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Environments of galaxies: Stellar mass and color dependence

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Abstract. Environments for galaxies are measured using a projected neighborhood density Σ. Distributions in Σ for galaxies with different stellar masses are compared with the result for a random distribution. A detailed investigation of the fraction of red-sequence galaxies as a function of environment and stellar mass shows that there is a unified relation.

Galaxies are more clustered than a random distribution with red-sequence (early-type) galaxies and/or more massive galaxies exhibiting stronger clustering. This has been investigated using for example the two-point correlation function (Zehavi et al. 2005). An alternative analysis that provides a more visceral impression of the environmental trends uses the projected density of neighboring galaxies.

The properties of galaxies as a function of density were investigated using SDSS data. Absolute magnitudes, rest-frame colors and approximate stellar masses were determined. The density for each galaxy was determined from projected distances to the nearest neighbors that were brighter than -20 in M_r and within $1000\,\mathrm{km\,s^{-1}}$ in z. The density is then given by $\Sigma_N = N/(\pi d_N^2)$ where d_N is distance to the Nth nearest neighbor: averaged for $N = 4$ and 5.

Full details of this analysis are given in Baldry et al. (2006) (see also Balogh, these proceedings). The results focused on the variation of the galaxy stellar mass functions with environment, and the fraction of red-sequence galaxies as a function of density and stellar mass. A comparison was made with models of galaxy formation and evolution. In this paper, the data is presented using distributions in Σ.

The solid lines in Fig. 1 show distributions in Σ for galaxies with four different stellar mass ranges. The average environmental densities increase gradually with mass up to $\sim 10^{11}\mathcal{M}_\odot$ with a dramatic increase for more massive galaxies that are above the Schechter characteristic mass in the stellar mass function. For comparison, the dotted lines show the result for a random distribution with an average number density of $0.005\,\mathrm{Mpc}^{-3}$ which corresponds to galaxies with $M_r < -20$. The galaxy distributions as well as having a higher average environmental density than the random distribution exhibit a more significant asymmetry. One possible interpretation is that the main peak at $\log\Sigma \sim -0.5 \pm 0.5$ [figs. (a-c)] corresponds to a multi-halo term (the galaxies used for determining Σ are situated in two or more dark-matter halos) while the extended tail at $\log\Sigma > 0.3$ corresponds to a predominantly single-halo term.

The galaxies were also divided into red- and blue-sequence galaxies based on their positions in the color-magnitude diagram. The triangles show the distributions in Σ for red-sequence galaxies which generally reside in higher density

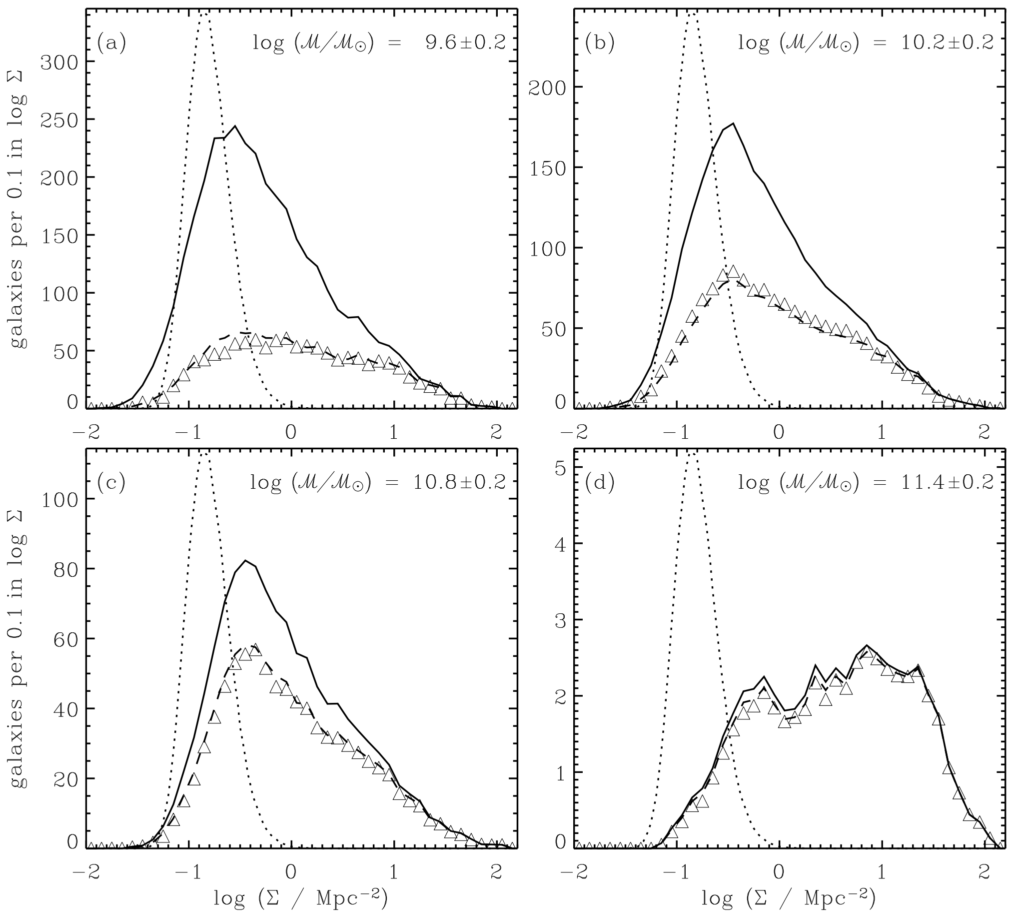

Figure 1. Distributions in environmental density. The *solid lines* represent histograms for galaxies with each panel showing a different stellar mass range. The *dotted lines* represent a random distribution scaled to match $0.5\times$ the number of galaxies. The *triangles* represent red-sequence galaxies from the data while the *dashed lines* are derived from the unified relation. The total counts for each mass range are normalized to a volume of $10^6\,\mathrm{Mpc}^3$.

environments than blue-sequence galaxies. The fraction of red-sequence galaxies was shown to depend on a unified relation of environment and stellar mass given by

$$f_r = 1 - \exp\{-[(\Sigma/10^{0.91}\mathrm{Mpc}^{-2})^{0.69} + (\mathcal{M}/10^{10.72}\mathcal{M}_\odot)^{0.59}]\} \qquad (1)$$

The dashed lines show how this relation can be used to reproduce the red-sequence distributions from the overall distributions in Σ. An interpretation related to the probability of a galaxy being a satellite and the effect of AGN feedback is discussed by Baldry et al. (2006).

References

Baldry, I., Balogh, M., Bower, R. et al. 2006, MNRAS, in press (astro-ph/0607648)
Zehavi, I., Zheng, Z., Weinberg, D. et al. 2005, ApJ, 630, 1