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Investigation of Dust Extinction in Sb Galaxies using Scale Length Ratios[1]

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Abstract. For a sample of 16 Sb galaxies, disc scale lengths r_D in B and I are investigated in order to study the dust content. The ratios $r_D(B)/r_D(I)$ increase from 1.0 for face-on galaxies to 1.5 for edge-on galaxies. Scale length ratios derived from model images increase from face-on to edge-on view by $\leq 10\%$ only, regardless of whether the model galaxies are optically thin or optically thick.

1. Introduction

The surface brightness profile of a galaxy is produced by the spatial distribution of the stars as well as the spatial distribution of the dust. Calculations have shown that the disc scale length of a spiral galaxy is severely affected by dust extinction. According to Byun et al. (1994), B and I surface brightness profiles can be used to measure the dust content. During the last years, significant colour gradients were found in discs of spiral galaxies (see Cunow 1998 for details). It is not clear yet to what extent these gradients are caused by gradients in the stellar population, by metallicity gradients or by dust extinction.

2. The Data

For 16 Sb galaxies, B and I surface brightness profiles are investigated. The galaxies were chosen according to the following criteria: morphological type $2.0 \leq T \leq 4.0$ and total B magnitude $13 \leq B_T \leq 16$. The sample covers the whole range from face-on to edge-on view. The absolute B magnitudes lie in the range $-21.13 \leq M_B \leq -18.63$ with an average of $< M_B >= -19.85$ (a Hubble constant of $H_0 = 70\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ and a deceleration parameter of $q_0 = 0.5$ are adopted throughout this paper). None of the selected galaxies shows dust lanes.

The observations were carried out with the CCD camera on the 1.0 m telescope of the South African Astronomical Observatory (SAAO). For each galaxy, $BVRI$ images were taken and elliptically-averaged surface brightness profiles

[1]Based on observations collected at the South African Astronomical Observatory, Sutherland, South Africa.

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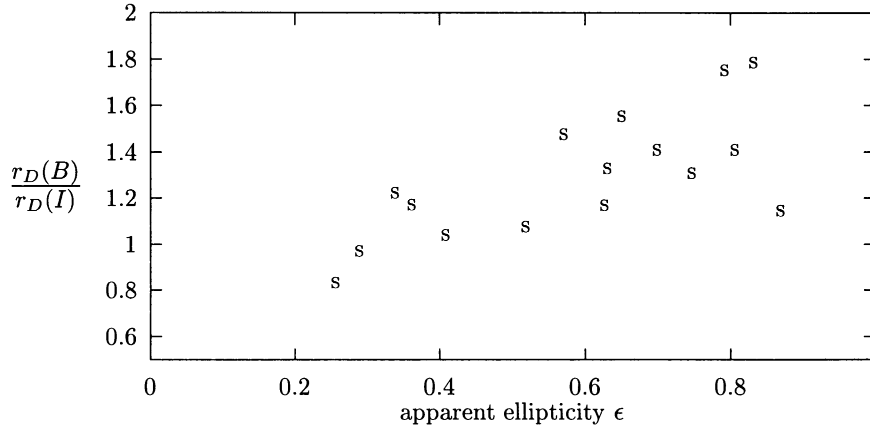

Figure 1. Disc scale length ratios plotted against the apparent ellipticity ϵ which is measured in the R band at $\mu = 21.5\,\text{mag arcsec}^{-2}$.

were measured. Details regarding the observations and data reductions can be found in Cunow (1998).

3. Disc Scale Lengths

In order to determine the disc scale length r_D, an exponential law was fitted to each profile. Because the linear parts of the profiles are the ones dominated by the disc, these parts were used for the fit. The uncertainty for r_D is $\sigma(r_D) \approx 10\%$ (Cunow 1998).

Figure 1 shows the ratio $r_D(B)/r_D(I)$ as function of apparent ellipticity ϵ, which is measured in the R band at an isophote of $\mu = 21.5\,\text{mag arcsec}^{-2}$. $r_D(B)/r_D(I)$ increases from 1.0 for face-on galaxies to 1.5 for edge-on galaxies. Figure 2 shows $r_D(B)/r_D(I)$ as a function of M_B and of $r_D(I)$ in kpc. The B magnitudes are obtained from the CCD images, and a k-correction of $k_B = 3z$ is adopted. $r_D(B)/r_D(I)$ does not show systematic changes with luminosity or with size, hence its variation with ϵ is an inclination effect and not due to a bias.

Byun et al. (1994) calculated B and I images for galaxies with a luminous stellar disc and an absorbing dust disc. The scale length of the stellar disc is assumed to be the same for B and I. For small optical depths, $r_D(B)/r_D(I)$ increases from face-on to edge-on view by $\leq 10\%$. For large amounts of dust, $r_D(B)/r_D(I)$ is constant or decreases slightly (see fig. 10 in Byun et al.).

Using the method of Byun et al., B and I images were calculated in this work with the assumption $r_D(B) = 1.14\,r_D(I)$ for the stellar disc. This provides information about the effects due to population and/or metallicity gradients. The model galaxies include a bulge, a luminous disc and an absorbing dust disc as described in Cunow (1992). Images were obtained for $\tau_0^B = 0;\ 0.5;\ 3;\ 10,$

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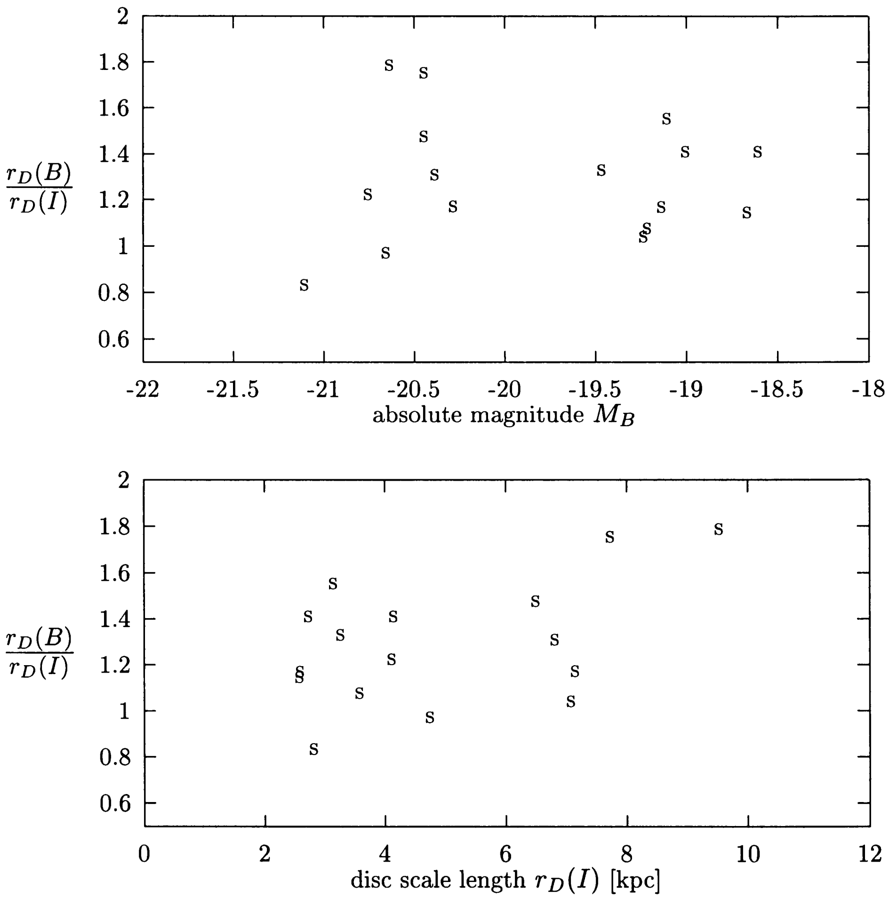

Figure 2. Disc scale length ratio $r_D(B)/r_D(I)$ plotted against the absolute B magnitude M_B and against the scale length r_D in the I filter.

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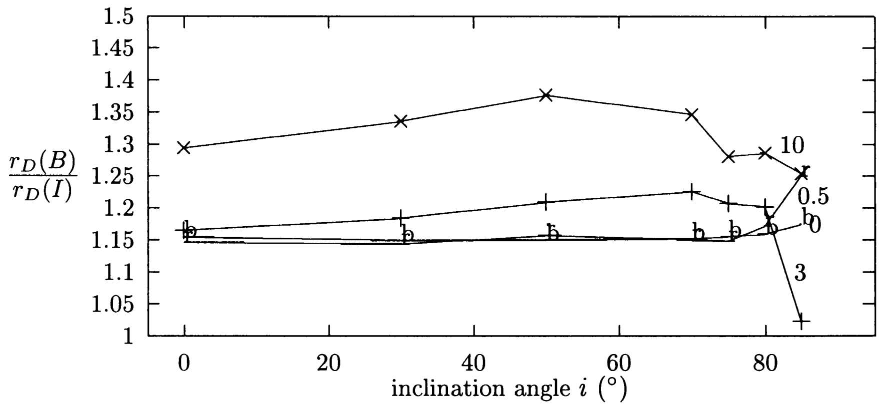

Figure 3. Scale length ratios $r_D(B)/r_D(I)$ determined from model images. $\tau_0^B = 0;\ 0.5;\ 3;\ 10$ are assumed for the central face-on optical depth in the B band. See text for details.

where τ_0^B is the central face-on optical depth in the B band. Figure 3 shows the results. $r_D(B)/r_D(I)$ changes from face-on to edge-on view by $\leq 10\%$, which is similar to the findings of Byun et al. (1994).

The model predictions are not in agreement with the observations, regardless of whether an intrinsic colour gradient is assumed and regardless of whether the model galaxies are optically thin or thick. This shows that either incorrect geometries were chosen for the model galaxies or the models as such must be modified.

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