Constraining galaxy evolution through internal colour gradients of early-type galaxies

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The study of the structure of galaxies in visual and near-infrared wavebands allows to disentangle between different formation scenarios.

Here we take advantage of new BVRIK photometry from the ESO New Technology Telescope to study galaxies in the cluster A2163B at redshift z=0.2.

Fig.1 shows the V-band (NTT-EMMI, left) and K-band (NTT-SOFI, right) images of A2163B.

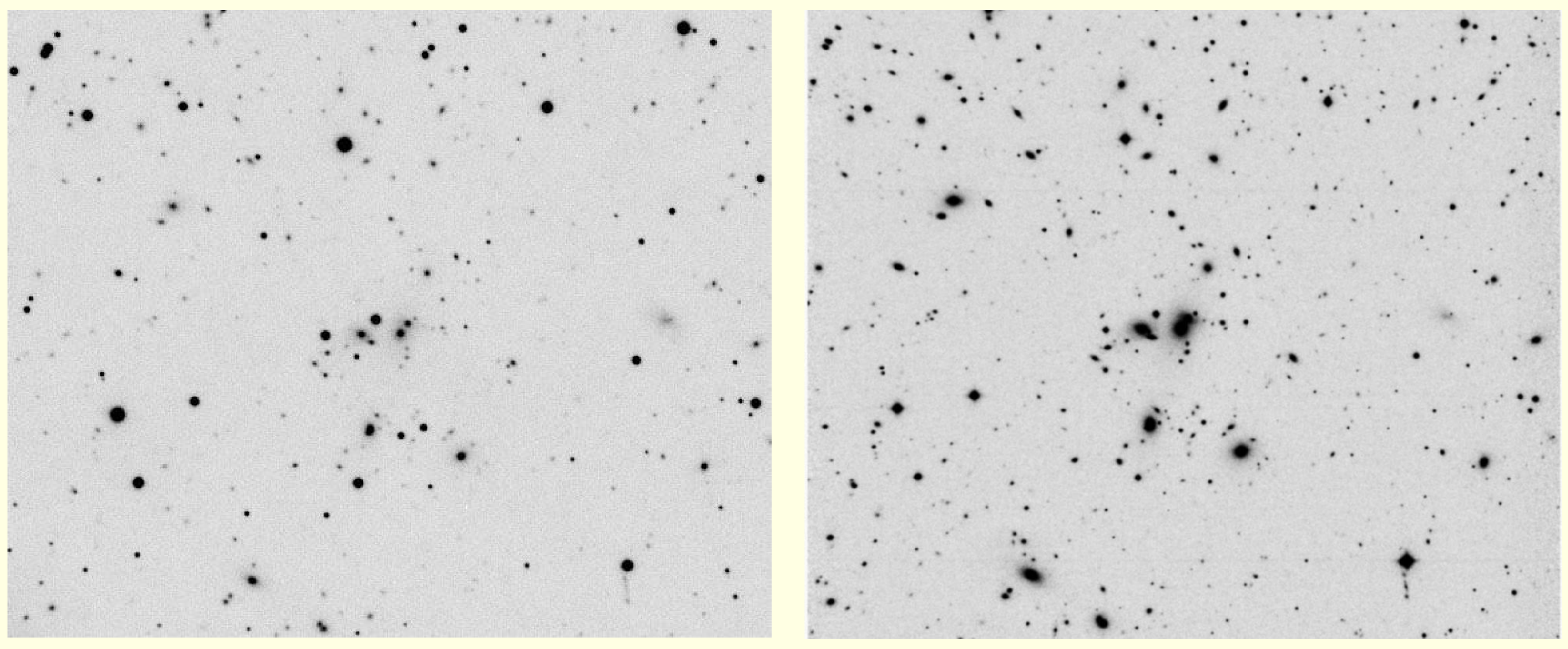

Fig. 1

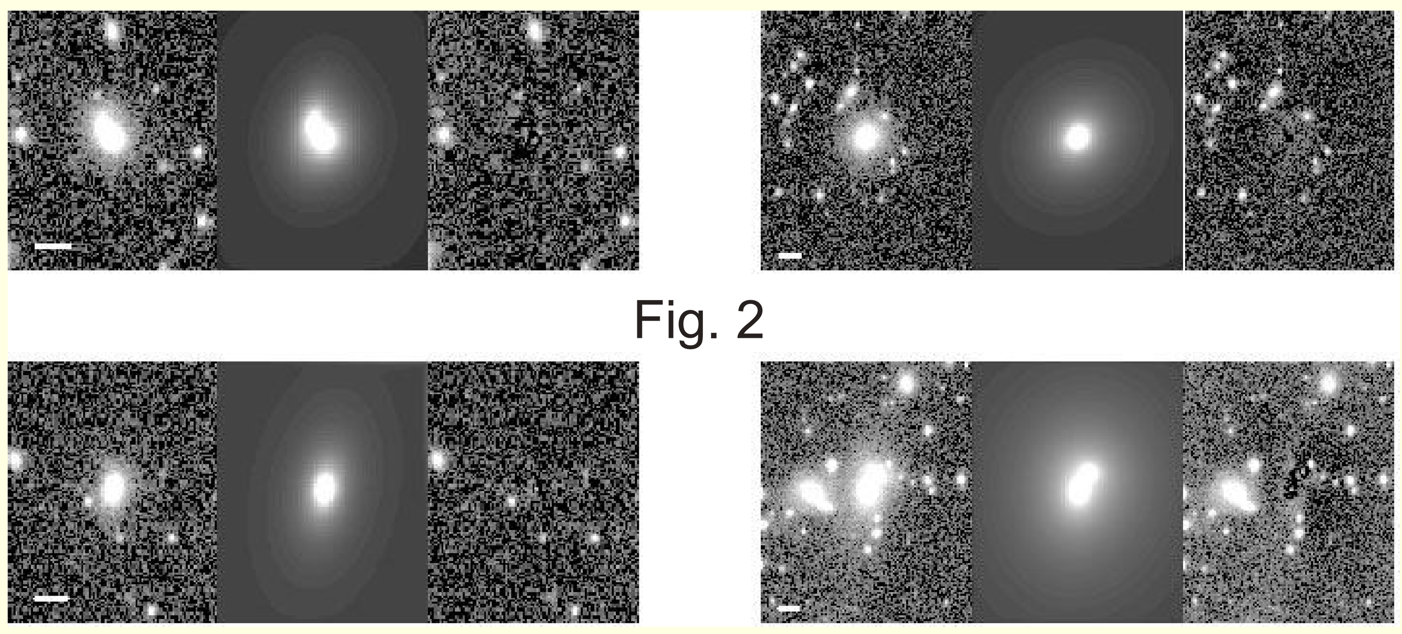

Fig. 2

Galaxy Model Residuals

Galaxies have been selected through photometric redshifts.

Structural parameters (half light radius r_e, mean surface brightness < $>_e$ and Sersic index n) have been derived through 2 -D fit of galaxy images (see examples in Fig.2).
The internal colour gradients of galaxies were derived from structural parameters for the population of spheroidal galaxies (Sersic index n>2).

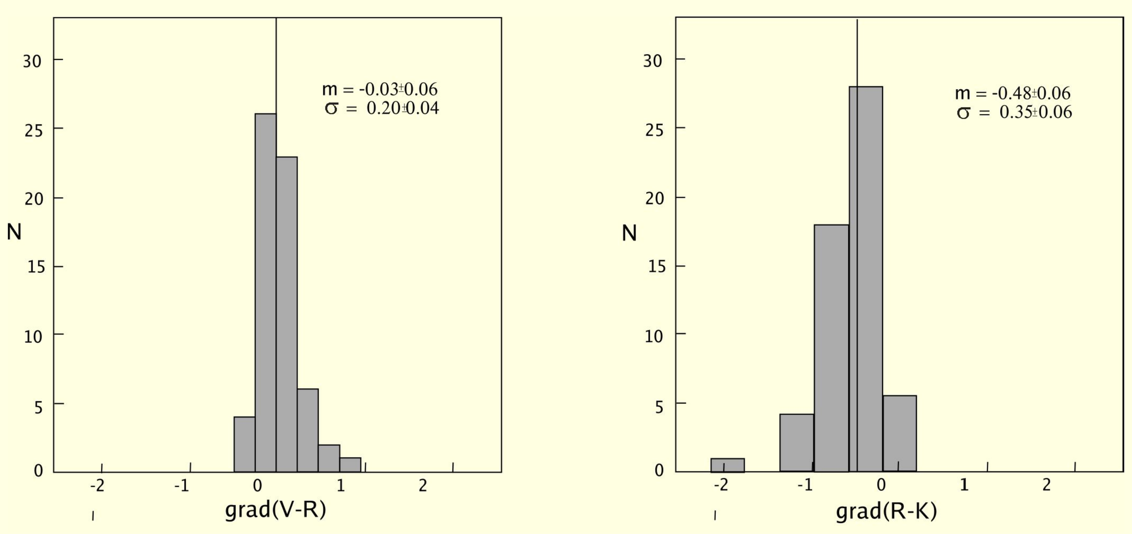

Fig. 3

It turns out that:
- in the visual wavebands, colour gradients are consistent with zero (see Saglia et al. 2000, A&A 360, 911; Tamura et al. 2000, MNRAS 119, 2134);
- the visual-NIR gradients are negative, implying that stellar populations are significantly redder in the centre, see Fig.3.

Together with previous estimates of visual-NIR colour gradients at intermediate redshifts (La Barbera et al. 2003, A&A, 409, 21), this implies an average metallicity gradient of -0.2dex, much smaller than that expected in a monolithic formation scenario (-0.5dex, see Carlberg 1984, ApJ, 286, 403).
Such a shallow metallicity gradient is explained within a hierarchical merging framework: merging tends to mix stellar populations, thus producing shallow colour gradients.

The NIR Kormendy relation at z=0.2 (Fig.4, left panel) has a slope of 3.20±0.19.

By taking into account the value of the slope in the visual (2.82±0.08, see La Barbera et al. 2003, ApJ, 515, 127) and the colour-magnitude relation, one would expected a NIR slope of 2.72±0.08, which is significantly (<2) smaller than the actual value.

This implies that the optical-NIR colour gradients of galaxies do not steepen (actually they become less steep) with galaxy mass, as is clear from the grad(V-K)- log r_e diagram shown in Fig.4 (right panel).

This result is in sharp disagreement with the prediction of the monolithic scenario.

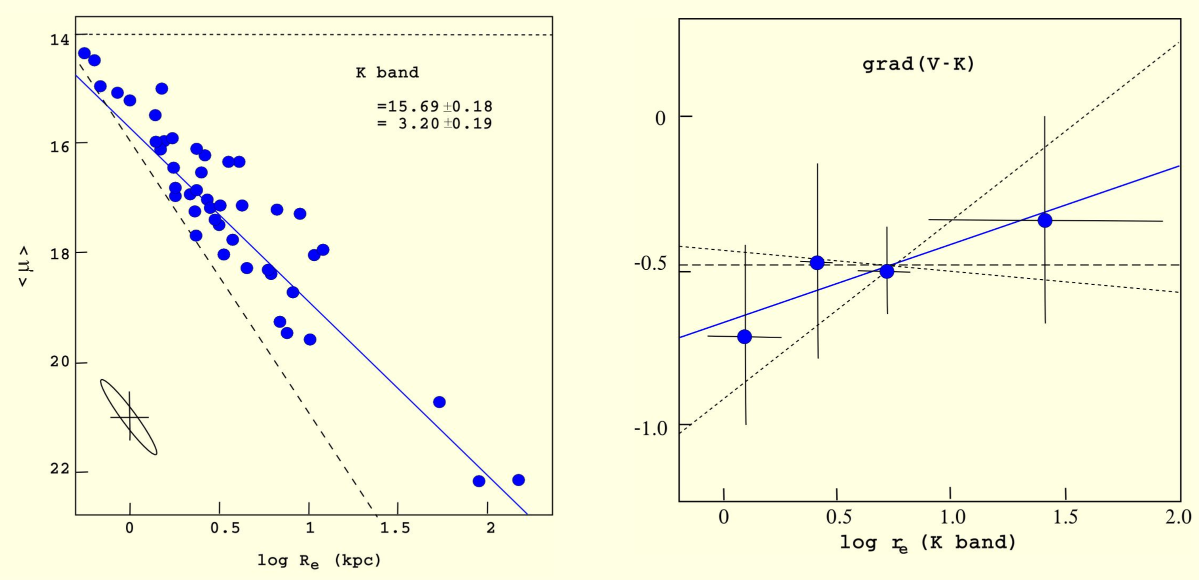

Fig. 4

With these data, we derived, for the first time, the NIR photometric plane ($\log r_e = a \cdot \log n + b \cdot \langle m \rangle_e + c$; PHP) of spheroidal galaxies at z=0.2 . Different projections of the PHP are shown in Fig.5 (shadows denote the regions affected by selection in magnitude).

The slopes of the plane (a=0.8±0.2, b=0.235±0.020) are consistent with those of the local visual PHP as derived by Graham (a=0.86±0.13, b=0.228±0.036; 2002, MNRAS, 334, 859).

The observed (intrinsic+measurement errors) dispersion about the plane is 0.17dex, similar to the scatter of the Fundamental Plane. However, since the correlation of the errors on the structural parameters is almost parallel to the plane, the instrinsic dispersion of the PHP turns out to be significantly larger than that of the Fundamental Plane.

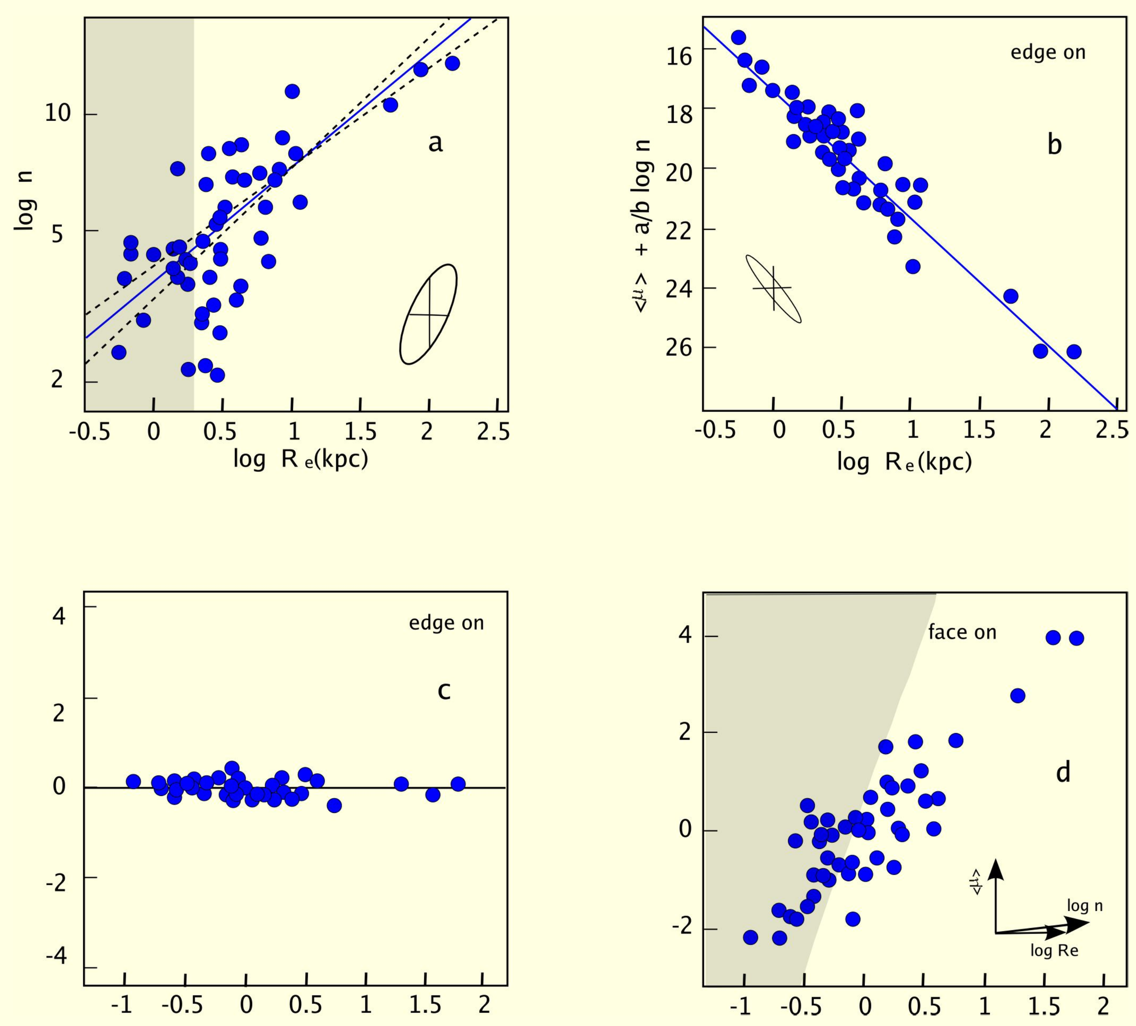

Fig. 5

In conclusion: the structural properties of spheroidal galaxies at z=0.2 are in sharp disagreement with the monolithic collapse scenario, and support a hierarchical merging framework of galaxy formation.