Dark Matter in Galaxies
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The stellar Mass–to–Light ratio in disc galaxies

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Abstract. The mass and distribution of baryons in galaxies is closely related to the inferred structure of the dark halo. A robust estimate of the baryon content requires knowledge of the typical mass–to–light (M/L) ratio of the stellar component. Various arguments favour a low $M_*/L_I < 1$ for late–type spirals. We show that "bottom–light" Initial Mass Functions (IMFs) favoured by recent literature do yield so low M/L ratios, for Sbc/Sc discs. We also predict the stellar M/L ratio, and hence the zero–point of the Tully–Fisher relation, to vary significantly with Hubble disc type. Finally, we provide colour–M/L relations to derive the stellar M/L ratio from the observed photometry, for different IMFs.

A number of dynamical arguments, as well as the brightness of the observed Tully–Fisher relation when compared to the estimated stellar mass in the Milky Way or to cosmological simulations of disc galaxy formation, favour a low M_*/L_I=0.7–1 for late–type spirals (Portinari et al. 2003; hereinafter PST).

In PST we studied the stellar M/L ratio in disc galaxies, with chemo–photometric models adopting different formulations for the Initial Mass Function (IMF): the classic Salpeter (1955) IMF and a number of "bottom–light" IMFs characterized by less mass stored in low–mass, low–luminosity stars (Kroupa 1998; Kennicutt et al. 1994; Larson 1998; Chabrier 2001, 2002). While the Salpeter IMF results in far too high M/L ratios, the Kroupa IMF is just slightly too "heavy" and all the other bottom–light IMFs yield $M_*/L_I < 1$ for Sbc/Sc discs (corresponding to a "star formation history parameter" b=0.8–1 in Fig. 1).

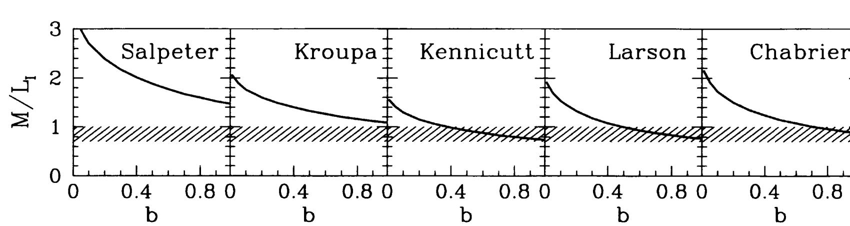

Figure 1. I–band stellar M/L ratio at varying b parameter of the star formation history. The shaded area marks the range M/L_I favoured by observations for Sbc/Sc spirals (corresponding to b=0.8–1).

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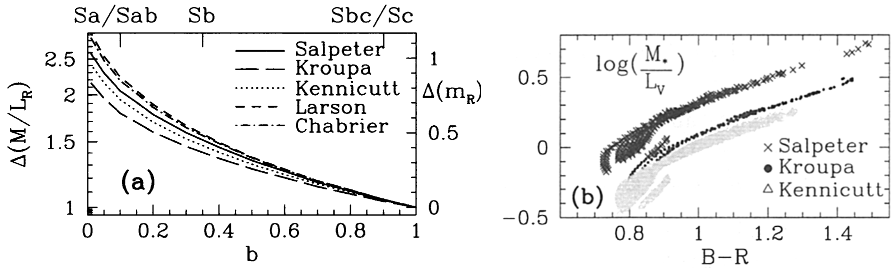

Figure 2. **(a)** Relative M/L ratio in the R–band, normalized to that of b=1 models. **(b)** Example of colour–M/L ratio relations.

Offsets in the Tully–Fisher relation with Hubble type. The stellar M/L ratio depends on the IMF but also on the star formation history of the galaxy, typically parameterized by $b = SFR/ < SFR >$, the ratio between the present–day and the average past Star Formation Rate. The Hubble sequence of galaxies is also a colour sequence, hence a sequence in characteristic star formation histories: b ~0.1 for Sa/Sab spirals, b ~0.35 for Sb, and b ~0.8–1 for Sbc/Sc (Kennicutt et al. 1994; Sommer–Larsen et al. 2003). Lower b–parameters correspond to an increasing percentage of old stellar populations, hence to an increasing stellar M/L ratio (Fig. 1). This results in systematic offsets for the luminosity zero–point of the Tully–Fisher relation. With respect to Sbc/Sc spirals, Sb's are expected to be 0.3–0.4 mag dimmer and Sa/Sab's 0.6–0.8 mag dimmer in the red optical bands (Fig. 2a), in good agreement with the empirical offsets determined by Kannappan et al. (2002).

Colour–M/L ratio relations. Colours are a probe of the star formation history of a galaxy, hence there is a tight correlation between the stellar M/L ratio and colours (Fig. 2b; Bell & de Jong 2001). To a first approximation, the IMF sets the zero–point of the M/L ratio, while the colour dependence (slope of the relation in Fig. 2b) is the same for all IMFs. In PST (Appendix B) we provide theoretical relations to infer the stellar M/L ratio from the observed colours, once an IMF is assumed.

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