The Evolution of the Color Gradients of Early Type Galaxies with Redshift

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Abstract. The color gradients (CG) of early type (ET) galaxies in Cl0949 (at $z \approx 0.4$) are compared to those of a local sample to investigate their origin under the assumptions that they reflect (i) pure age or (ii) pure metallicity gradients. Simulations of the passive evolution of the CG favour option (ii), option (i) being consistent with the data only if local ET galaxies are sufficiently old (> 15 Gyr).

Color gradients in ET galaxies likely reflect systematic variations of the age and the metallicity of the resident stellar populations with galactocentric distance. The age-metallicity degeneracy prevents a unique interpretation of what drives the color gradients, i.e. if they mostly reflect age or metallicity gradients. One possible way to derive clues on this issue is to map the evolution of CG with redshift, since we generally expect that for increasing lookback time CG become steeper (flatter) if they reflect an age (metallicity) gradient (see [5]). To this end, we have derived the CG of 20 ET galaxies in Cl0949, by measuring surface brightness profiles on HST WFPC2 images in the F555W, F675W and F814W filters (hereafter V, R and I), and fitting logarithmic gradients to the color profiles. Cl0949 being located at $z \approx 0.4$, these filters map approximately the rest-frame U, B and V bands. Thus we have considered a sample of local ET cluster galaxies with determined U, B and V surface brightness profiles ([1],[4], [2]) to compare their CG to those derived from our HST data. A full account of this work is given in [5].

The direct comparison of the CG distributions in the two samples shows that the evolution is small. The median values of the $(U-B)$, $(U-V)$ and $(B-V)$ CG of the local sample galaxies are $-0.14, -0.16$ and -0.05 mag/dex respectively. These are very close to the median CG of the Cl0949 sample galaxies, which amount to $-0.11, -0.12$ and -0.06 mag/dex in $(V-R), (V-I)$ and $(R-I)$.

We performed a quantitative comparison of the CG distributions of the two samples by simulating the expected evolution under the two extreme hypotheses of (A) pure age and (M) pure metallicity color gradients. The simulations are based on [3] SSP models updated to cover the metallicity range $-1.35 \leq$ [Fe/H] ≤ 0.35 and ages from 30 Myr to 18 Gyr. We have adopted H_0=65 Km/sec/Mpc, $\Omega_m = 0.2$, Λ=0.8, yielding a lookback time of $\approx$4.5 Gyr for the Cl0949 galaxies. For each object in the local sample, the color at 0.2 Effective Radii (R_e) is used to

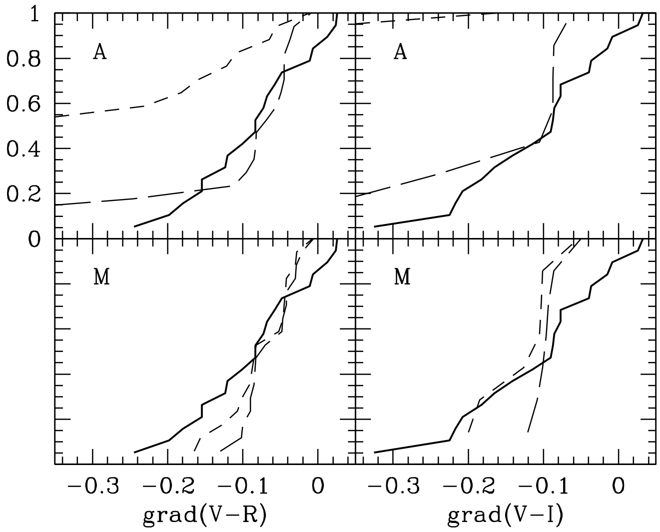

Figure 1: Cumulative distribution of the observed and model CG (see text)

determine the metallicity of the central SSP, assuming an age of 10 or 15 Gyr. The color at 2 R_e is used to infer the age gradients at constant metallicity (case A), or the metallicity gradient at constant age (case M). The SSP models representative of the central and outer stellar populations are then rejuvenated and redshifted, to determine the predicted CG at redshift $z \approx 0.4$.

Figure 1 shows the cumulative distributions of the $(V-R)$ and $(V-I)$ CG observed in the Cl0949 galaxies (solid lines) compared to our models for case A (top panels) and case M (bottom panels), having assumed an age of 10 (short dashed) or 15 (long dashed) Gyr for the central SSP of local ET galaxies. It appears that the M models are in fair agreement with the data, while the A models predict too steep CG at $z \approx 0.4$ especially when ages as young as 10 Gyr are considered for the centers of local ET galaxies.

References

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