Near UV Properties of Early–Type Galaxies at $z \sim 1$

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Summary. We have used spectral fits to SSP–based atmosphere models to derive an estimate of the average stellar age for an almost complete sample of 15 Early-Type Galaxies (ETG) at $0.88 < z < 1.3$. The results are in only partial agreement with the age estimates previously obtained for the same objects from an analysis of the $\mathcal{M}/L_B$ ratio, derived from the Fundamental Plane (FP) parameters. In particular spectral fits seem to underestimate the age of the most luminous ETG, and therefore do not reproduce the downsizing effect, which is clear for the FP ages. We also analyse the relationship between the spectral–fit ages and various near–UV spectral indices.

1 Introduction

The determination of the age of Early–Type Galaxies (ETG) as a function of galaxy mass and environment is crucial for the understanding of galaxy formation and evolution and provides the means of discriminating between the currently competing models of galaxy evolution (Renzini 2006). Using the dynamical, morphologic and photometric parameters which are used for the Fundamental Plane (FP, Djorgovski & Davis 1987), di Serego Alighieri et al. (2006) have made an estimate of the age of an almost complete sample of 15 ETG at $0.88 < z < 1.3$ selected from the K20 survey (di Serego Alighieri et al. 2005). This age estimate was based on an evaluation of the virial mass $\mathcal{M}$ and rested on interpreting the differences in $\mathcal{M}/L_B$ as age differences, using single stellar population synthesis models. Therefore luminosity–weighted average stellar ages were obtained.

The results of this analysis are that the age of ETG increases with the galaxy mass in all environments (the so–called *downsizing*, Cowie et al. 1996) and that cluster galaxies appear to have the same age, within 5%, as field galaxies at any given galaxy mass. The second result is important, since it is contrary to the predictions of the most recent incarnation of the hierarchical models of galaxy formation and evolution (De Lucia et al. 2006), and it is

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somewhat controversial (Thomas et al. 2005). In order to check its validity, we have looked for an independent estimate of galaxy ages and present here the preliminary results of our study.

2 Galaxy Ages from Spectral Fits

Figure 1 shows the rest–frame blue and near UV part of the spectra of our sample of 15 ETG at $0.88 < z < 1.3$, which have been used to derive the velocity dispersion (di Serego Alighieri et al. 2005). These spectra have a resolution of $\Delta\lambda/\lambda = 1400$ and have a S/N ratio variable between 20 and 40. They are therefore suitable for stellar population analysis. We have fitted them with high resolution SSP–based atmosphere models by Bertone et al. (in prep.) in order to derive an estimate of the average SSP age. To break the age–metallicity degeneracy, we have adopted the metallicity derived from the measured velocity dispersion using an empirical relationship (Annibali et al. 2007). We stress that, although both age determination methods are based on the same spectra, they are rather independent.

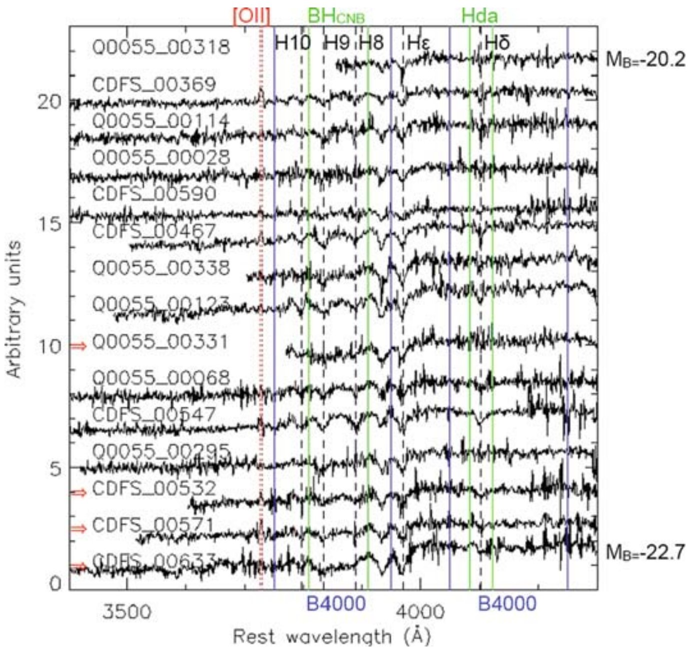

Fig. 1. The intermediate resolution spectra of the 15 ETG at $z \sim 1$ from the K20 survey. The spectra are ordered with galaxy luminosity decreasing upward. A number of important spectral features are marked, with their wavelength range. The ETG, for which the spectral–fit age is lower than the FP age, are marked with arrows.

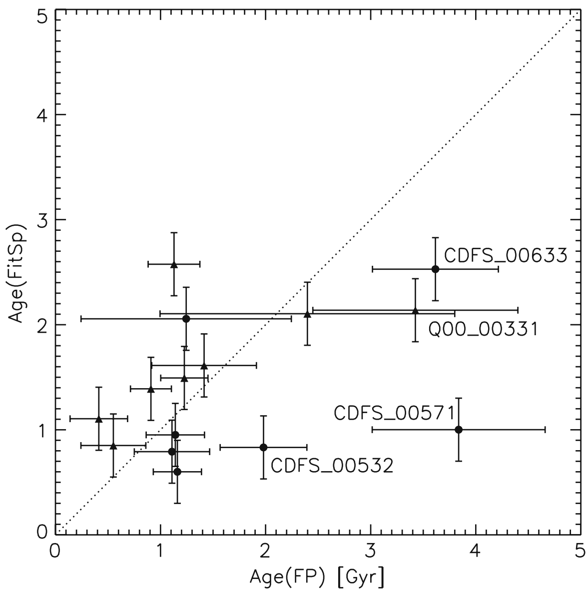

Fig. 2. A comparison of the ages obtained from the FP parameters with those obtained from the spectral fits. In both cases we have used metallicities derived from the velocity dispersion (Annibali et al. 2007). Some objects with discrepant ages are labeled.

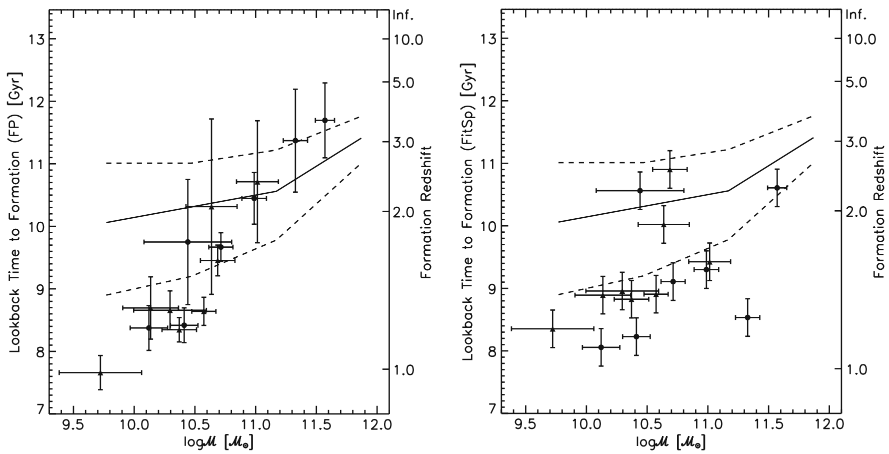

Fig. 3. The dependence of the lookback time to formation with the galaxy mass: on the left the age is estimated from the FP parameters, while on the right it is estimated from spectral fits. The downsizing effect is clear on the left, but not on the right. The continuous line shows the median model ages obtained from a semianalytical model of hierarchical galaxy evolution, while the dashed lines are their upper and lower quartiles (De Lucia et al. 2006).

Figure 2 shows the comparison between the ages obtained from the FP parameters and the analysis of the $\mathcal{M}/L_B$ ratio with those obtained by fitting the spectra with SSP models. We note that the discrepant objects, which are marked by arrows in Fig. 1, are the most luminous ones. In fact the spectral fitting technique gives ages between 0.5 and 2 Gyr for all the ETG, including the brightest ones, while the techique based on the $\mathcal{M}/L_B$ ratio assigns larger ages to the most luminous ETG. Although we cannot assess with certitude which method is best, we note that, adopting the spectral–fit ages, most of the downsizing effect would disappear (see Figure 3).

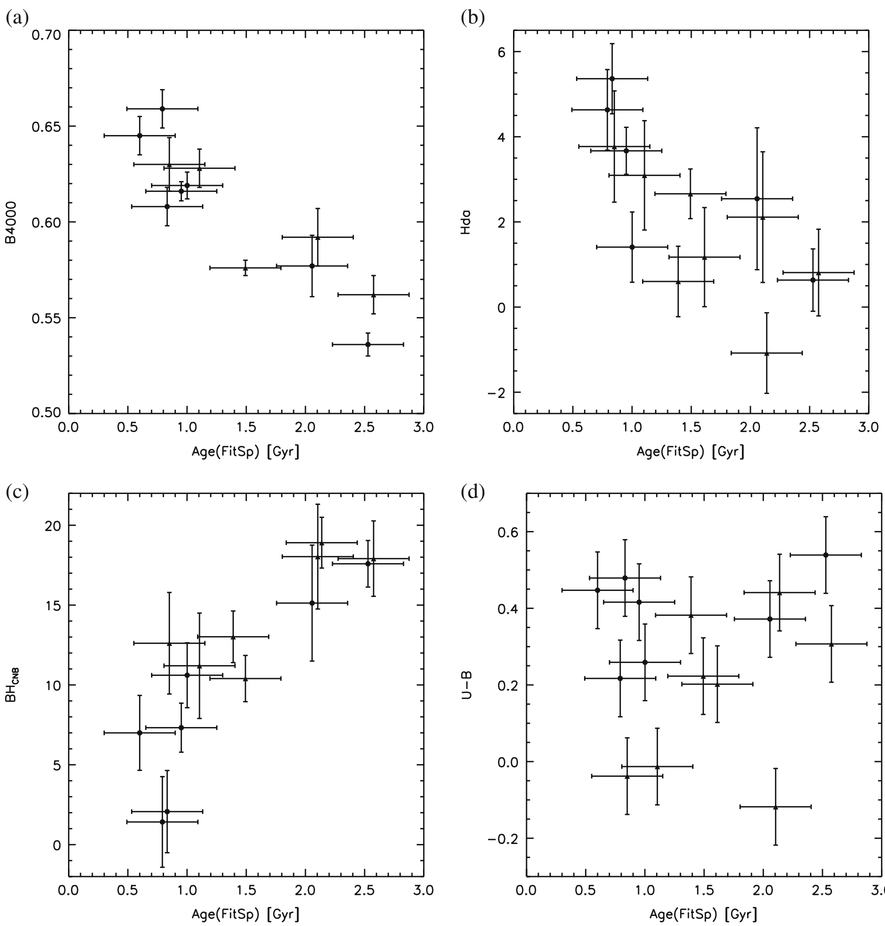

Fig. 4. The dependence of some blue/near–UV spectral indices and colour with the spectral–fit ages.

3 Spectral Indices

The blue/near–UV region of the spectrum contains several important spectral indices (Brodie & Hanes 1986), some of which are marked in Fig. 1. These are also good indicators of the stellar population content of each galaxy and offer therefore a complementary information which is potentially usefull for the age determination (Longhetti et al. 2000). We show in Fig. 4 the dependence of these spectral indices with the age estimated from the spectral fits.

It is interesting, although not completely surprising, that there is a good correlation between ages and spectral indices. On the other hand the U-B colour does not seem to correlate with the spectral–fit age.

4 Conclusions

A comparison between the ages of a sample of 15 ETG at $z \sim 1$ estimated using spectral fits to atmosphere models with those derived from the FP parameters shows a disagreement for the most luminous galaxies, which appear younger with the spectral fit method, thereby destroying the downsizing effect with this method. We suggest that spectral–fit ages are quite sensitive to rather small amounts of current or recent star formation activity, which involve only a small percentage of the stellar mass of the galaxy. This would be consistent with the good relationship found with the near–UV spectral indices. On the other hand FP ages seem to be more relevant for the average stellar population of ETG at $z \sim 1$.

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