ON THE RELATION BETWEEN RADIUS, LUMINOSITY AND SURFACE BRIGHTNESS IN ELLIPTICAL GALAXIES

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ABSTRACT. We have analyzed luminosity profiles of E galaxies in six clusters of galaxies. We have found a relationship between radius, luminosity and surface brightness for galaxies in each of the clusters. Moreover, it seems that there is a dependence of the zero point of the relation with environment. This relationship implies that there is not a universal luminosity profile for elliptical galaxies.

We have used values for effective radius r_e and M_V for each galaxy in six clusters of galaxies (Strom and Strom 1978a,b,c,) to construct a linear regression of log r_e versus M_V. The residuals of these fits are correlated with the surface brightness in the R band, μ_e, we therefore made a regression of the residuals versus μ_e which has a dispersion four times smaller. However, galaxies that deviated most from the mean relationship were found to be the most and least luminous in each sample meaning that the dependence on M_V was not properly removed. Therefore a simultaneous regression was made of the form:

$$\log r_e = A + B\, M_V + C\, \mu_e. \qquad (1)$$

This relation has an even smaller dispersion than above mentioned relations. Moreover, differences in the values for the coefficients B and C (which are equal within a few sigma) between different clusters, are much smaller than corresponding differences for correlation of residuals. Assuming then that there is a universal value for B and C, we looked for those coefficients B and C that minimize the dispersion between the different clusters. Resulting values are:

$$\tilde{B} = -0.178\ (\pm 0.002), \text{ and } \tilde{C} = 0.165\ (\pm 0.002).$$

Further, a value for $\tilde{A}$ as in Table 1 was found, from a least-squares fit of log r_e versus $\tilde{A} + \tilde{B}\, M_V + \tilde{C}\, \mu_e$, using the above values for $\tilde{B}$ and $\tilde{C}$. In Figure 1 we plot the estimated effective radius $\tilde{A} - 0.178 M_V + 0.165\mu_e$ versus log r_e with values for coefficients taken from Table 1.

Equation (1) can also be expressed as $r_e \approx L^{\alpha}\, I_e^{\beta}$ where $\alpha = 0.445$ (± 0.005) and $\beta = -0.413$ (± 0.005). A universal luminosity profile will give instead $\alpha = 0.5$ and $\beta = -0.5$. Values found for α, β imply that more luminous galaxies have shallower profiles. A further discussion on the effects of environment on relation (1) can be found in Recillas-Cruz and Serrano (1986).

T. de Zeeuw (ed.), Structure and Dynamics of Elliptical Galaxies, 389–390.

TABLE 1. Fits of log r_e versus $\tilde{A} + \tilde{B}\, M_V + \tilde{C}\, \mu_e$ for $\tilde{B} = -0.178$ and $\tilde{C} = 0.165$.

Cluster	$\tilde{A}$ (std. error)		log r_e*[a] (kpc)	log r_e**[b] (kpc)
Coma Center	-6.71	(±0.04)	0.422	0.34
Coma West	-6.66	(±0.04)	0.470	0.41
Perseus Center	-6.68	(±0.02)	0.449	0.41
Perseus Outer Region	-6.66	(±0.03)	0.469	0.46
Perseus LSB	-6.61	(±0.01)	0.522	....
Abell 2199 Center	-6.62	(±0.02)	0.510	0.45
Abell 2199 Outer Region	-6.59	(±0.03)	0.542	0.53
Abell 1367	-6.60	(±0.04)	0.525	0.56
Abell 1228	-6.57	(±0.05)	0.554	0.52
Hercules	-6.54	(±0.04)	0.587	0.55

a. Log r_e^* is evaluated from equation (1) at $M_V = -21.5$ and $\mu_e = 20$.
b. Log r_e^{**} is the value for the effective radius taken from log r_{26} by Strom and Strom (1978d), and estimated at $\mu_e = 20$.

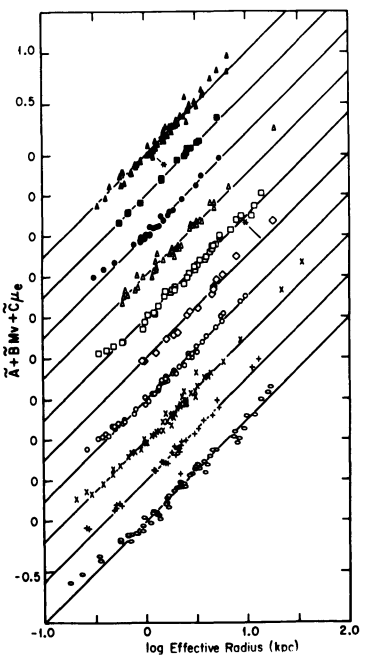

Fig. 1. Plot of the estimated effective radius A - $0.178M_V$ + $0.165\mu_e$ versus the true radius r_e. Lines correspond to the identity. Each cluster has its origin shifted as indicated to avoid overcrowding of data points. Filled symbols correspond to central regions of Coma (Δ), Perseus ( ) and Abell 2199 (O). Open symbols (Δ, , O) correspond to outer regions of same clusters. Other symbols are: ( ) for Perseus LSB, ( ) for Abell 1367 (+) for Abell 1228 and (O) for Hercules.

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