The evolution of [pseudo-]bulges in Disk galaxies in the last ~8 Gyrs

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abstract

The surface brightnesses and colours of the [pseudo-]bulges of two samples of galaxies at z~0 (742) and 0.1<z<1.1 (170) are compared using deep, archive, imaging from SDSS and HST-ACS/WFC3. We find a significant evolution of these properties in the surveyed cosmic time (~8 Gyr), these central structures decreasing their surface brightness μ_0(g) in 2.5 mag/arcsec^2, and their rest-frame g-r color reddening in ~0.3 mags. These variations are almost parallel to the evolution of the stellar disks, but a slight, relative over-reddenning of the centres seems to fit into an inside-out dearth of SF (further tests still required).

introduction

We use the surface brightness as a proxy for stellar mass density and colours as proxies for ages of the **photometric centres** ([pseudo-]bulges) of **disk galaxies**. The main goal is to see how these regions evolve over time, compared with the stellar disks, to put some **constraints on the assembly process of these galaxies.**

selection of samples

We compare two samples of disc galaxies, one at z~0 (**742** objects), built upon the **NYU-VAGC** (Blanton et al. 2005), and another at 0.1<z<1.1 (**170** targets) which is drawn from **GEMS+COMBO-17** catalogues (Rix et al. 2004, Barden et al. 2005). The objects have been selected to be disc-like (Sérsic index <2.5), fairly luminous (V_{rest}<-18 mag), non-interacting, and with low inclination (<60º). Their stellar masses, estimated using the prescription from Bell et al. 2003, range between ~10^8 and ~10^{11} M_{sun}, with median values of log(M_*) being 9.5 and 9.7 for the local and higher-redshift samples, respectively.

results

Between z~1 and z~0 **we measure a reddenning by ~0.3 mag in (g-r) and a dimming of ~2.5 mag in central surface brightness in g band in the centres of disk galaxies (with M*~$10^{9\text{-}10}$ M_{sun}).** Stellar disks, in comparison, redden by ~0.2 mag (g-r) and decrease their brightness by ~3.2 magnitudes (g).

In r-i, centres do not effectively redden between z~1 and z~0, the average colors being more similar for all subsamples.The disks do show some marginal reddenning by only 0.1 mag in the same interval. The evolution in the central surface brightness and disk magnitude in “r” band are similar to those in “g”.

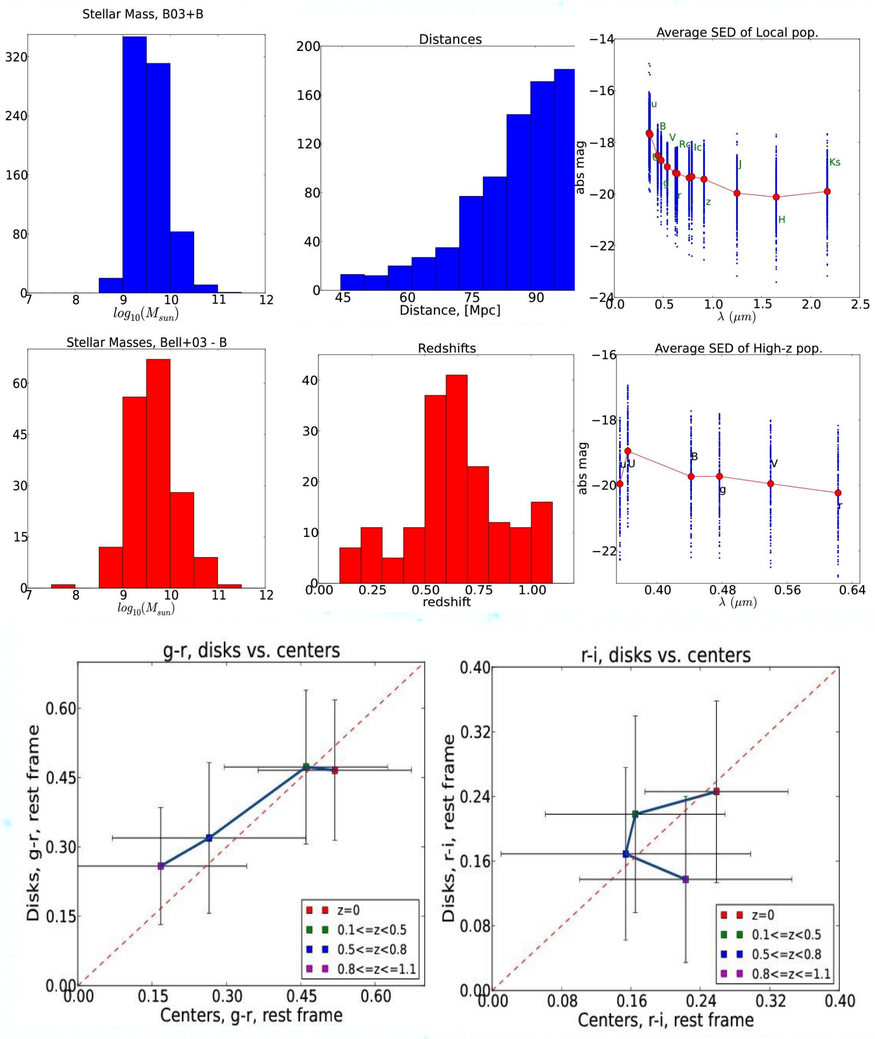


Fig. 1 (left)

Upper row: Stellar masses, distances, and median SED for the local sample.

Below: analogous figures for the higher-z sample.

Fig. 2 (right)

Left: color(g-r) - μ_0/magnitude (g) diagrams for centres/disks. Theoretical lines of different metallicities are from Bruzual & Charlot 2003. Error bars are 1 sigma dispersions. The empty circles are individual galaxies, their masses coded in the size, and redshift ranges in the color.

Right: idem, for r-(r-i).

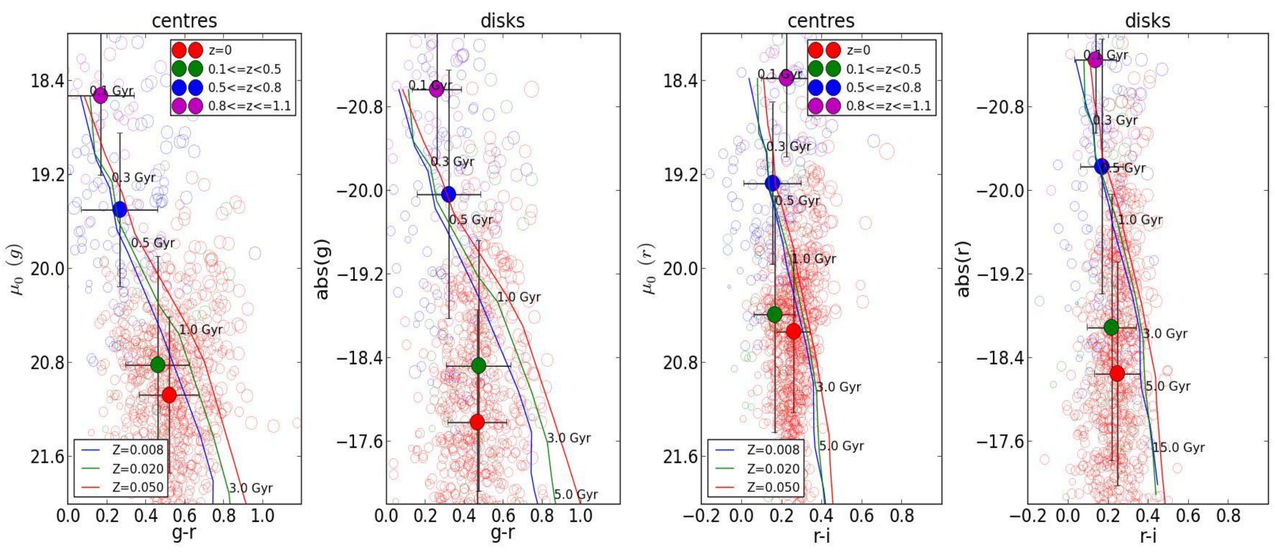


Fig. 3 (left)

Left: colour (g-r) of disks vs. colour of centres, for each sample. Error bars are dispersions.

Right: Analogous for (r-i).

conclusions

- Without correcting for dust extinction, **disk galaxies at z~1 show brighter (2.5 mag/arcsec^2 in g) and bluer (~0.3 mag in g-r) [pseudo-]bulges than their local counterparts.**
- **This evolution does not seem to be compatible with pure passive evolution.**
- Now and then, **there are signs of recent SF in these central areas, an activity which has decreased over time, and more so than in the disks** (though more statistical tests are still necessary to assess the reliability of this last result).

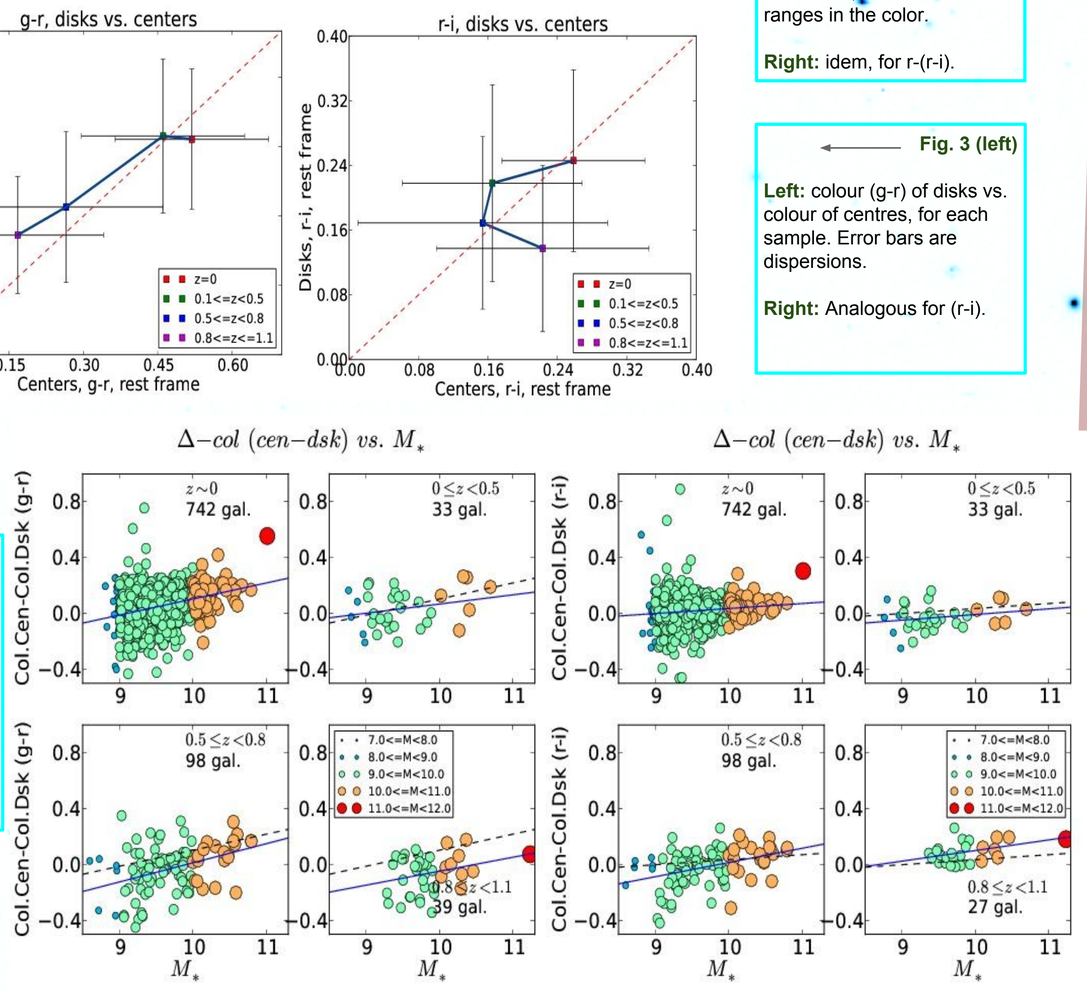
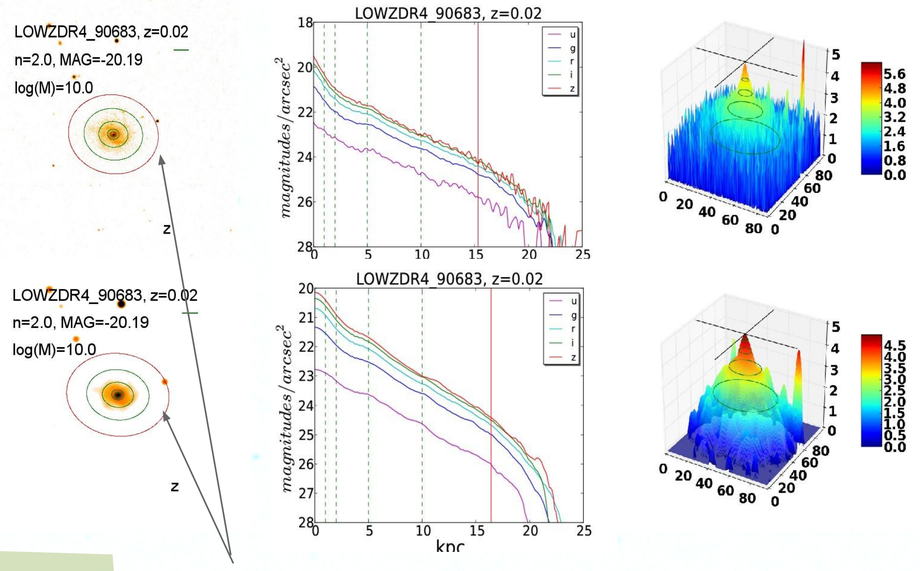


Fig. 4

Left: Color contrast, Centre - Disk, in (g-r), vs. stellar mass.

Right: analogous for (r-i).



The green ellipses have sma=1,2,5 and 10 kpc. The red ellipse marks the Petrosian radius.

Fig. 5

Upper row: stamp in z band, radial profiles of surface brightness and 3D image of intensities in (z) band for a galaxy in the local sample, at its natural resolution (SDSS).

Lower row: analogous figures obtained at the common resolution of 0.125 kpc/pix, 1.5 kpc fwhm.

data & photometric analysis

The images used to study the local sample are taken from **SDSS-DR7** (Abazajian et al. 2009), covering the wavelength range 0.35<~ λ <~0.91 μm. For the higher-z sample, we serve from deep HST images from **GOODS-South/ACS** (Giavalisco et al. 2004) and **CANDELS** (Koekemoer et al. 2011), covering ~0.43 <~ λ <~1.54 μm (0.3 <~ λ <~ 1 μm at z~0.6, in the rest-frame).

Artificial redshift degradation: To ensure a meaningful comparison of the galaxies in the wide range of redshifts explored, **all images have been resampled and convolved** with gaussian kernels to have **a common scale of 0.125 kpc/pixel and a PSF of 1.5 kpc FWHM.** The limit resolution (FWHM) is given by the images in band F160W at z~1.

After equating resolutions, radial profiles of surface brightness are extracted, and the average surface brightness within a radius of 0.5 kpc centered on the galaxy is taken as μ_0. The disc magnitudes are taken as the cumulative magnitude beyond an inner radius of 2 kpc.

references

Abazajian et al. 2009
Barden et al. 2005, ApJ, 981, 635
Blanton et al. 2005, AJ, 129, 2562
Bruzual & Charlot 2003, MNRAS, 344, 1000
Bell et al. 2003, ApJ, 149, 289
Giavalisco et al. 2004, ApJ, 600, 103
Koekemoer et al. 2011, ApJS, 197, 36
Rix et al. 2004, ApJS, 173, 152