Constraining the ages and metallicities of cluster ellipticals

R.P.Saglia, D. Mehlert, R. Bender

Institut für Astronomie und Astrophysik
Scheinerstraße 1, D-81679 Munich, Germany

and

Gary Wegner

Dept of Physics and Astronomy, Dartmouth College
Wilder Lab., Hanover, NH 03755, U.S.A.

ABSTRACT

We review the evidence for cluster early-type galaxies being old with a moderate spread in age. We present the results of a spectroscopic long-slit survey of Coma Cluster galaxies. We derive radially resolved major axis profiles of the Hβ, Mg and Fe line indices for 35 early-type Coma galaxies. Using available stellar population models of elliptical galaxies we discuss the distribution in age and metallicity of the central regions of the galaxies implied by the data. High mean ages (8 Gyrs) with $\approx$ 30% scatter are assigned to pure ellipticals, while galaxies with disks span the wide range of ages 2-12 Gyrs. The relatively small range in luminosities covered by the sample explains the restricted range of metallicities derived (from -0.1 to 0.5 dex relative to solar using current population synthesis models). Bright galaxies appear to be up to $\approx$ 0.6 dex overabundant in Mg with respect to Fe; galaxies with disks have nearly solar ratios (0 to 0.2 dex). On the mean, the index gradients imply that the outer regions of early-type galaxies are metal poorer (0.1 dex per decade in radius) and older (0.04 dex per decade in radius) than the inner parts. We examine the (*global* and *local*) Mg-σ and the Fundamental Plane relations defined by the 35 galaxies of the sample. The intrinsic scatter of both relations is small, implying tight constraints on the scatter in age and metallicity of the galaxies at a fixed σ. These constraints are marginally consistent with the analysis of the Mg, Fe and Hβ indices for the sample of pure ellipticals, but much tighter for the S0 sample. We conclude that recent (small) episodes of star formation might be contaminating the Hβ values of galaxies which have disk components. The *local* Mg-σ relation is similar in slope and zero-point to the *global* one on the mean, with S0 galaxies having shallower, and E galaxies steeper, local slopes than the mean. Our data rule out monolithic collapse formation models à la Carlberg and are qualitatively in agreement with the expectations of the gaseous merging picture.

Subject headings: galaxies: early type - galaxies: clusters - galaxies: stellar populations

1. Introduction

Elliptical galaxies have red colors, no cold gas and no regions of star formation and therefore have been always considered the prototypes of very old systems. This picture has been questioned in the last years, when their line indices have been measured and analyzed. Line indices are one of the most powerful tools to investigate the stellar populations of early-type galaxies, and therefore constrain their star formation history and the models of galaxy formation. They have superior predictive power than optical (and infrared) colours, which might be affected by dust (Goudfrooij and De Jong 1995, Wise and Silva 1996). A careful selection of pairs of indices with nearly orthogonal dependences on metallicities and ages, like Mg_2, Mg_b, Fe, Hβ, Hδ and Hγ (Worthey 1994) overcomes the problem of the metallicity-age degeneracy, allowing in principle the determination of both quantities. Using the simple stellar population models of Worthey (1994), Gonzales (1993) studied the Hβ, Mg and Fe indices of a sample of early-type galaxies, mainly from the field and with no well-defined selection criterion. He found that the objects span a wide range of central Hβ values and concluded that early-type galaxies can be as old as 12 Gyrs and as young as 2 Gyrs. Tantalo, Chiosi and Bressan (1998) reexamined the sample reaching the same conclusion.

However, the evidence for the stellar populations of *cluster* ellipticals being old and with a small scatter in age is compelling. The small scatter of the color-magnitude relation (Bower, Lucey and Ellis, 1992; Bower, Kodama and Terlevich 1998) at low redshifts, the evolution of the slope, zeropoint and scatter of the same relation up to redshift $z \approx 1$ (Standford, Eisenhardt and Dickinson 1998), the small scatter of the Fundamental Plane (Jørgensen, Franx and Kjærgaard 1996) and the evolution of its zeropoint with redshifts up to $z \approx 0.8$ (van Dokkum and Franx 1996, Kelson et al. 1997, Bender et al. 1998, van Dokkum et al. 1998), the evolution of the Mg-σ relation with redshift (Bender, Ziegler and Bruzual 1996; Ziegler and Bender 1997) are all consistent with passive evolution and high ($z > 2$) formation redshift. In addition, the analysis of the central line indices of a complete sample of early-type galaxies in the Fornax cluster (Kuntschner and Davies 1998) points to high formation ages of the ellipticals of the sample, with only S0 galaxies showing evidence for recent star formation events.

This apparent conflict might be partly due the intrinsic problems connected to the measurement and interpretion of line indices. The Hβ index might be partially filled, if diffuse gas emission is present (Davies, Sadler and Peletier 1993). The correction based on the estimate of the OIII equivalent width is highly insecure (Carrasco et al. 1996). A promising way is the use of the $H_{\gamma A}$ index, which is less affected by emission (Kuntschner and Davies 1998). The index Mg_b might also be affected by emission contaminating the side bands in the centers of ellipticals (Goudfrooij and Emsellem 1996). On the theoretical side, simple stellar population models, with one single age and one metallicity, are certainly inadequate to describe complex systems like early-type galaxies. The objects are expected to have a spread in metallicity and age (Greggio 1997). In addition, different combinations of age- and metallicity-sensitive indices, like Hβ-Mg_2 or H$\beta-$ <Fe>, fail to give consistent estimates of the ages and the metallicities of the objects (Trager 1997). This stems mainly from the $\alpha-$elements overabundance problem: elliptical galaxies appear to have Mg/Fe ratios larger than solar, while Worthey's (1994) models assume solar abundances. Models addressing this difficulty are being constructed (Tantalo, Chiosi, Bressan 1998). Finally, recent (small) episodes of star formation might enhance the values of Hβ, biasing the estimate of the mean age of the stellar populations (de Jong and Davies 1997).

The conflict might however reflect a physical difference. In particular, the environment might play a role and/or early-type galaxies with disks might be younger than pure ellipticals. Semi-analytical models in the framework of hierarchical clustering predict a marked difference between the properties of early-type galaxies in clusters and in the field (Kauffmann 1996). In these models ellipticals in high density environments have old mean stellar ages (8-12 Gyrs), while bright field ellipticals have younger stellar populations (5-8 Gyrs). In both cases S0 galaxies show a larger spread in mean ages.

The Coma cluster, the richest cluster in the local universe, is the ideal place to test the theories of galaxy formation as a function of environmental density and morphological type. We have collected long slit major axis spectroscopy for 35 E and S0 galaxies, with distances from the cluster centers corresponding to a range of 3 dex in cluster density (Mehlert et al. 1998a, Paper I). A detailed discussion of their stellar population metallicities and ages is given in Mehlert et al. (1998b, Paper II). Two objects of the sample, which appeared to have decoupled cores, have been discussed in Mehlert et al. (1998c, MSBW98). Here we summarize the main results of these studies. In §2 we discuss the distribution of the central values of the line indices measured, their radial gradients and the interpretation in terms of ages and metallicities. In §3 we consider the global constraints on the spread in age and metallicity of our sample of galaxies coming from the tight Mg-σ and Fundamental Plane correlations. Conclusions are drawn in §4.

2. Line indices and gradients

We selected 27 early-type galaxies from the inner square degree of the Coma cluster, and 8 in the outer parts. Comparison with the catalogue of Jørgensen and Franx (1994) shows that the (inner) sample is complete to $M_R = 12.63$ and 42% complete in the range $12.63 < R_T < 14.06$, or $R_T < -21.73$ with $H_0 = 50$ Mpc/km/s and cz_{CMB}=7200 km/s. The outer sample is complete to $R_T = 12.96$. The spectroscopic observations were performed at the 3.5 Calar Alto telescope, the 2.7 m McDonald telescope, and at the 2.4 m telescope of the Michigan-Dartmouth-M.I.T Observatory. Long-slit spectra along the major axis of the galaxies were taken around the Mg line, encompassing Hβ and the Fe lines. After standard reduction the spectra were analyzed to derive kinematic profiles (rotational velocities and velocity dispersion profiles along the line of sight plus higher orders of the velocity distribution, see Bender, Saglia and Gerhard 1994) and line indices profiles of Hβ, Mg$_2$, Mg$_b$ and $\langle$Fe$\rangle$ (following Faber et al. 1985, and Worthey 1992). Details of the sample selection, observations and data reduction can be found in Paper I.

Figure 1 shows the distribution of the central values of the indices [MgFe] (defined as $\sqrt{\mathrm{Mg}_b\langle\mathrm{Fe}\rangle}$, following Gonzales 1993) and Hβ averaged over 0.5 r_e (where r_e is the half-luminosity radius) of the 35 early-type galaxies of the Coma Cluster sample. The Hβ values of the galaxies classified as pure ellipticals span a rather restricted range, with $<\mathrm{H}\beta>\approx 1.8$. In contrast, galaxies classified as S0 can have Hβ values as high as 2.5. This is similar to what found by Kuntschner and Davies (1998) for a sample of early-type galaxies of the Fornax cluster, but contrasts with Gonzales (1993) and Faber et al. (1995) who find that (mainly *field*) early-type galaxies show a large variation in Hβ. Further investigations are needed to clarify whether *disks* are present also in the galaxies of this sample (De Jong and Davies 1997). Using the simple stellar population models of Worthey (1994), the central values of the indices [MgFe] and Hβ can be converted into (indicative) ages and metallicities. The low values of the Hβ indices of the elliptical galaxies in the sample translate in a large mean age ($t > 6$ Gyr for all except one object) with 40% spread. In contrast, S0 galaxies span a range in ages between 2 and 12 Gyr. An anti-correlation between the ages and metallicities is present which may be a result of the superposition of the two classes of objects. It is however worth stressing the limitations of the simple stellar population models. Single age, single metallicity models cannot be expected to describe in detail the early-type stellar populations, which probably have a spread both in age and metallicity (Greggio 1997). The large Mg values of bright ellipticals can be obtained only with extreme ages, which are larger than the age of the Universe (Trager 1997). Ages and metallicities derived using different pairs of indices (Mg_b-$H\beta$, Fe-$H\beta$) are not consistent (Gonzales 1993).

Some of the problems arise from the α-elements overabundance that bright elliptical galaxies appear to have. Figure 2 shows the distribution of the central values of Mg_b and $\langle Fe \rangle$. While (small) galaxies with disks have a distribution nearly compatible with solar ratios, (bright) ellipticals have Mg/Fe index ratios much larger than solar. The Mg/Fe index ratios anticorrelate with the central values of $H\beta$: the highest ratios are found in large (elliptical) systems with low $H\beta$. Similarly, galaxies with large central velocity dispersions have the largest Mg/Fe ratios. Similar correlations have been found by Fisher, Franx and Illingworth (1995). When interpreted using Worthey's (1994) grid of models following the method outlined by Greggio (1997), the Mg/Fe ratios of the brightest galaxies of the sample imply an overabundance of the Mg elements $[Mg/Fe] = \log((Mg/Fe)/(Mg/Fe)_\odot)$ up to 0.6 dex. The less massive S0 are compatible with solar ratios or a slight overabundance (0.2 dex).

Figures 3 and 4 show the correlations between the logarithmic gradients of the Mg_b and Fe indices with their central values. Large galaxies with large values of the central indices have the largest (negative) gradients, while smaller (S0) galaxies have nearly flat index profiles. Similar correlations have been found for 114 and 42 elliptical galaxies in the field by Gonzales and Gorgas (1996) and Carollo, Danziger and Buson (1993), respectively. In contrast, no obvious correlation between the $H\beta$ gradients and other galaxy pa-

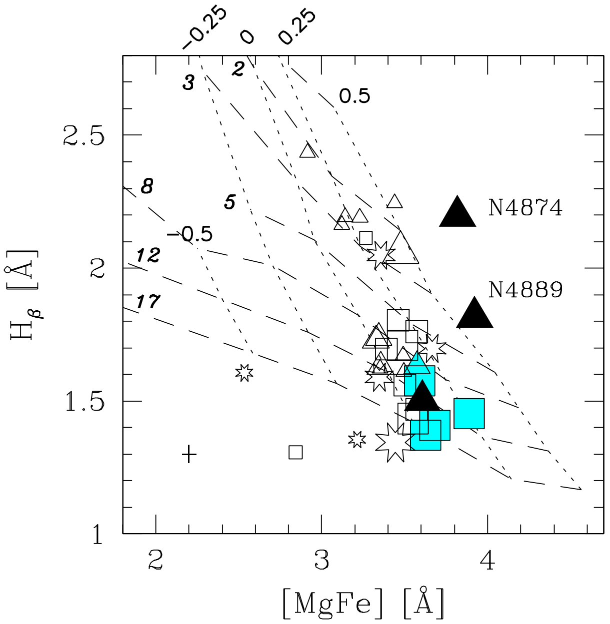

Fig. 1.— The distribution of the central values of the indices [MgFe] and $H\beta$ averaged over 0.5 r_e of the 35 early-type galaxies of the Coma Cluster sample. Filled triangles indicate cDs, open squares Es, open triangles S0s, open stars E/S0s. The size of the symbols is proportional to the luminosity of the galaxies. Galaxies with central disks are filled in gray. Shown are the lines of constant metallicity (long dashed) and age (dotted) of the models of Worthey (1994). The cross shows the typical errors.

rameters is found. Finally, Fig. 5 shows the correlation between the central value of the Mg/Fe ratio and its gradient. Galaxies with high central overabundances tend to reduce them in the outer parts. The correlation is however dominated by the galaxies with central disks. Without them, the gradients are small on the mean, as found by Davies, Sadler and Peletier (1993). Finally, no strong correlation is found between gradients and projected distances D to the cluster center, after the correlations previously discussed are taken into account. Fig. 6 shows the residuals as a function of D, where a weak tendency (at the 1.5 σ level) is found for galaxies in the outer parts of the cluster to have slightly steeper gradients. A larger sample of galaxies in the outer regions of the cluster is needed to assess this result on a firmer statistical basis.

Using Worthey's (1994) models to translate the mean observed gradients in Mg_b, Fe and $H\beta$ into age and metallicity gradients inside the galaxies, we find $\Delta \log Z/\Delta \log(r/r_e) = -0.12$ (with 0.05 dex range) and $\Delta \log t/\Delta \log(r/r_e) = 0.04$ (with 0.03 dex range) when considering the Mg_b profiles. We derive $\Delta \log Z/\Delta \log(r/r_e) = -0.04$ (with 0.26 dex range) and $\Delta \log t/\Delta \log(r/r_e) = -0.005$ (with 0.02 dex range) when considering the Fe profiles. The inner regions of the early-type galaxies of Coma appear to be metal richer and slightly younger than the outer parts. The steeper mean metallicity gradient derived by Daveis, Sadler and Peletier (-0.23) derived for a sample of 13 bright ellipticals using Mould (1978) models and Mg_2 profiles stems mainly from the correlations between the gradients and their central values (see above).

3. The Mg-σ and Fundamental Plane relations

The high signal-to-noise ratio of the collected spectra (see Paper I) allows the study of the Mg-σ and Fundamental Plane correlations with nearly noise-free data and therefore to assess their intrinsic scatter. Fig. 7 shows the Mg-

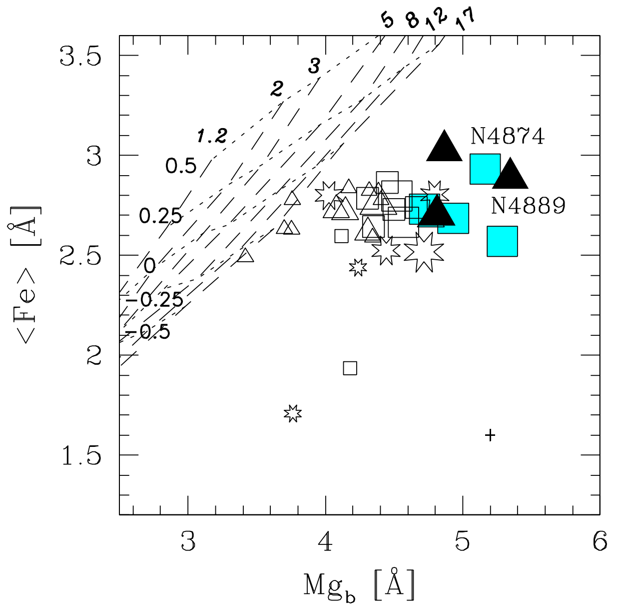

Fig. 2.— The distribution of the central values of Mg_b and ⟨Fe⟩. Symbols and lines as in Fig. 1.

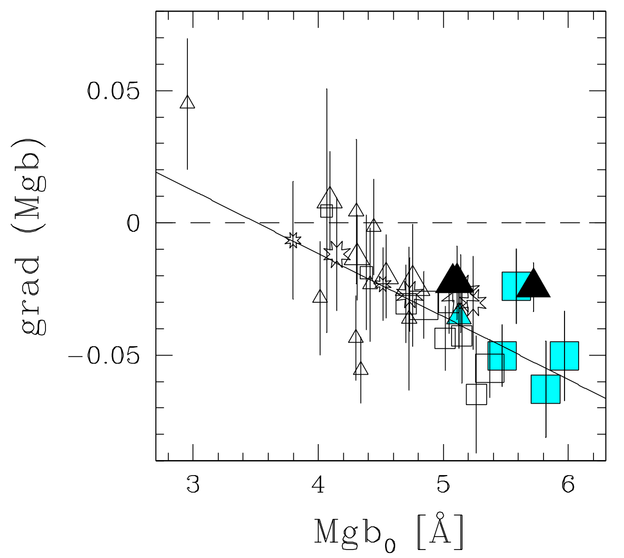

Fig. 3.— The logarithmic gradients of Mg_b as a function of the central values of the index. Symbols as in Fig. 1. The line shows the linear fit to the data.

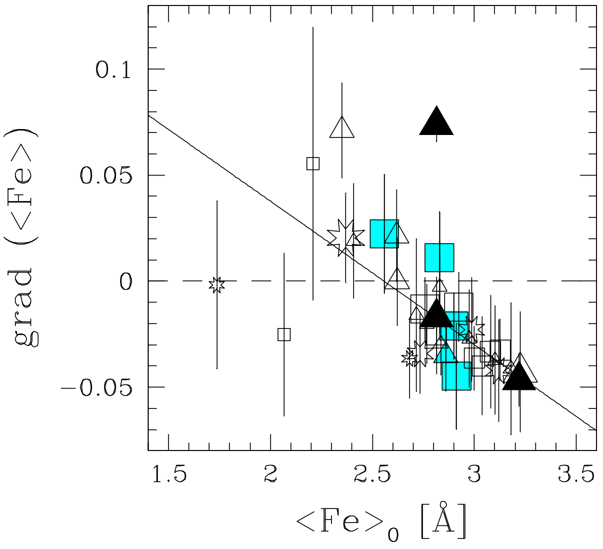

Fig. 4.— The logarithmic gradients of <Fe> as a function of the central values of the index. Symbols as in Fig. 1. The line shows the linear fit to the data.

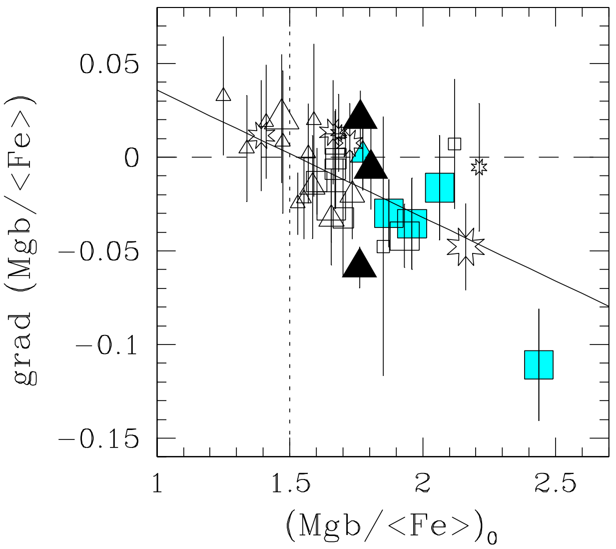

Fig. 5.— The gradient of the Mg to Fe ratio as a function of its central value. Symbols as in Fig. 1. The full line shows the linear fit to the data. The dotted line shows the solar value.

σ correlation as a function of the radius xr_e inside which the mean values of Mg_b' (where $Mg_b' = -2.5\log(1 - \mathrm{Mg}_b/32.5)$ following Colless et al. 1998) and σ have been computed. A linear fit to the data averaged over $0.1r_e$ and excluding the cD galaxies NGC 4874 and NGC 4889 gives the relation $\mathrm{Mg}_\mathrm{b}^{'} = 0,137(\pm 0,020)\log\sigma_\circ - 0,155(\pm 0,046)$, which agrees well with the recent determination of Colless et al. (1998), based on 500 early-type galaxies in 84 clusters. The slope and zeropoint of the relation vary in the range (0.116, 0.137) and (−0.108, −0.155) when x covers the range (0.1,2). The scatter of the relation is intrinsic (the errors contribute less than 35% to the measured scatter) and approximately constant at 0.009-0.01 mag, being 1/4 smaller than the estimate by Colless et al. (1998). No large systematic difference in the slope, zeropoint and scatter is detected splitting the sample according to the morphological type or according to the projected cluster distance. Moreover, no systematic trend of the residuals from the relation is detected with photometric or kinematic parameters of the galaxies, nor with other central line indices. The *local* correlation between Mg_b' and σ inside each galaxy follows the *global* relation *on the mean*, but with a variety of slopes. In particular, S0 galaxies have on the mean shallower local Mgσ relations than bright ellipticals.

Fig. 8 shows the edge-on view of the Fundamental Plane as a function of the radius xr_e inside which the mean value of the velocity dispersion has been determined. We used the equation $\log r_e = 1.256\log\sigma + 0.345SB_e - 9.041$ as determined by Jørgensen, Franx and Kjærgaard (1993) for the Coma cluster. Excluding the galaxies IC 4051 and NGC 4944 and taking into account the errors, we determine the intrinsic scatter to be 0.052 dex in $\log r_e$, or 12.7 % in distance when using the central values of σ ($x = 0.1$ or 0.25). The scatter increases for larger averaging radii. Using $x = 0.1$, the intrinsic scatter is reduced to 8% if only the 26 galaxies of the inner sample (D< $40'$) are taken into account. The

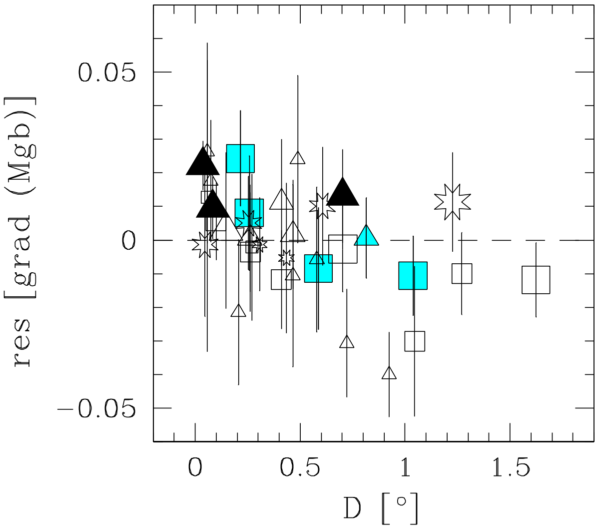

Fig. 6.— The residuals from the correlation between Mg_b gradients and their central values as a function of the projected cluster distance. Symbols as in Fig. 1.

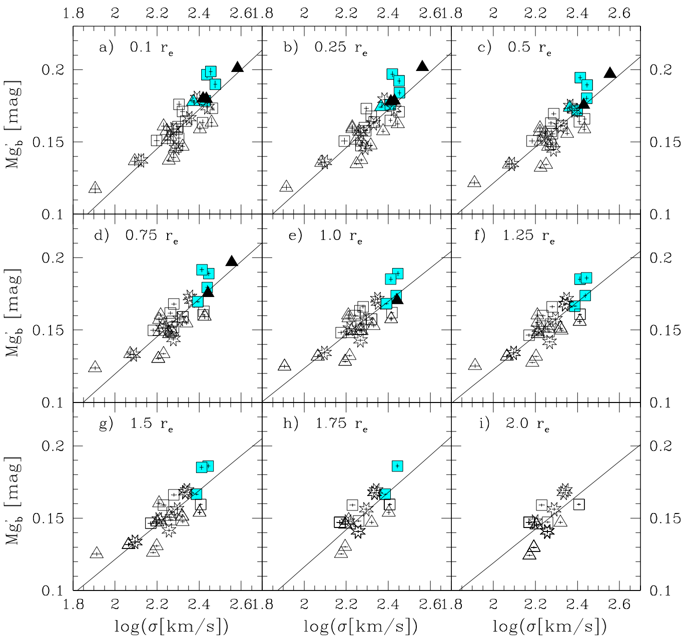

Fig. 7.— The $Mg'_b-\sigma$ relation for different values of the radius xr_e inside which mean values of Mg'_b and σ are computed. The lines show the linear fits to the data. Symbols as in Fig. 1.

residuals from the FP do not correlate strongly with the kinematic and photometric parameters, or the residuals from the Mg-σ relation, or the central line indices. A possible trend with rotational support and anisotropy is suggested. In addition, the galaxies with the largest deviations from the Fundamental Plane also appear to have large deviations from the Mg$-\sigma$ relation.

The combined intrinsic scatter of the Mg$-\sigma$ and Fundamental Plane relations can be used to constrain the global scatter in age and metallicity of the galaxies of the sample. Following Colless et al. (1998), we assume that the observed scatter in the Mg$-\sigma$ and the FP relation is due totally to variations in the metallicity and age of the galaxies at a given σ. Using the same equations of Colless et al. (1998), Fig. 9 shows that the small scatter of the Mg-σ and Fundamental Plane allows for no more than $\approx$ 20% scatter in relative metallicity and age at a given σ. The constraint is even tighter for the inner sample, where $\delta t/t \approx 12\%$. This (upper) limit is barely compatible with the scatter in age and metallicity inferred from Fig. 1 (which, however, does not take into account the errors of the measurements and the range of σ present) for the elliptical galaxies of the sample, but is a factor 2 smaller than the scatter in age derived for the S0 galaxies. This underlines that the Hβ index might not be a good indicator of the mean age of a stellar population. As shown by de Jong and Davies (1997), contamining an old stellar population with a up to 20% of its mass with a younger component can produce high global values of Hβ.

4. Conclusions

We summarize the results of the analysis of the profiles of the Mgb, $\langle$Fe$\rangle$ and Hβ line indices for a (nearly complete) sample of 35 early-type galaxies in the Coma cluster as follows.

1. Elliptical galaxies span a narrow range of central Hβ values ($\approx$ 1.8). In contrast, S0 galaxies span a much wider range (1.8-2.5).

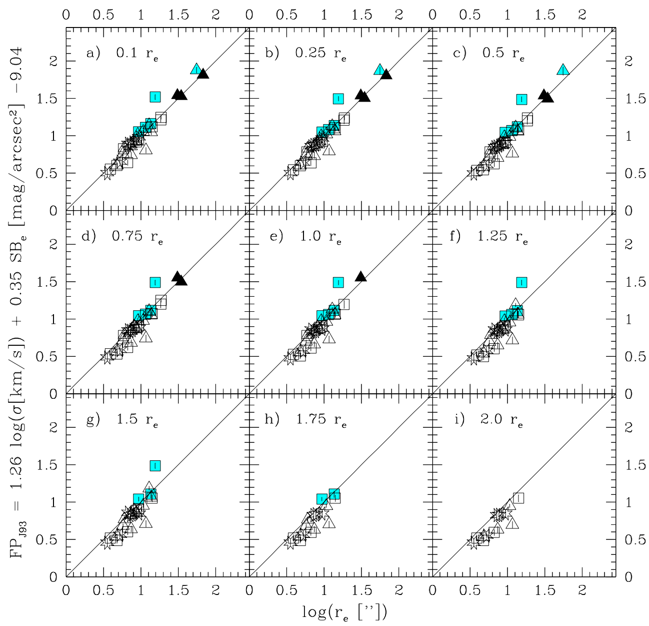

Fig. 8.— The edge-on view of the Fundamental Plane as a function of the radius xr_e inside which the mean value of the velocity dispersion has been determined. Symbols as in Fig. 1.

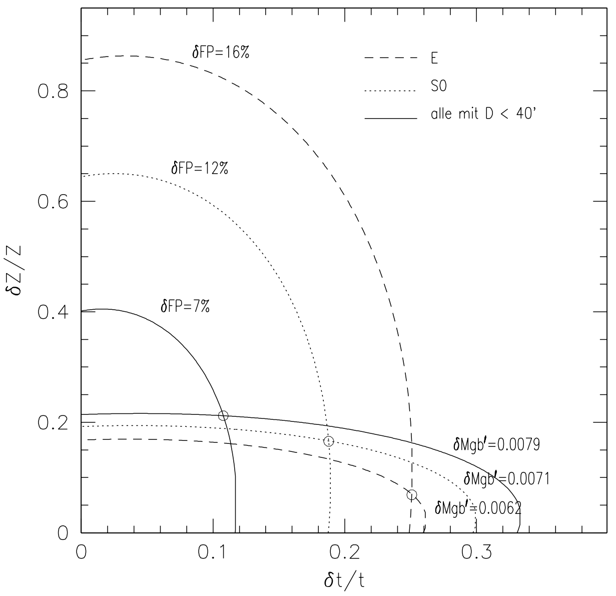

Fig. 9.— The global constraints on the scatter in age and metallicity derived from the combined scatter of the Mg$-\sigma$ and FP relation.

2. Bright elliptical galaxies are Mg/Fe enhanced, S0 galaxies have nearly solar ratios (0 to 0.2 dex). The Mg/Fe line ratios correlate with the central velocity dispersion and the Hβ value of the galaxies.

3. Gradients of the Mg and Fe line indices correlate with the central values of the indices, or with the mass of the galaxies. Bright ellipticals have steeper (negative) gradients. The Hβ profiles are nearly flat on the mean.

4. The gradients of the Mg/Fe line ratio are slightly negative and correlate with the central values of the ratios. Bright galaxies have steeper (negative) gradients which reduce their overabundance in the outer parts.

5. Environmental effects are negligible. Once the mass dependence of the gradients has been taken into account, a weak tendency of galaxies in the the outer regions of the cluster to have steeper gradients is found.

6. Elliptical and S0 galaxies define a very tight Mg$-\sigma$ relation, with intrinsic scatter of 0.009 mag. No strong correlation between the residuals from the correlation and photometric, kinematic and stellar population parameters of the galaxies is observed.

7. The *mean local* Mg$-\sigma$ relation inside the galaxies has slope and zeropoint similar to the *global* relation. However, bright ellipticals have steeper *local* relations than S0 galaxies.

8. Elliptical and S0 galaxies define a tight Fundamental Plane, with intrinsic scatter in distance of 13%. The scatter is reduced to 7% if only galaxies with projected cluster distances less than 40 arcmin are considered. The residuals from the FP relation suggest a correlation with the degree of rotational support of the galaxies. Galaxies

with the largest FP deviations have also the largest deviations from the Mg$-\sigma$ relation.

Using the simple stellar population models of Worthey (1994), point (1) implies old ages in a rather small range (8-15 Gyrs) for the ellipticals of the sample, and a wider spread (2-12 Gyrs) for the S0s. This conclusion approximately matches the expectations of the semi-analytical models of hierarchical galaxy formation in clusters (Kauffmann 1996). However, several notes of caution are due. Points (6) and (8) constraint the global spread in the age of formation rather tightly, to be less than $\approx$ 20%. This limit is barely compatible with the MgFe-Hβ ages for the ellipticals of the sample, but is certainly inconsistent with the large spread observed for S0 galaxies. Recent (minor) episodes of star formation are possibly affecting the Hβ lines for galaxies with disks, hampering the determination of the mean age of the stellar population. In addition, point (2) suggests that bright ellipticals are overabundant in $\alpha-$elements, while the models available adopt solar ratios. Moreover, the expected spread in metallicity and age of the early-type stellar populations is not taken into account by SSP models (Greggio 1997). This weakens the confidence in the absolute age dating. Finally, diffuse interstellar gas might be partially filling the Hβ lines. Gonzales (1993) finds a mean contamination of 0.15 Å. We estimate that in the most favorable case this correction could reduce the present scatter in age by a third.

Point (2) implies a further constraint on the duration of the star formation in bright ellipticals. Thomas, Greggio and Bender (1998a, 1998b and reference therein) discuss the chemical enrichment due to the different types of Supernovae. While SNII overproduce $\alpha-$ elements, SNIa enrich the interstellar medium in Fe. Since SNIa start to explode only $10^8 - 10^9$ yrs after a burst of star formation, star formation time scales shorter than this limit are necessary to produce the overabundance observed. The alternative option of a very flat IMF is also viable, but less appealing. S0 galaxies do not show very large overabundances; therefore much larger timescales of the star formation are acceptable. The anticorrelation between overabundances and central values of Hβ supports this conclusion. Thomas et al. (1998a) also compare the predictions of two formation scenarios of bright ellipticals, the fast clumpy collapse and the late merging spirals. The first case os able to account for the observed abundance pattern, while the second has difficulties and requires merging of objects of similar mass.

When interpreted using Worthey's (1994) models, the radial gradients of the Mg, Fe and Hβ line indices (points (3) and (4)) imply weak negative metallicity gradients, zero or negative overabundance gradients, and zero (or slightly positive) age gradients. Monolithic collapse models with Salpeter IMF (Carlberg 1984) predict much stronger metallicity gradients, and positive overabundance gradients (the outer parts being formed first, are at least contaminated by SNIa). They are therefore ruled out. Definitive quantitative predictions for the merging scenario are still lacking, but the prospects are favorable. Stellar mergings weaken existing gradients (White 1980), easing the problems of too strong gradients generated in gaseous bursts. Negative overabundance gradients are expected when merging two gaseous-rich models with fast enough star formation rate, because the gas forming new stars is expected to rapidly flow to the center (Barnes and Hernquist 1996). In addition, this process naturally generates the central decoupled cores of bright ellipticals that have been observed in our sample (MSBW98 and references therein).

Semi-analytical models of hierarchical galaxy formation (Kauffmann 1996) predict a marked difference of mean ages of the stellar populations in cluster and field galaxies. We do not detect strong differences between our inner and outer samples of galaxies, where the cluster density has varied by 3 orders of magnitude. Similarly, Colless et al (1998) fail to detect differences in the zeropoints of the Mg-σ relation of 84 clusters spanning a wide range in central velocity dispersion, X-ray temperature and luminosity, and Bernardi et al. (1998) detect a minute difference in zeropoint between cluster and field galaxies.

The (small) scatter of the (global) Mg$-\sigma$ relation (point (6)) mainly reflects the scatter in age and metallicity of the galaxies at a given σ. The Mg$-\sigma$ relation appears to be mainly driven by metallicity; age and metallicity at a given σ appear slightly anticorrelated. The existence of a *mean local* Mg$-\sigma$ relation similar to the *global* one is intriguing. Whether this is driven by the *local escape velocity* (Franx and Illingworth 1990, Davies et al. 1993) or *local density* (Bender et al. 1993) is unclear at present.

The scatter of the Fundamental Plane (point (8)) has a dynamical component (rotation and anisotropic support), which can be investigated properly with the help of detailed dynamical models. But certainly the contribution from the scatter in age and metallicity cannot be neglected.

To conclude, the properties of the stellar populations of the brightest ($M_V < -21$) Coma cluster early-type galaxies as derived from their Mg, Fe and Hβ line index profiles are grossly compatible with a merging formation scenario, with large mean ages and supersolar metallicities. However, large systematic uncertainties still affect these quantities. Improved modeling should take into account $\alpha-$overabundant stellar tracks, fitting functions extending to the high-metallicity, high-overabundance region, the possible spread in age and metallicity. On the observational side, the measurement of age-sensitive line indices less affected by emission could improve the accuracy of the age determinations. More galaxies in the outer region of the cluster should be observed to assess the environmental issue on a firmer statistical basis. The use of 8m-class telescope should extend the present study to fainter early-type galaxies, probing the low-metallicity objects that could not be observed here.

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