Proto-clusters at high-z: structures and stellar populations

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Abstract

We have been targeting ∼10 proto-clusters at $1.4 < z < 3.1$ covering the peak epoch of galaxy formation on our Mahalo-Subaru project. We emply unique sets of narrow-band filters on wide field instruments of Subaru (Suprime-Cam at optical and MOIRCS at NIR) to map out line-emitting star-forming galaxies (Hα, [OIII], and [OII] emitters) associated to the proto-clusters. We present that all of our targets show prominent large-scale structures in and around them, indicating that they are still in vigorous assembly phase. Moreover, we show that star formation activity in the cluster cores is very high at $z \sim 2$ involving a significant fraction of dusty star-bursting galaxies, but such strong activities at proto-cluster centers at high redshifts declines sharply as time progresses, and the peak of star formation activity is shifted outwards to surrounding lower density regions. This clearly indicates the "inside-out" formation of galaxy clusters.

Spectroscopic follow-up observations reveal that the proto-cluster galaxies at $z \sim 2$ tend to have much higher ionization states than present-day counterparts, characterized by the presence of strong [OIII] emission lines. Moreover, we find that their gaseous metallicities in dense environment are systematically higher than those in the general fields at $z \sim 2$. This is probably due to some environmental effects on the gas inflow/outflow processes.

Using HST imaging, AO-assisted narrow-band imaging, and ALMA observations, we are now at the stage of resolving internal structures of individual galaxies to know the physical processes of galaxy formaiton in action and their environmental dependence. We will also review these on-going/future projects.