a SED there is an unique stellar mass which explains it. Moreover, it takes a number of assumptions on the stellar populations of spirals, it depends on the estimate of the galaxy distance as D^2 (uncertain to some level for local objects). Moreover, it carries theoretical uncertainties (in log $M_{\rm D}$) up to 0.3 dex. The kinematical method may suffer from the uncertainty on the actual distribution of DM in galaxies, depends on the disc inclination angle as $(1/\sin i)^2$ and therefore is uncertain for low inclination galaxies, and it depends on the estimate of the galaxy distance as D. The main advantages of the photometric method are that it makes no assumption on the mass distribution and it requires only a limited observational effort; the main advantage of the kinematical method is that the disc mass can be obtained straightforwardly from model-independent observables and within an uncertainty of 0.15 *dex*: in fact $M_{\rm D} \sim f\, G^{-1}\, V^2(2R_{\rm D})2R_{\rm D}$, where f can be estimated from the slope of the RC inside $2R_{\rm D}$, within 0.1 dex uncertainty (Persic & Salucci 1990a,b), while $R_{\rm D}$ is generally known within a 0.07 dex uncertainty.

Combination of the two methods is particularly useful in DM-dominated dwarfs where the kin method fails since the stellar disc is largely non-self-gravitating at any radius and in galaxies with large uncertainties in the distances that propagate themselves on to the pho estimates.

The aim of this paper is to measure the disc masses of a sample of 18 spirals with both methods and to compare them. We use combined Sloan Digital Sky Survey (SDSS) and Two Micron All Sky Survey (2MASS) photometry covering the *ugrizJHK* bands to fit each galaxy's SED to a broad range of stellar population models with varying star formation history (SFH), age, dust content and burst fraction. With respect to previous pho estimates the present one takes advantage of measurements in eight bands ranging from the u to the K. High-quality RCs will provide the kinematical data, whose analysis will benefit from the results of recent work.

Comparing, for a fair sample of galaxies, the disc mass estimates obtained with the two different methods is worthwhile for the following reasons. First, the average of the two estimates will give a very reliable measure of the stellar disc mass for objects of different luminosities, thus providing an unprecedentedly accurate stellar mass versus light relationship. Secondly, it allows for an investigation of the assumptions taken by each of the two methods, providing additional information on the structure and evolution of galaxies. Finally, it will indicate the still poorly known uncertainties of the pho estimates of the disc mass, setting the situation in which they can be used in mass modelling.

The sample consists of 18 galaxies (see Fig. 1 for their images). Among them 16 galaxies are late-type spirals taken from Courteau (1997) and Vogt et al. (2004). The data analysis technique applied to these RCs has been described in Yegorova & Salucci (2007); in order to also include some early-type objects we decided to add UGC4119 and UGC6351 whose data were obtained in Asiago Observatory with the 182cm Copernico telescope in 2006 January. The sample includes all the SDSS local spirals with eight band measurements (i.e. a good coverage of the entire SED) necessary for the highest precision estimate of the 'photometric' mass and with smooth, symmetric, regular, high-resolution (>10 independent data inside two disc length-scales) RCs. Some of the latter requirements are implemented to make us sure that the selected RCs are not affected by non-axisymmetric features, such as bars and spiral structure that, in any case, affect the RC slopes rather than the RC amplitudes (that plays the major role in the kin estimates). Finally, the values of $R_{\rm D}$ are taken from Courteau (1997) and Vogt et al. (2004), including their inclination angles i, that being relatively highly inclined $i \sim 60^0$, do not affect their kin estimates.

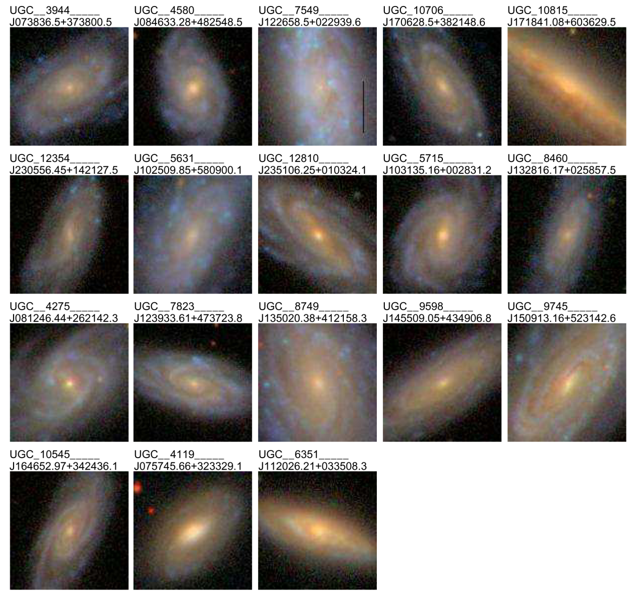

Figure 1. SDSS *gri* composite colour images of the galaxies in our sample in the same order of Table 1.

Notice that in the literature kin disc masses have been obtained for many other objects that, unfortunately, do not have the set of photometric data sufficient for the specific aim of this work.

The plan of this work is the following. In Section 2 we will describe the kinematical method, in Section 3 the spectrophotometric method, the resulting mass and M/L will be shown in Sections 4 and 5, and a discussion is presented in Section 6.

2 THE KINEMATICAL METHOD

In spirals the stellar component is represented by a Freeman disc (Freeman 1970) of surface density

$$\Sigma_{\rm D}(r) = \frac{M_{\rm D}}{2\pi R_{\rm D}^2}\, {\rm e}^{-r/R_{\rm D}} \qquad (1)$$

that contributes to the circular velocity V as

$$V_{\rm d}^2(x) = \frac{1}{2}\frac{GM_{\rm D}}{R_{\rm D}} x^2 (I_0K_0 - I_1K_1), \qquad (2a)$$

where $x = r/R_{\rm D}$ and I_n and K_n are the modified Bessel functions computed at $x/2$. A bulge of mass $M_{\rm b} = \epsilon\, M_{\rm D}, \epsilon = (1/20 - 1/5)$ concentrated inside $R_{\rm b} < 1/3\, R_{\rm D}$ is often present. The amplitude and the profile of the RCs for $R > R_{\rm b}$ is influenced by the central bulge in a negligible way for $\epsilon < 1/5$. Furthermore, in the RC mass modelling, even if we neglect a quite significant stellar bulge component ($\epsilon = 0.2$), we obtain a disc mass value higher than the actual one, but matching that of the total stellar mass ($M_{\rm D} + M_{\rm b}$) (Persic, Salucci & Ashman 1993), therefore, providing a suitable mass to be compared with the total galaxy luminosity and with the spectrophotometric mass estimate.

Given the aim of this paper, it is worth representing the DM component with the simplest halo velocity profile $V_h^2\,(r)$ [linked to the mass profile by $V_h^2\,(r) = GM_h(< r)/r$]:

$$V_h^2(x) = V_h^2(1)(1 + a^2)x^2/(a^2 + x^2) \qquad (2b)$$

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with $V_h^2(1) \equiv V_h^2(R_D)$ and a free parameters. The above velocity profile implies a density profile with an inner flat velocity core of size $\sim aR_D$, a constant central density and an outer r^{-2} decline, which, however is never reached in our RCs since generally they do not extend beyond $R_{last} \sim 3R_D$. Let us highlight that in the region in which most of the baryons lie and where we will measure the disc mass, equation (2b) can approximate, with proper values of the free parameters, a number of different halo distributions, including the NFW, the Burkert and the pseudo-isothermal ones. Obviously, for $R > R_{last}$, V_h needs not to be represented by equation (2b).

The kinematical estimate of the disc mass M_{kin} is obtained by fitting the observed rotation velocities V to the model velocity curve V_{mod}:

$$V^2(x) = V^2_{mod} \equiv V^2_d(x, M_{kin}) + V^2_h(x; V_h(1), a). \quad (3)$$

The model parameters, including the disc mass M_{kin}, are obtained by minimizing the usual quantity (data − model)^2.

An advantage of this method emerges by noticing that M_{kin} are found very similar to the disc masses computed by means of the approach discussed above: (i) by means of the equation $|\mathrm{d}\log V_d(x)/\mathrm{d}\log x \simeq \mathrm{d}\log V(x)/\mathrm{d}\log x| < 0.05$ we determine the inner baryon dominance region (Salucci & Persic 1999), i.e. the region inside which the slope of the disc contribution to the circular velocity coincides (within the observational errors) with the slope of the latter; (ii) we fit the RCs of this region with only the disc contribution. Since in most cases this region extend out to R_D, we can write $M_{kin} \simeq G^{-1}\, V^2(1)\, (I_0K_0 - I_1K_1)|_{0.5}\, R_D$: it is obvious that the 'theoretical' uncertainties on the kinematical estimates of the disc masses are modest when the RCs show an inner region which is well reproduced by the stellar component alone.

The RC fits are excellent (see Fig. 2), as those obtained in Ratnam & Salucci (2000) and Salucci et al. (2000), showing that within the inner parts of spirals, light traces the dynamical mass. Thus, the inner RC of spirals are reproduced by just a stellar disc with a suitable choice of its M/L. In this way we get the value M_{kin} for the disc mass and the formal uncertainty σ_{kin} on $\log M_{kin}$, found to range between 0.10 and 0.20 dex, and mostly due to the (small but non-zero) observational error in the RCs and in the estimate of R_D. The resulting values for the disc masses are given in Table 1.

A further support for the reliability of the above estimates emerges by the fact that the values of $\log M_{kin}$ are found to be within 0.1 dex of those computed by means of the following approach: (i) with the equation $|\mathrm{d}\log V_d(x)/\mathrm{d}\log x \simeq \mathrm{d}\log V(x)/\mathrm{d}\log x| < 0.05$ we determine the inner baryon dominance region (Salucci & Persic 1999), i.e. the region inside which the slope of the disc contribution to the circular velocity coincides (within the observational errors) with the slope of the latter; (ii) we fit the RCs of this region with only the disc contribution. Then, it is very likely that the kin method is not significantly affected by model-dependent uncertainties.

Table 1. Columns: (1) name of the galaxy, (2) reference disc velocity $\equiv (1/2)GM_{kin}/R_D$, (3) kinematical mass (log), (4) its uncertainties, (5) spectrophotometric mass (log), (6) its uncertainties, (7) absolute B-band magnitude (HyperLeda data base), (8) RC references: Courteau-1, Vogt-2, our data (Asiago Observatory)-3.

Name	V_d	M_{kin}	dM_{kin}	M_{pho}	dM_{pho}	M_B	Reference
UGC3944	100	10.12	0.12	10.03	0.11	−19.82	1
UGC4580	135	10.48	0.12	10.7	0.13	−21.31	1
UGC7549	62	9.3	0.2	9.24	0.28	−19.72	1
UGC10706	208	11.08	0.2	10.68	0.2	−21.26	1
UGC10815	229	11.1	0.12	10.94	0.13	−20.99	1
UGC12354	100	10.02	0.12	9.41	0.28	−20.13	1
UGC5631	90	9.91	0.2	9.63	0.1	−19.53	1
UCG12810	220	11.21	0.12	11.14	0.11	−21.84	1
UGC5715	190	10.76	0.12	10.99	0.11	−21.8	1
UGC8460	145	10.56	0.12	10.44	0.14	−20.65	2
UGC4275	190	10.85	0.12	10.48	0.2	−21.15	2
UGC7823	165	10.66	0.12	10.63	0.18	−20.86	1
UGC8749	170	10.72	0.12	10.24	0.11	−20.32	1
UGC9598	160	10.69	0.12	10.52	0.12	−20.93	1
UGC9745	155	10.61	0.12	10.58	0.17	−21.01	1
UGC10545	155	10.98	0.12	10.87	0.14	−21.46	1
UGC4119	290	10.74	0.2	10.66	0.11	−20.43	3
UGC6351	220	10.54	0.2	10.46	0.14	−19.19	3

3 THE SPECTROPHOTOMETRIC METHOD

We infer stellar masses from multicolour photometry following Drory, Bender & Hopp (2004). We compare multicolour photometry to a grid of stellar population synthesis models covering a wide range in SFHs, ages, burst fractions and dust extinctions. We use photometric data in the *ugriz* bands from the SDSS Data Release 4, augmented with *JHK* data from the 2MASS. We perform matched-aperture photometry with apertures defined in the SDSS r-band image to obtain integrated galaxy colours to the Petrosian radius. Photometric errors are 0.03–0.08 in J, H and K, respectively, ∼0.1 mag in the u band, and ∼0.01 mag in the g, r, i and z bands. Just as a reference of the galaxy luminosities, we give in Table 1 their absolute B-band magnitudes.

Our stellar population model grid is based on the Bruzual & Charlot (2003) stellar population synthesis package. We also use an updated version of these models (G. Bruzual, private communication). We parameterize the possible SFHs by a two-component model: a main component with a smooth analytically described SFH, and, superimposed, a short recent burst of star formation. The main component has a star formation rate of the form $\psi(t) \propto \exp(-t/\tau)$, with $\tau \in [0.1, \infty]$ Gyr and a metallicity of $-0.6 < [\mathrm{Fe/H}] < 0.3$. The age, t, is allowed to vary between 0.5 Gyr and the age of the Universe (14 Gyr). We superimpose a burst of star formation, modelled as a constant star formation rate episode of solar metallicity and of 100 Myr duration. We restrict the burst fraction, β, to the range $0 < \beta < 0.15$ in mass (higher values of β are degenerate and unnecessary since this case is covered by models with a young main component). We adopt a Chabrier (2003) initial mass function (IMF) for both components. The main component and the burst are allowed to independently exhibit a variable amount of extinction by dust. This takes into account the fact that young stars are found in dusty environments and that the starlight from the galaxy as a whole may be reddened by a (geometry-dependent) different amount.

We compute the full likelihood distribution on a grid in this six-dimensional parameter space $(\tau, [\mathrm{Fe/H}], t, A_V^1, \beta, A_V^2)$, the likelihood of each model being $\propto \exp(-\chi^2/2)$. In each object, we compute the likelihood distribution of the stellar M/L values that will give the best estimated value M_{pho}/L, by weighting the M/L relative to a spectrophotometric model and marginalizing it over all stellar population parameters. The uncertainty in the derived M_{pho}/L, and hence in stellar mass, is obtained from the width of this distribution and given in Table 1. While estimates of stellar population parameters such as the mean age, the SFH, the burst fraction, and the dust content are subject to degeneracies and often are poorly constrained by the models, the value of the stellar disc mass obtained by marginalizing over the stellar population parameters is a lot more robust.

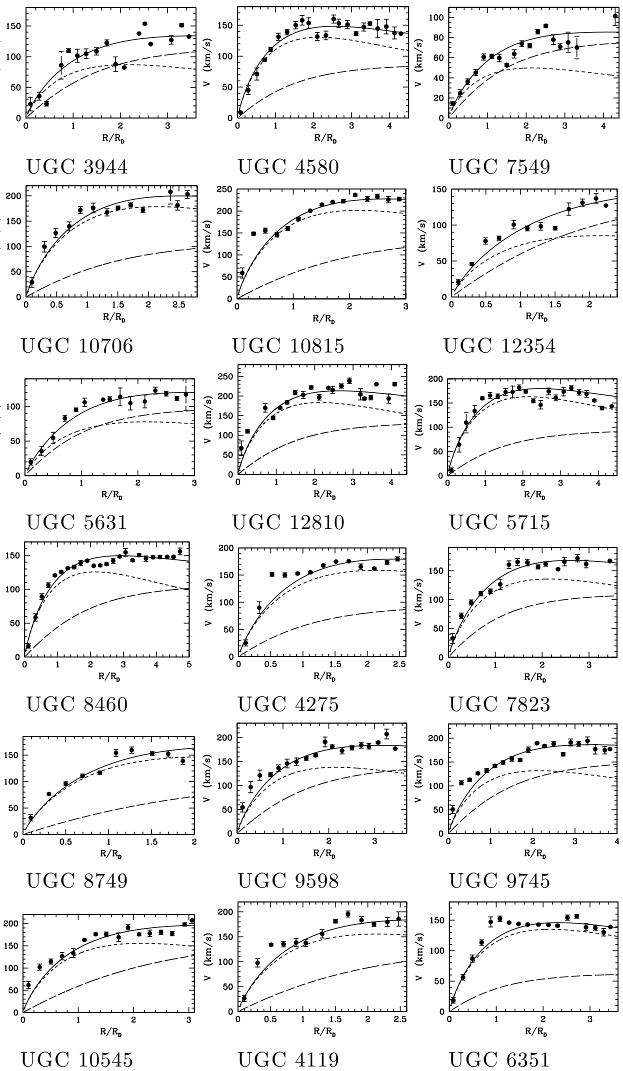

Figure 2. Mass models of the galaxies in our sample. Filled circles with error bars – the RCs, short-dashed line – the contribution of the stellar disc, long-dashed line – the contribution of the dark halo, solid line – the model circular velocity.

On average $\sigma_{\rm pho}$, the width of the distribution of the likelihood of $M_{\rm pho}/L$, at 68 per cent confidence level is between 0.1 and 0.2 dex. The uncertainty in the estimated stellar mass is mostly 'theoretical'; it has a weak dependence on the stellar mass itself [in that it increases with lower signal-to-noise ratio (S/N) photometry] and much of the variation of the errors is in spectral type: early-type galaxies have more tightly constrained masses than late-types because their SFHs are tightly constrained while the ones of late-type galaxies are less well constrained due to degeneracies with age and recent burst fractions. This dependence of the uncertainties on spectral type is the dominant source of uncertainty in the photometric mass of our sample. The contribution to the uncertainty due to photometric errors is negligible in our relatively high-S/N photometry, however, about 20 per cent of the uncertainty is due to errors in the determination of the extrapolated total magnitudes and colours.

Note that masses computed with the BC07 models are lower by 0.1–0.15 dex compared to the ones using the BC03 models. This is due to the higher red and infrared luminosities of intermediate-age ($\sim$0.8–2 Gyr) stellar populations in the newer models which owing to a larger contribution of post-AGB stars in the newer models. This particularly affects our sample of mostly relatively late-type spiral galaxies with extended SFHs and significant recent star formation.

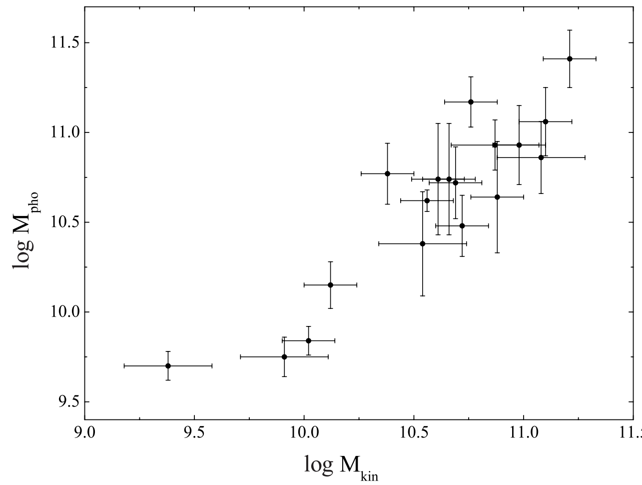

Figure 3. The *log* $M_{\rm kin}$ versus *log* $M_{\rm pho}$ relationship.

4 RESULTS

The two different estimates of the disc masses are shown in Fig. 3. A correlation yields

$$\log M_{\rm pho} = (-0.4 \pm 1.27) + (1.02 \pm 0.12) \log M_{\rm kin} \qquad (4)$$

with an rms of 0.23 dex. By considering the errors on the separate determination of $M_{\rm kin}$ and on $M_{\rm pho}$ the slope and zero-point of the relation are consistent respectively with 1 and 0. From Fig. 3 and equation (4) it is evident that the two estimates are *statistically* equivalent, i.e. *on average*: $M_{\rm pho} = M_{\rm kin}$. Within a small scatter both mass estimates are suitable measures of the true disc (stellar) mass. On an individual basis, however, the match can be less impressive given the presence of outliers up to 0.5 dex off the relationship.

Equation (4), showing that the value of the slope of relationship is near to unity, implies that the slope of any relation between a quantity Q and the disc mass $M_{\rm true}$, given by $\log Q$ = constant + $\alpha_{\rm true} \log M_{\rm true}$ does not change when we substitute the unknown $M_{\rm true}$ values with the available $M_{\rm pho}$ ones. Moreover, considering that the estimated uncertainty on $\log M_{\rm pho}$ is about 0.25 dex (a quantity much lesser than its variation among spirals), we can substitute $M_{\rm true}$ in the same way, in order to derive quantities such as the disc mass function, the halo-to-disc mass ratio or in statistical investigations of the Tully–Fisher (TF).

5 THE MASS-TO-LIGHT RATIOS IN SPIRALS

Biases, observational errors and systematics of the two determinations are independent, therefore we can define as an accurate measure of the disc mass $M_{\rm D}$ as the log average of the two different estimates:

$$\log M_{\rm D} \simeq \frac{1}{2}(\log M_{\rm pho} + \log M_{\rm kin}). \qquad (5)$$

From this we compute the spiral M/L (AB magnitudes in the Johnson filters). We find that this quantity, in spirals, ranges over 1.2 dex in the B band and 0.7 dex in the I band and, not unexpectedly, depends on the galaxy broad-band colour. In fact, we find the relation

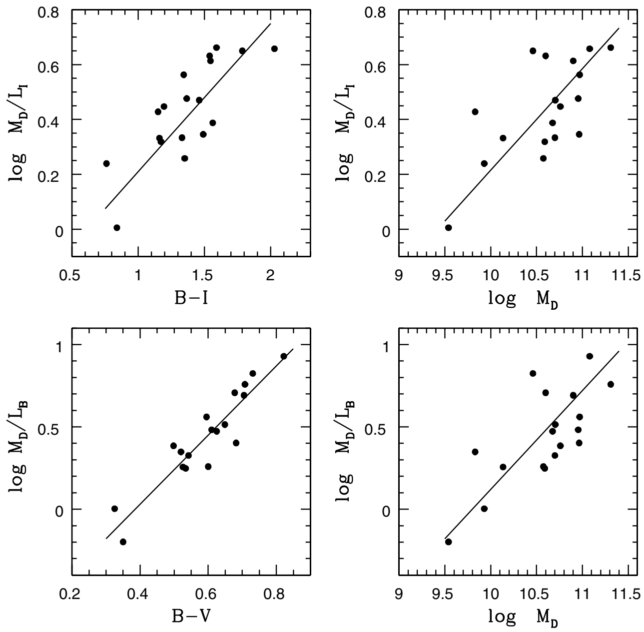

Figure 4. Mass-to-light ratios versus colour and disc mass.

(see Fig. 4)

$$M_D/L_B = (0.66 \pm 0.13) \times 10^{(2.1\pm0.3)(B-V)-0.3} \quad (6a)$$

that, within the very small rms of about 0.05 dex, reflects the fact that older stellar populations are redder and have higher M/L values. Similarly, we get

$$M_D/L_I = (1.6 \pm 0.3) \times 10^{(0.54\pm0.1)(B-I)-1} \quad (6b)$$

(about rms = 0.07 dex).

The agreement between the two determinations allows us to establish, from the *I* luminosity and *B–I* broad-band colours, a solid *statistical* estimate of the stellar mass of spirals (i.e. well within an uncertainty of 0.1 dex), that may be reduces further reduced when the whole SED is considered.

Although not derivable from basic stellar physics as the previous ones, we find that the M/L correlates with stellar mass (or luminosity) see Fig. 4,

$$M_D/L_B = (0.6 \pm 0.18)(M_D/10^9\,M_\odot)^{0.6\pm0.2} \quad (7a)$$

within an rms of 0.12 dex and

$$M_D/L_I = (0.7 \pm 0.25)(M_D/10^9\,M_\odot)^{0.35\pm0.1} \quad (7b)$$

within an rms of about 0.15 dex.

6 DISCUSSION

In this paper we find that the two main methods to measure the disc masses in spirals, namely the SED and the RC fitting are both robust, solid and consistent. In an illustrative way, in bulgeless systems, already the stellar disc mass estimates $0.66\,L_B\,10^{[2.1(B-V)-0.3]}$ and $f\,G^{-1}\,3.6\,V^2(R_D)R_D$ that we obtain from a simplified implementations of the two methods are equivalent and reliable.

On the other hand, the agreement between the two methods implies a support for (i) the existence of a inner baryon-dominated region, inside which the stellar disc saturates the gravitational potential overwhelming that of the DM halo and (ii) the assumed IMF and SFHs: significantly different choices would lead to $M_{pho} \neq M_{kin}$.

Our results confirm in a substantial way the work by Bell & de Jong (2001): they found, within reasonable assumptions, that the stellar population models predict a strong correlation between a colour of a stellar population and its stellar M/L; moreover, it emerged that the slope of such relationship is quite insensitive to the SFHs and the mean ages of galaxies. For the present sample we find (see Fig. 3) statistically relevant M/L versus colour relationships, with values of their slopes (2.1 and 0.54 in the *B* and *I* bands, respectively) in good agreement with those of Bell & de Jong (2001) (1.8 and 0.6). In addition, from the compatibility of the stellar population models with the TF relation, $\log L = a + b \log V$, Bell & de Jong claimed 'maximum disc' mass distributions. In spite of the fact that the TF relation is strongly biased by the DM in a luminosity and radial dependent way (Yegorova & Salucci 2007), our results support such view: if *on average* we assume the 'photometric' values for the disc masses and we mass model the RCs, we obtain a dark luminous mass decomposition very similar to the 'maximum disc' one.

The derived values of the disc masses imply that spiral galaxies, unlike ellipticals, have a quite wide range in the M/L values, i.e. almost a dex, reflecting an intrinsic spread in the ages of their average stellar populations, confirmed by their spread in colours. Moreover, it is evident that spiral discs are significantly less massive than the elliptical spheroids of the same luminosity. For ellipticals we have $M_{sph}/L_B \sim 4\,\lambda^{0.2}, \lambda = L_B/(2\,10^{10}\,L_B)$ (e.g. Borriello et al. 2003), with $0.5 \leqslant \lambda \leqslant 10$, while for spirals we have found (in section 3): $M_D/L_B \sim 2\,\lambda^{0.6}$ with $0.01 \leqslant \lambda \leqslant 5$. In the luminosity range where ellipticals and spiral coexist, spheroids are therefore more massive by an amount 1.5–2.5 than discs of the same luminosity.

Finally, there is one case in which M_{pho} is too uncertain to substitute the disc mass M_{true} value: the DM halo cusp-core controversy. In fact, if in the kinematical mass modelling of a RC we assume $M_{true} = M_{pho}$, we also introduce in this crucial constraint an error of a size ranging from −0.23 to +0.23 dex; this triggers a serious uncertainty and a troublesome not-uniqueness in the RCs best-fitting solutions. One practical example is ESO 287−G13 in Gentile et al. (2004), according to the results of the present work the pho estimate of the *I*-band M/L of this object ranges between 0.6 and 2.3. However, while the lowest value allows a stellar disc plus a gaseous disc and a NFW halo, the highest value, instead, leads the above model to be strongly inconsistent with the RC.

After the results of this pilot study we can claim that, by measuring the disc mass for a reasonable number of objects ($N = 100$) by means of *both* high-quality kinematics and extended SEDs, it will be possible (1) to establish an accurate colour versus disc mass relationships that, when applied to very large samples ($N > 1000$) will give a reliable (for a number of issues) measure of the latter with much less observational effort than any other method; (2) to use the agreement of the two different measures as an observational tool to investigate the SFH and the IMF of spirals.

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REFERENCES

Bell E. F., de Jong R. S., 2001, ApJ, 550, 212
Bell E. F., McIntosh D. H., Katz N., Weinberg M. D., 2003, ApJS, 149, 289

Borriello A., Salucci P., Danese L., 2003, MNRAS, 341, 1109
Bruzual G., Charlot S., 2003, MNRAS, 344, 1000
Chabrier G., 2003, ApJ, 586, L133
Courteau S., 1996, ApJS, 103, 363
Courteau S., 1997, AJ, 114, 2402
Drory N., Bender R., Hopp U., 2004, ApJ, 616, L103
Freeman K. C., 1970, ApJ, 160, 811
Gentile G., Burkert A., Salucci P., Klein U., Walter F., 2004, ApJ, 634, 145
Kassin S. A., de Jong R. S., Weiner B. J., 2006, ApJ, 643, 804
Kregel M., van der Kruit P. C., 2005, MNRAS, 358, 481
Pérez I., Fux R., Freeman K., 2004, A&A, 424, 799
Persic M., Salucci P., 1990a, MNRAS, 247, 349
Persic M., Salucci P., 1990b, MNRAS, 245, 577
Persic M., Salucci P., Ashman K. M., 1993, A&A, 279, 343
Persic M., Salucci P., Stel F., 1996, MNRAS, 281, 27
Ratnam C., Salucci P., 2000, New Astron., 5, 427
Salucci P., Persic M., 1999, A&A, 351, 442
Salucci P., Ashman K. M., Persic M., 1991, ApJ, 379, 89
Salucci P., Ratnam C., Monaco P., Danese L., 2000, MNRAS, 317, 488
Shankar F., Lapi A., Salucci P., De Zotti G., Danese L., 2006, ApJ, 643, 14
Tinsley B. M., 1981, MNRAS, 194, 63
Tonini C., Salucci P., 2004, in Dettmar R., Klein U., Salucci P., eds, Proc. Baryons in Dark Matter Haloes. SISSA, Trieste, p. 89.1
Tonini C., Lapi A., Shankar F., Salucci P., 2006, ApJ, 638, 13
Vogt N. P., Haynes M. P., Herter T., Giovanelli R., 2004, AJ, 127, 3273
Weiner B. J., Williams T. B., van Gorkom J. H., Sellwood J. A., 2001, ApJ, 546, 916
Yegarova I. A., Salucci P., 2007, MNRAS, 377, 507

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