The Fundamental Plane for HydraI and Coma

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Abstract. We have analyzed the the Fundamental Plane (FP) (in Gunn r) and the Mg_2–σ relation for E and S0 galaxies in the central parts of the clusters HydraI and Coma. For the HydraI sample, we have also studied the FP in Johnson B and Johnson U.

1 Introduction

The Fundamental Plane (FP) for E and S0 galaxies, $\log r_{\mathrm{e}} = \alpha \log \sigma + \beta \log <\!I\!>_{\mathrm{e}} + \gamma$, (Djorgovski & Davis 1987; Dressler et al. 1987) may provide constraints on galaxy formation and evolution. Further, the FP can be used to determine relative distances, if it is universal at least to some accuracy. In both contexts comparison of the FP for large samples of galaxies in different clusters provide essential knowledge on how similar (or different) the stellar populations of E and S0 galaxies are in different cluster environments. The Mg_2–σ relation (Burstein et al. 1988) gives additional information about the stellar populations.

Observational data for the clusters HydraI and Coma are used in this paper.
HydraI: 45 E and S0 galaxies within the central $68' \times 83'$. CCD surface photometry in Gunn r and Johnson B, and for 19 galaxies also in Johnson U (Milvang-Jensen & Jørgensen, in prep.). Velocity dispersions and Mg_2 indices from Jørgensen et al. (1995b) and Milvang-Jensen & Jørgensen (in prep.). The sample is 80% complete to m_{T} (Gunn r) $= 14\overset{\mathrm{m}}{.}5$ ($M_{\mathrm{T}} = -20\overset{\mathrm{m}}{.}0$ with $H_0 = 50\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$).
Coma: 116 E and S0 galaxies within the central $64' \times 70'$. CCD surface photometry in Gunn r from Jørgensen et al. (1995a). Velocity dispersions and Mg_2 indices from the literature and Jørgensen (in prep.). The literature data have been calibrated to a consistent system and aperture corrected (cf. Jørgensen et al. 1995b). The sample is 93% complete to m_{T} (Gunn r) $= 15\overset{\mathrm{m}}{.}05$ ($M_{\mathrm{T}} = -20\overset{\mathrm{m}}{.}75$).

2 The Fundamental Plane

We fit the FP by minimization of the sum of the absolute residuals perpendicular to the plane. For photometry in Gunn r we find

$$\begin{array}{llllll} \text{HydraI}: & \log r_{\mathrm{e}} = & 1.51 \log \sigma & -\ 0.80 \log <\!I\!>_{\mathrm{e}} + \gamma_{\mathrm{cl}} & & \sigma_{\mathrm{fit}} = 0.108 \\ & & \pm\ 0.17 & \pm\ 0.05 & & \\ \text{Coma}: & \log r_{\mathrm{e}} = & 1.28 \log \sigma & -\ 0.83 \log <\!I\!>_{\mathrm{e}} + \gamma_{\mathrm{cl}} & & \sigma_{\mathrm{fit}} = 0.095 \\ & & \pm\ 0.04 & \pm\ 0.03 & & \end{array} \qquad (1)$$

The uncertainties were derived by a bootstrap procedure. $\sigma_{\rm fit}$ is the rms scatter in the $\log r_{\rm e}$ direction. Figure 1 shows the FP edge-on. The coefficients of the two FPs are not significantly different. If we fix β at the value -0.82 and only fit α, we find $\alpha_{\rm HydraI} = 1.64 \pm 0.16$ and $\alpha_{\rm Coma} = 1.32 \pm 0.05$. The difference, $\Delta\alpha = 0.32 \pm 0.17$, is significant at the 2 sigma level.

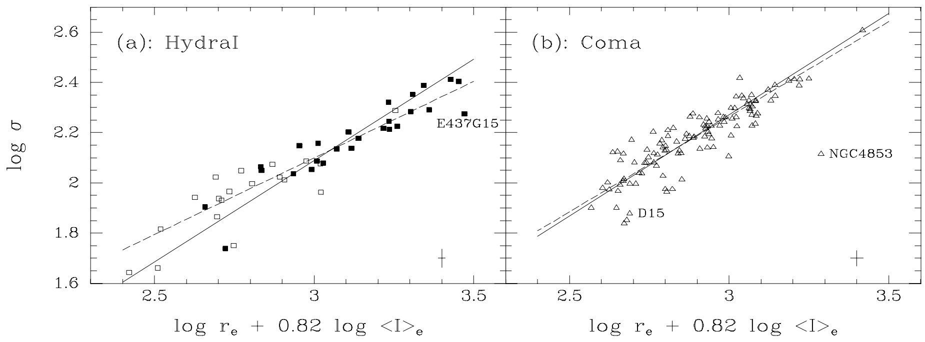

Fig. 1. The FP in Gunn r seen edge-on. $r_{\rm e}$ is in arcsec. Solid line: $\alpha = 1.24$ (Jørgensen et al. 1996). Dashed lines: (a) $\alpha = 1.64$, (b) $\alpha = 1.32$. Filled boxes – HydraI galaxies $M_{\rm T} \leq -20.^{\rm m}75$. Open boxes – HydraI galaxies $M_{\rm T} \geq -20.^{\rm m}75$. Triangles – Coma galaxies. E437G15, D15 and NGC4853 deviate strongly from the $\rm Mg_2$–σ relation.

The apparent difference is mostly due to the difference in limiting magnitude for the two samples. If the galaxies below the Coma completeness limit are omitted from the two samples, the difference is non-significant, $\Delta\alpha = 0.06 \pm 0.25$. Thus, no significant differences in the coefficients for the FP can be detected. Differences in α on the 10% level cannot be ruled out. A fit to the two clusters together gives $\alpha = 1.34 \pm 0.05$, $\beta = -0.83 \pm 0.03$. This is not significantly different from the coefficients found by Jørgensen et al. (1996), $\alpha = 1.24 \pm 0.07$, $\beta = -0.82 \pm 0.02$, based on 226 E and S0 galaxies in 10 clusters.

From the photometry in Johnson B and Johnson U for galaxies in HydraI we find that the scatter around the FP is 0.110 in Johnson B, and 0.068 in Johnson U (for 19 galaxies). The scatter in Gunn r for the same sub-sample of 19 galaxies is 0.089. These results mean that the intrinsic scatter in the three passbands is the same. This sets limits on the internal extinction in the galaxies. It may also be used to set limits on age and metalicity variations as sources of the scatter.

3 The $\rm Mg_2$–σ Relation

The $\rm Mg_2$ line index has been measured for 42 of the HydraI galaxies, and 113 of the Coma galaxies. The slopes of the $\rm Mg_2$–σ relations for the two clusters are very similar. We find 0.171 ± 0.037 for HydraI and 0.186 ± 0.013 for Coma; cf. Fig. 2. This is also in agreement with the results from Jørgensen et al. (1996),

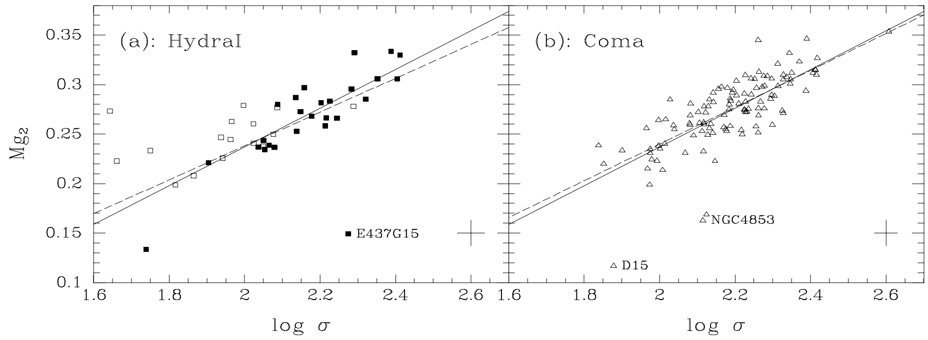

Fig. 2. The Mg_2–σ relation. Three values of the slope are shown: Solid line: 0.196 (Jørgensen et al. 1996). Dashed lines: (a) 0.171, (b) 0.186. Filled boxes – HydraI galaxies $M_T \leq -20\overset{m}{.}75$. Open boxes – HydraI galaxies $M_T \geq -20\overset{m}{.}75$. Triangles – Coma galaxies. E437G15 has a strong disk and $v_{rot} > 150\,\mathrm{km\,s^{-1}}$. D15 and NGC4853 have post starburst spectra.

0.196 ± 0.016. Using the latter, we find that also the zero points for the two clusters are the same: -0.155 ± 0.007 for HydraI and -0.153 ± 0.003 for Coma. We conclude that the galaxies in the central parts of the HydraI cluster and the Coma cluster follow the same Mg_2–σ relation.

4 Conclusions

The FP for E and S0 galaxies in the HydraI cluster and the Coma cluster have been compared. Also, the Mg_2–σ relation has been studied. No significant differences in the coefficients for the FP can be detected, though differences in α on the 10% level cannot be ruled out. The distributions of galaxies within the FP are similar for the two clusters. The galaxies in the two clusters follow the same Mg_2–σ relation. From surface photometry of the galaxies in the HydraI sample in Gunn r, Johnson B and Johnson U we find, that the scatter of the FP does not depend significantly on which passband is used. This shows that internal extinction in the galaxies cannot be a major source of the scatter. It may also be used to set limits on variations in mean age and metal content.

References

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