Galaxy Evolution across the Hubble Time
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Panoramic Views of Cluster Evolution Since $z = 3$

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1. Optical Survey of $z < 1.3$ Clusters

We have been conducting PISCES project (Panoramic Imaging and Spectroscopy of Cluster Evolution with Subaru; Kodama *et al.* 2005) with making use of the wide-field imaging capability of Subaru. Our motivations are first to map out large scale structures and define local envioronments of galaxies therein, and then to investigate the variation in galaxy properties as a function of environment and mass. We have completed multi-colout imaging of 8 distant clusters between $0.4 < z < 1.3$ so far, and we have mapped out filamentary/clumpy structures in and around the clusters across 15–30 Mpc scales (see some examples in Fig. 1). These two clusters have secure spectroscopic confirmation of the physical association of the structures to the main body of the clusters. From the photometric and spectroscopic properties of galaxies over a wide range in environment, we have found that the truncation of galaxies is seen in the outskirts of clusters rather than in cluster cores. We have also seen a clear environmental dependence of the "down-sizing" in the sense that the stage of down-sizing is delayed in lower density environments..

2. NIR Survey of $z > 2$ Proto-Clusters

We are now extending the study of dense environment to higher redshift ($z > 2$) by wide-field near-infrared imaging of proto-clusters around radio loud galaxies using a new wide-field instrument MOIRCS on Subaru. Most of these field are known to show a large number of Lya/Ha emitters at the same redshifts of the radio galaxies. We have seen a clear excess of near-infrared selected galaxies (JHK-selected galaxies as well as DRG) in these fields, and these are indeed proto-clusters with not only young emitters but also evolved populations. Spatial distribution of such NIR selected galaxies is filamentary and track similar structures traced by the emitters. There is an hint that the bright-end of the red sequence first appeared between $z = 3$ and 2 (see Fig. 2).

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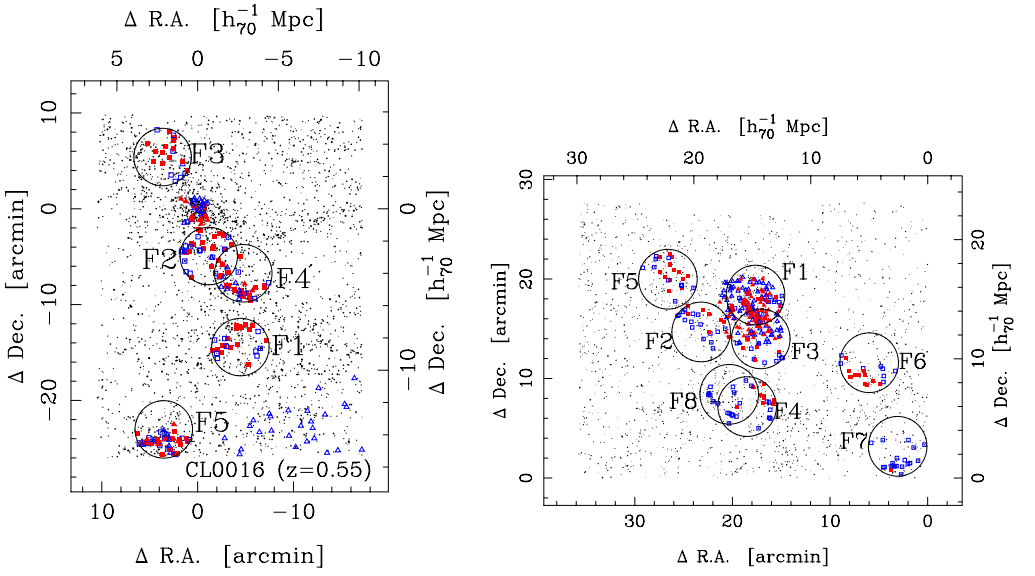

Figure 1. Large scale structures of the two distant clusters, CL0016+16 at $z = 0.55$ on the left (Tanaka *et al.* 2006b, in prep.) and RXJ0152.7–1357 at $z = 0.83$ on the right (Tanaka *et al.* 2006a). Spectroscopically confirmed cluster members and non-members are shown in filled and open symbols (squares/triangles), respectively. Other member candidates on the basis of photometric redshifts are shown by small dots.

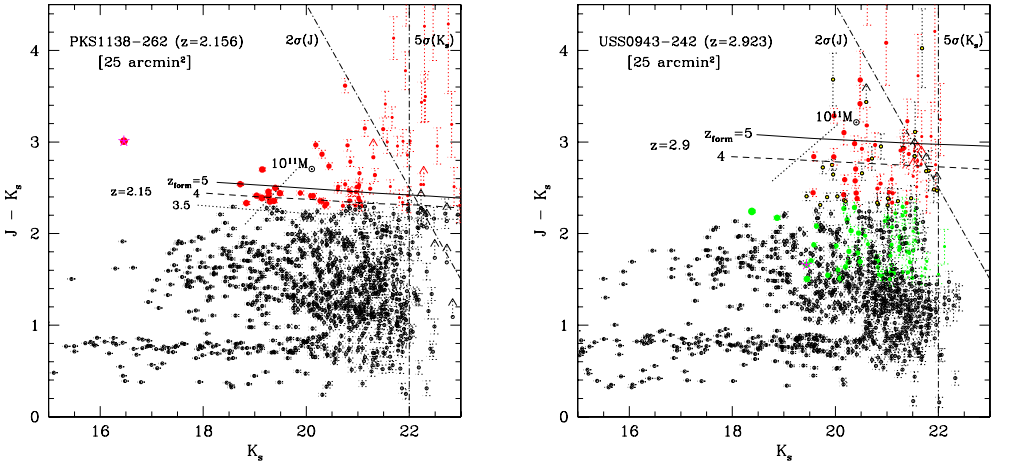

Figure 2. Colour-magnitude diagrams of the two proto-clusters at $2 < z < 3$. Filled circles indicate proto-cluster member candidates selected with $J - K > 2.3$ (PKS1138) and JHK diagram (USS0943), respectively (see Kajisawa *et al.* 2006 for our new JHK selection technique of passive/active galaxies at $2 < z < 3$). Solid, dashed and dotted lines show the expected location of colour-magnitude relations at the radio galaxies' redshifts in the case of passive evolution (Kodama *et al.* 1998). The iso-stellar-mass lines of $10^{11}\mathrm{M}_{\odot}$ are also shown.

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