CORRELATIONS BETWEEN $r^{1/4}$-LAW PARAMETERS FOR BULGES AND ELLIPTICAL GALAXIES

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The correlation between the effective radius r_e and surface brightness μ_e for elliptical galaxies is a fundamental scaling law that theories of galaxy formation must explain. When r_e and μ_e are derived by fitting two-parameter fitting functions such as the de Vaucouleurs $r^{1/4}$ law to brightness profiles, the errors in the parameters are strongly coupled. The purpose of this paper is to rederive the $\mu_e(\log r_e)$ relations for ellipticals and bulges, taking account of the coupling in the errors and using only high-accuracy CCD data. Our preliminary conclusions are: (1) The coupled errors are too small to affect significantly the correlation derived for elliptical galaxies. (2) The correlation for bulges is not very different from that for ellipticals, but the galaxy sample is small and the errors in the parameters are large due to the inherent uncertainty in bulge-disk decomposition.

Brightness profiles of elliptical and early-type disk galaxies are taken from all published CCD photometry and from new CCD photometry obtained with the Canada-France-Hawaii Telescope (Kormendy 1986; these proceedings). Distances were derived using group velocities and Schechter's (1980) $\gamma = 2$ Virgo Cluster infall model, assuming a Local Group infall velocity of 300 km s^{-1} and a Virgo distance of 15.7 Mpc. All magnitudes were converted to the V bandpass.

For elliptical galaxies, the $r^{1/4}$-law parameters were obtained by least-squares fits to the mean profiles. We used only the parts of the profiles that are well described by $r^{1/4}$ laws. The parameters of the bulges of disk galaxies were obtained by simultaneous decomposition of the profiles into bulge and disk components; we assumed that disks are exponential. Galaxies with non-exponential disks or small bulge-to-disk ratios cannot be decomposed in this way and were discarded.

Because of strong coupling between the two $r^{1/4}$-law parameters, the error bars in the $\mu_e - \log r_e$ diagram are not perpendicular to the coordinate axes. For each galaxy we have calculated ellipses of constant $\chi^2 = \nu^{-1}\Sigma_i(\mu_i - \mu_{fit})^2/\sigma^2$, ν = number of degrees of freedom, as follows. The point plotted for each galaxy is that of lowest χ^2. Moving out from this point along 92 radial lines in the plane, the points were found at which χ^2/ν had increased by amounts corresponding to 99 % confidence levels. An ellipse was fitted to the resulting points. The main uncertainty is in ν; this was the reason why we adopted a strict confidence level.

The $\mu_{eV} - \log r_e$ diagram for 89 ellipticals is shown in Figure 1a; μ_{eV} and $\log r_e$ are tightly correlated. The best-fitting straight line is similar to relations derived previously (e.g., Kormendy 1982). The χ^2 ellipses are small enough that this relation is securely derived. Fig. 1b shows the same diagram with the parameters for 30 bulges added. The bulges do not obviously deviate from the parameter correlation for ellipticals. However, the fitting errors are larger than for ellipticals; a larger sample of measurements is needed.

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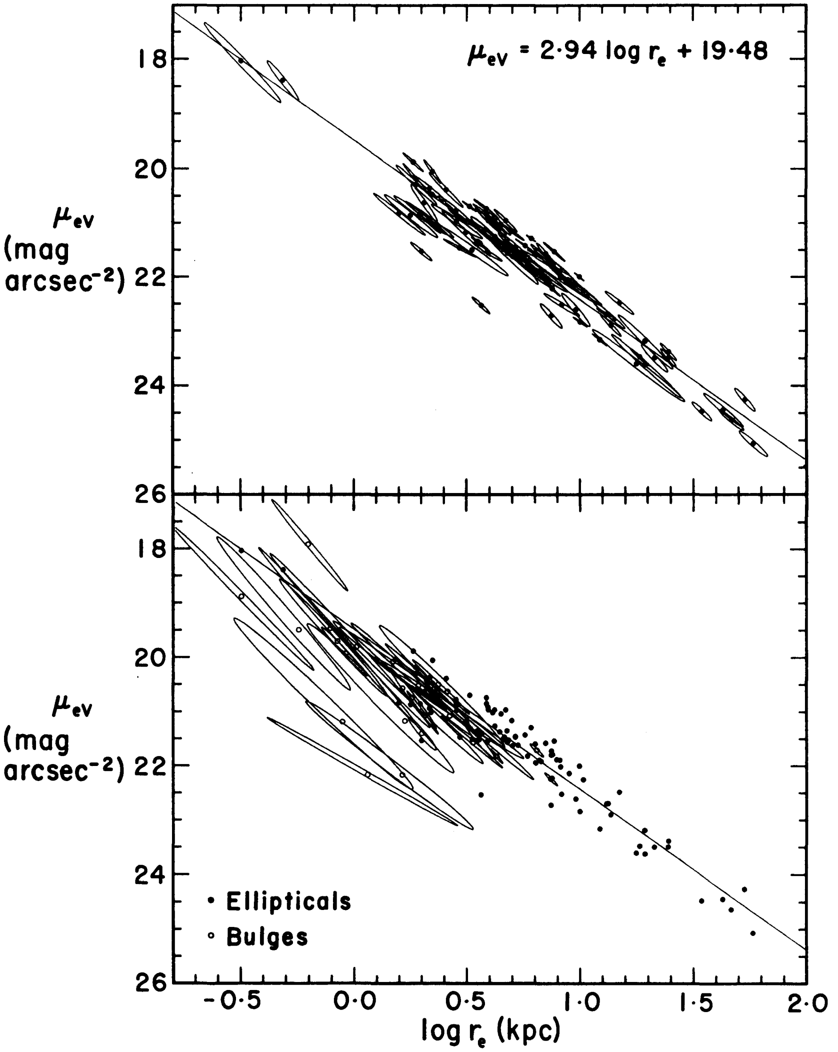

Fig. 1 – μ_{eV} *vs* log r_e with χ^2 ellipses for $r^{1/4}$-law fits to (a, upper) elliptical galaxies and (b, lower) bulges of early-type disk galaxies. The *straight line* is a least-squares fit to the points for elliptical galaxies.

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