

Proto-clusters and high- z radio galaxies

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Abstract

High redshift radio galaxies are great cosmological tools for pinpointing the most massive objects in the early Universe: massive forming galaxies, active super-massive black holes and proto-clusters.

We report on the results of a large program conducted mainly with the Very Large Telescope to search for forming clusters of galaxies near powerful radio galaxies at $2 < z < 5.2$ and simultaneously investigate the nature of giant Ly-alpha nebulae centered on the massive radio galaxies. Deep narrow- and broad-band images of eight radio galaxies and their surroundings were obtained, with subsequent spectroscopy to obtain redshifts for the candidate Ly α emitters. In at least six fields an overdensity of Ly α emitters is found near the radio galaxy; considering also the significant clustering in redshift space of the emitters, we argue that we have discovered six forming clusters of galaxies (protoclusters). Based on the estimated masses and the volume density, we conclude that the observed structures are the likely progenitors of present-day massive ($10^{15} M_{\odot}$) clusters of galaxies. A comparison with numerical simulations of the development of large scale structure in the Universe provides strong additional evidence for the hypothesis that these structures are forming massive clusters.

Finally, we discuss some of the physical properties of these forming clusters, of the cluster members, and of the central massive radio galaxies