АСТРОФИЗИКА

ТОМ 38 НОЯБРЬ, 1995 ВЫПУСК 4

EXAMPLES OF CLUSTERING AROUND HIGH REDSHIFT RADIO-GALAXIES

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1. *Introduction.* Motivated by the interest of high redshift galaxy clusters, in such different fields as the study of large scale structures formation or the birth and evolution of galaxies, various observational campaigns are know carried out in order to enlarge our knowledge of an Universe twice younger than today. Moreover, at such large redshifts, the prevalence of clusters and other large scale structures is yet unknown and the evolution of these structures may well be at a critical stage, where observations can directly constrain cosmological models.

However only a handful of clusters are known at $z>0.8$. Indeed, finding cluster candidates at redshifts close to one is by no means an easy task: perturbed by a large fraction of foreground galaxies it is not possible to merely rely on projected number over-densities to define clusters. We consider here the fact that at $z<0.5$ one third of bright radio galaxies and QSOs lie within rich clusters (Hill & Lilly, 1991; Yee & Ellingson, 1993), and we extend this methodology to $z>0.8$. The extensive survey of radio-galaxies environments, both using IR and optical as well as multi-slit spectroscopy, should then allow the indentification of cluster candidates.

We present here the succesful indentification of galaxy clusters around two powerful radio-galaxies, 3C265 (z=0.81) and 3C184 (z=0.996). A more detailed analysis of these observations can be found in Le Fèvre & Deltorn, 1995.

2. *Clustering indentification*

2.1. Observations and reductions. V and I (resp. 600 and 1200s) exposures were obtained for a 10'×10' field centered around 3C265 at the CFHT using the MOS spectrograph imaging mode. Similarly we observed 3C184 in R, I and K' bands (resp.

900, 2400 and 2700s). Standard CCD image processing was conducted using the IRAF software, producing a catalog of 1684 objects for 3C184 and 956 objects for 3C265. The completeness limit in the *I* band for each catalog is respectively 22.5 and 22. Additional images were obtained using a narrow band filter centered on the redshifted [OII] line (3600s for 3C184 and 3900s for 3C265).

Multi-slit spectroscopy was obtained with MOS (3×4800s with a 37 slit mask for 3C184 and 3×3600s with a 39 slit mask for 3C265), with a resolution of 0.355nm in the dispersion). The measured galaxies were selected in function of their flux excess in the [OII] filter, and such that their magnitude was comprised between the magnitude of the radio-galaxy and 22. Spectra were processed using the MULTIRED package implemented in IRAF (Le Fèvre et al., 1995).

2.2 Galaxy density excess in redshift space. Two galaxies within 150 and 1140 km/s from the radio-galaxy were found in the 3C184 field (out of 14 secure measured redshifts). As for 3C265, four galaxies have velocities less than 900km/s from the radio-galaxy (out of 24). Fig. 1 presents the redshift distribution for both fields, compared with field galaxy redshift distribution from the CFRS (Crampton et al, 1995). From a random sample of field galaxies, we would expect 0.03 galaxies out of 14 at z=0.996 and 0.1 out of 24 at z=0.81. Although the small number of observed redshifts prevents us from robust statisitical tests, these probabilities give good confidence on the reality of the observed over-densities.

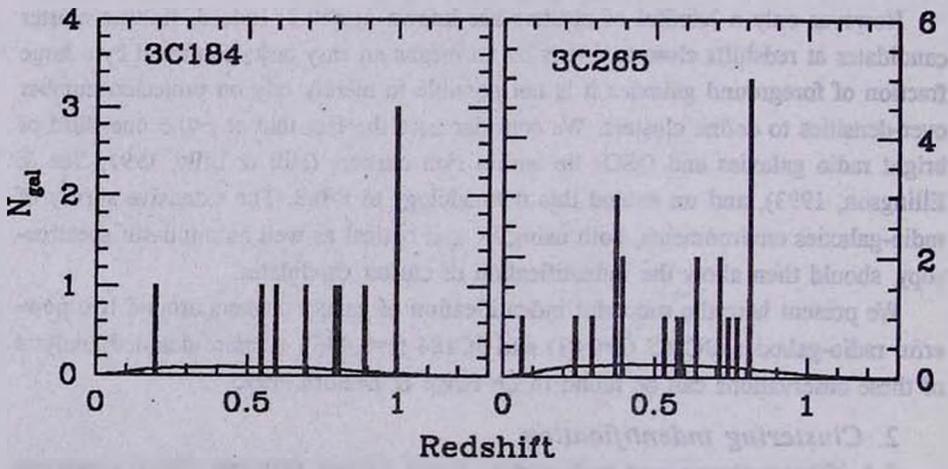

Fig. 1. Redshifts distribution respectively in the 3C184 field (left) and the 3C265 field (right). The continuous line represents the CFRS redshift distribution for I<22, plotted with the same redshift bin as the 3C184 and 3C265 distributions (i.e. 1500km/s).

2.3. Sky projected density excess. Using the photometric catalogs constructed for the two fields we compute both a projected number density map (Dressler, 1980) and the excess of galaxies with $V\text{-}I > 1$ (for the 3C265 field) and $R\text{-}I > 0.2$ (3C184) which should be predominantly at $z > 0.5$ (bruzual & Charlot, 1993). Fig. 2 shows the radial density excess plots around 3C184 and 3C265.

The excess of galaxies is respectively 2.7 and 3.4, corresponding to 8σ and 12σ above the mean galaxy background. Boh radio-galaxies therefore lie in significant projected galaxy over-densities. The number of galaxies brighter than m_3+2 and within $0.5h^{-1}$Mpc from 3C184 and 3C265 is $N_{0.5}=10$ and 20 resp.We also observe a projected multi-modal morphology that might indicate a young dynamical state of the clusters; however the importance of contamination from foreground galaxies at such redshifts prevents us from drawing any strong conclusion as for the real clusters structures.

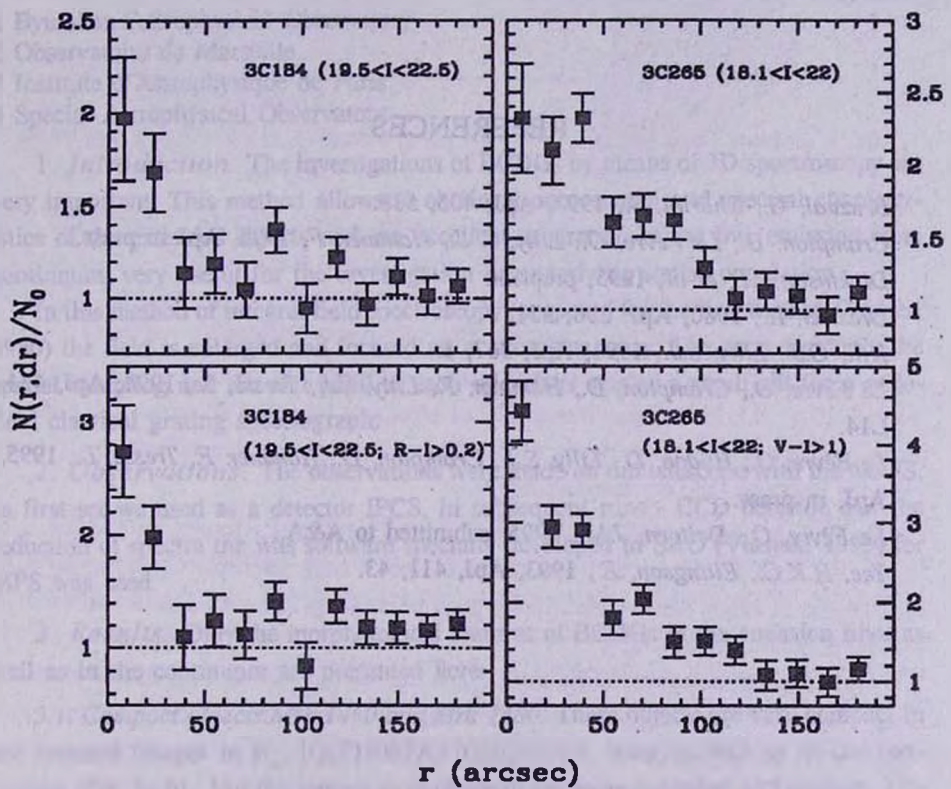

Fig. 2. Projected galaxy density excess around 3C184 (left) and 3C265 field (right). The number of galaxies has been computed in 15.7 arcsec wide rings, and normalized to the mean background galaxy density.

3. *Conclusion.* Indications of clustering around two high redshift 3C radio galaxies have been presented. based on the measured galaxy density excess both in redshift space and in projection on the sky. More velocity measurement are needed in order to investigate the detailed properties of the clusters and of the galaxies in these environments. These two examples nevertheless add to the still quite poor, but growing, list of very high redshift structure candidates (Le Fèvre et al, 1994; Dickinson et al, 1995). As more examples of clustering of galaxies are identified at $z \approx 1$ and above, direct comparisons with large scale structure evolution theories will become possible.

Примеры скоплений галактик вокруг радиогалактик с большими красными смещениями. Представлены результаты отождествления скоплений галактик вокруг двух радиогалактик, 3C265(z=0.81) и 3C184(z=0.996).

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