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A new (2D+1) cluster finding algorithm for photometric redshift surveys

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Abstract. A new adaptive (2D+1) algorithm to estimate the galaxy number density in photometric surveys is presented. An application to the Chandra Deep Field South illustrates its effectiveness in finding clusters and allows to investigate the density dependence of galaxy type distribution in one already known z≃0.7 cluster and in a newly detected z≃1.0 one. The color evolution of the red sequence is olso discussed

Key words. galaxies: clusters- galaxies: distances - redshift - galaxies: evolution

1. Introduction

Unbiased samples of clusters and groups can be obtained from 3D spectroscopic surveys, where Friend of Friend (FOF) method (Huchra & Geller 1982) is only limited by galaxy velocity dispersion. Finding clusters in 2D surveys, which can be be much deeper, requires additional a priori assumptions on either galaxy luminosity function, as in the Matched Filter algorithm (Postman et al. 1996) or the presence of a red sequence (Gladders et al. 1998). The bias produced by these assumptions can hardly be evaluated at z≥ 1. Photometric redshift provide a resolution

$$\Delta z = (z_{spe} - z_{phot})/(1 + z_{spe}) \approx 0.02$$

for $0 \leq z \leq 2$ (Fontana et al. 2000) sufficient for the statistical identification of large-scale structures . We have developed a new algorithm to compute a three dimensional galaxy density, which we call (2+1)D to remind that the positional accuracy along the line of sight is much lower than the angular one. Yet *all the available positional information is taken into account simultaneusly*. The (α, δ, z) space is divided in cells whose size in each direction depends on the relevant positional accuracy. Objects are counted in increasing volumes V around each cell, until a fixed number N is reached and a density $\rho = N/V(gal/Mpc^3)$ is assigned to the cell. The increasing incompleteness at high redshift is properly taken into account by assigning to each object a weight $1/s(z)$ where $s(z)$ is the following function:

$$s(D_L(z)) = \frac{\int_{-\infty}^{M_{LIM}(z)} \Phi(M)dM}{\int_{-\infty}^{M_{inf}} \Phi(M)dM} \quad (1)$$

where M is the absolute magnitude in a reference band, $\Phi(M)$ is the luminosity function, $M_{LIM}(z)$ is the absolute magnitude corresponding to the limiting magnitude of the survey at each z, while M_{inf} is the value of M_{LIM}

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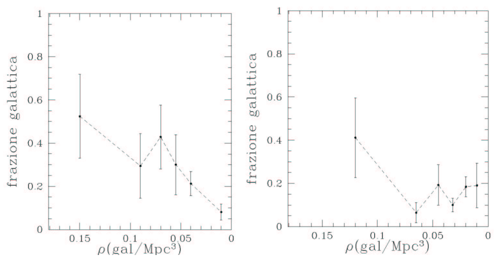

Fig. 1. The fraction of red gaalxies as a function of density at z≃0.73 (left), z≃1.0.(right)

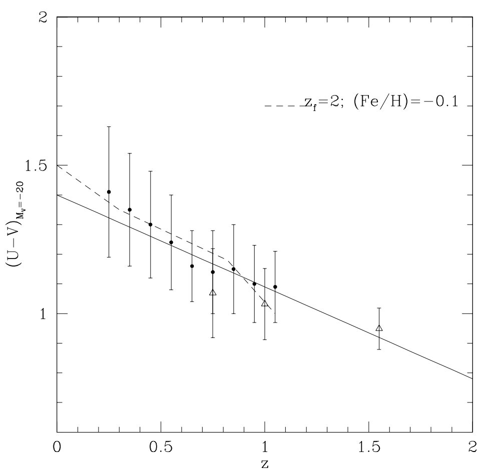

Fig. 2. The redshift dependence of the red sequence color at magnitude V=-20. Passively evoloving galaxies formed at $z_f = 2$ with $Fe/H = -0.1$ (continuos line)

at the limiting redshift (volume) considered. Clusters or groups are defined as connected regions with density exceeding a fixed threshold and the analysis of galaxy properties as a function of the density can be performed.

2. The CDFS Survey: galaxy colors in distant clusters

The (2+1)D algorithm has been applied to a *UBVRIZJK* catalogue in the Chandra Deep Field South (Poli et al. 2003). Following Carlberg at al. (2000) we define the red fraction as the fraction of galaxies with rest-frame B-R ≥ 1.25.

The increasing fraction of red galaxies with growing density is summarized in fig 1 for the two groups at z≃0.73 (left), z≃1.0.(right) This color segregation confirms the physical reality of the two clusters, where the red sequence is also well detected. The slope of the red-fraction vs. density relation may in principle provide a constraint for galaxy formation/evolution models. Selecting the red galaxies in the rest-frame U-V vs V plane, as done in Bell et al. (2004), it is possible to fit the red sequence with a linear relation and define a conventional color at V=-20 to study its dependence on redshift. In figure 2 the result is shown for the z≃0.73 and z≃1.0 and for objects at z ≃1.5, where a third overdensity has been identified. The results are consistent with the analysys of COMBO-17 data (circles in Fig. 2) (Bell et al. 2004), that refers to z≤1.1 galaxies, which, in turn, is consistent with the passive evolution of a population formed at $z_f = 2$ with metallicity $Fe/H = -0.1$. Our preliminary results seem to indicate that the color of red sequence is consistent with the estrapolation of the above relation up to z=1.5.

3. Conclusions

- The (2+1)D cluster finding algorithm, based on photometric redshifts, was able to select high redshift clusters in the CDFS Survey
- The reality of clusters at z=0.7 and z=1.0 is proved by the galaxy color segregation.
- The fraction of red galaxies as a function of density provides new constrains for models of galaxy formation/evolution
- The color evolution of the red sequence seems to agree with the extrapolation of the known relation up to a redshift 1.5

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