A Starbursting Proto-Cluster in Making Associated with a Radio Galaxy at $z = 2.53$ Discovered by Hα Imaging

HAYASHI, Masao*
(University of Tokyo)

KODAMA, Tadayuki, TADAKI, Ken-Ichi, KOYAMA, Yusei, TANAKA, Ichi
(NAOJ)

Galaxy clusters in the local Universe are dominated by early-type galaxies evolving passively, in contrast to general fields where late-type galaxies with active star formation are preferentially found [2]. However, it remains unknown when and how the environmental dependence of galaxy properties appeared. Proto-clusters at $z \gtrsim 2$ are ideal targets to address the issues, because approaching the formation epoch means that we can directly witness present-day cluster galaxies being vigorously growing.

Here, we show a discovery of a starbursting proto-cluster around a radio galaxy USS 1558-003 at $z = 2.53$ where there are a lot of cluster galaxies forming stars. The field surveyed has been known as an over-dense region of distant red galaxies (DRGs) [3]. Using NB2315 filter in MOIRCS on Subaru Telescope, which is perfectly matched to detect Hα emissions from galaxies at $z = 2.53$, a panoramic survey of Hα emitters (HAEs) is conducted in the proto-cluster. We have then succeeded in mapping out the 2-dimensional structure of the proto-cluster, and investigating the star forming activities and the stellar mass content of this forming cluster. The three main results we have found are summarized below (see also figure 1, and our paper [1] for more details).

(1) The proto-cluster is composed of three conspicuous groups of galaxies. One of them is surrounding the radio galaxy, and another is about 1.5 Mpc (physical scale) away from the radio galaxy to the south-west, and the other is in between the two clumps. These groups show significant excess in the number densities of both HAEs and DRGs. Their close separations suggest that they would merge together in the near future and grow to a single, more massive galaxy cluster at later times.

(2) A large fraction of the HAEs in this proto-cluster have star formation rates (SFRs) higher than $100\,M_{\odot}\,\mathrm{yr}^{-1}$, indicating that at $z \sim 2.5$, the progenitors of cluster early-type galaxies are vigorously forming in the biased high density regions. Star formation activity is high everywhere irrespective of environment within the proto-cluster region, and the properties of individual HAEs show little environmental dependence, except that the HAEs in the densest clump may have slightly higher SFRs compared to those in other regions.

(3) Most of the HAEs have blue colors, but some emitters have very red colors comparable to DRG. The red HAEs tend to be clustered in the three highest density clumps in contrast to lower-z clusters where similar red emitters are avoiding the cluster cores and preferentially located in the medium density regions or the outskirts of the clusters. Since the red emitters are likely to be dusty starburst galaxies in the transitional phase, this result may indicate that some environmental effects, such as galaxy-galaxy interaction, are at work on galaxies in the dense proto-cluster core at $z = 2.53$ and they are just changing their properties rapidly.

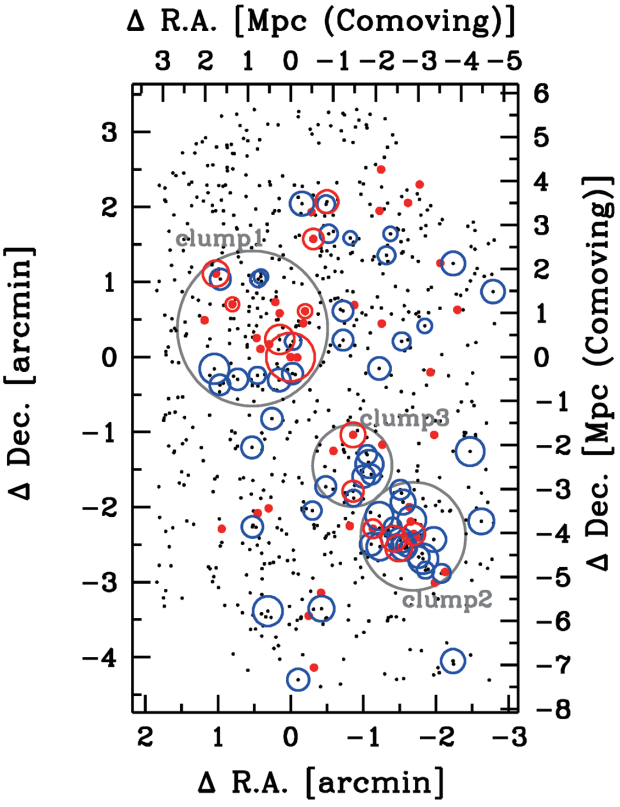

Figure 1: The spatial distribution of HAEs at $z = 2.53$ shown by blue open circles with the size scaled with SFR, i.e., larger symbols mean higher SFRs [1]. Gray open circles show three clumps where HAEs are strongly clustered. The red HAEs with $J - Ks > 1.38$ are also specified with red open circles. The red filled dots show DRGs, while the black dots show all galaxies detected in the field.

* belonged to NAOJ when the paper [1] was published.

References

[1] Hayashi, M., et al.: 2012, *ApJ*, **757**, 15.
[2] Dressler, A., et al.: 1997, *ApJ*, **490**, 577.
[3] Kodama, T., et al.: 2007, *MNRAS*, **377**, 1717.