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COLORS OF INTERMEDIATE Z BULGES IN THE GOYA SURVEY

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The chronology of bulge and disk formation is a major unsolved issue in galaxy formation, which impacts on our global understanding of the Hubble sequence. We present colors of the nuclear regions of intermediate-redshift disk galaxies, with the aim of obtaining empirical information of ages of bulges at $0.1 < z < 1.3$.

We work with two galaxy samples from the HST Groth Strip Survey (Groth et al. 1994). An inclined sample, $50^o < i < 70^o$, with 123 objects and a face-on one, $i < 50^o$, with 125 objects. Both samples are apparent-diameter limited at $R_{F814W} > 1.4''$.

From those samples we selected sub-samples of bulge galaxies by adopting a simple surface brightness criterion to measure the prominence of the bulges above the disks. We define the bulge prominence as the excess central brightness above the inward extrapolation of an exponential fit to the outer major axis profile, measured in the F814W image.

We estimated bulge colors from the color profile in a wedge aperture along the semi-minor axis on the "clean" side of the galaxies at 1.3 times the PSF of the HST images, which is about $0.2''$. This corresponds to 0.87 kpc at z=0.3 to 1.56 kpc at z=1.0. We also measured the colors at $0.1''$, to compare and estimate the effect of the dust. K-corrections for colors and magnitudes were computed using COSMOPACK (Balcells et al. 2003) and HyperZ v1.2 (Bolzonella et al. 2000).

In Figure 1 we show the rest-frame central $(B-R)$ colors vs R-band galaxy absolute magnitude, for both samples, inclined and face-on. In the luminous range of local bulges, high-z bulges show a spread of colors (filled circles). Some are as red as local bulges, indicating that their populations have comparatively similar ages and metallicities. Bluer bulges probably harvest young populations, a likely indication of late bulge formation. We observe that almost all bulges are in the same luminosity range, from -20 to -22. Regarding to the non-bulge distribution (open circles), we see that they are definitively bluer than local bulges and there is also a larger percentage of fainter galaxies. But what we observe is that this percentage is smaller in the face-on sample (there are less faint galaxies than in the inclined sample), this could be due to the effect that inclination has over the surface brightness.

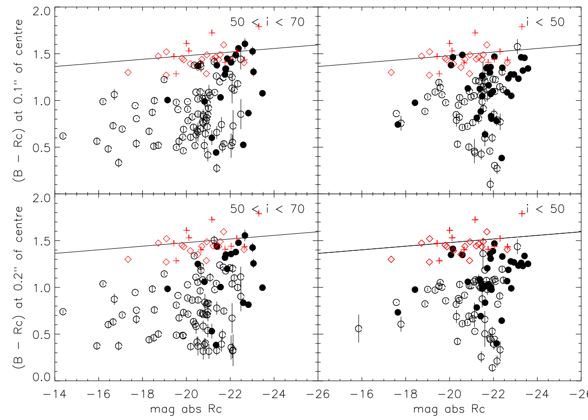

Fig. 1. Rest-frame central $(B-R)$ colors vs R-band galaxy absolute magnitude, for both samples, inclined and face-on. The filled circles are the colors of bulges and the open circles the central colors of non-bulge galaxies. The crosses and diamonds are Local Universe bulge colors with and without dust, respectively, from Peletier & Balcells (1996) and solid line is the color-magnitude distribution of old elliptical galaxies also in Local Universe, from Schweizer & Seitzer (1992).

When representing those colors versus redshift we observe that bulge distributions have a red envelope at $(B-R) \sim 1.3-1.4$ that does not become bluer with redshift, at least until $z \sim 0.9$. We could see also, in a color histogram, that bulge samples are dominantely redder than the non-bulge samples; as bulges have been selected only according to the central brightness excess, this would mean that it is related to redder colors.

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