Discovery of Extended Ionized Clouds in a Cluster of Galaxies at $z \sim 0.4$

YAGI, Masafumi (NAOJ)
GU, Liyi (SRON)
NAKATA, Fumiaki, HATTORI, Takashi (NAOJ)
KOYAMA, Yusei, KODAMA, Tadayuki (NAOJ/SOKENDAI)
YOSHIDA, Michitoshi (Hiroshima University)

Extended ionized clouds (EIGs) in intergalactic space has been reported by several studies of nearby cluster of galaxies [1-8] The clouds are thought to be made by ram-pressure stripping and/or galaxy interactions. Parent galaxies of EIGs tend to show post-starburst signature, especially in lower mass galaxies [8]. The stripping of the gas is therefore thought to be an important mechanism of the evolution of galaxies in clusters. There is also a study that the number of post-starburst galaxies in a cluster increases with redshift and typical luminosity of the post-starburst galaxies is larger at $z = 0.4$ than our neighborhood [9]. One can thus expect that there are more EIGs at $z = 0.4$. Nevertheless, no systematic survey has been tried so far.

There are two $z \sim 0.4$ cluster of galaxies obtained with the Subaru prime focus camera (Suprime-Cam), which have narrow-band data of redshifted Hα at the cluster's redshift; Abell 851 (A851) and CL0024+17 (CL0024) [10-12]. We re-analyzed the data with an improved method for extended objects and searched for EIGs. In A851, we found 9 EIGs, while none in CL0024.

We then identified possible parent galaxy of the 9 EIGs in A851. Five have redshift information in literature and/or unpublished data. We used Faint Objects Camera and Spectrograph (FOCAS) of the Subaru Telescope to obtain the rest 4, to confirm that all of the 9 parent galaxies are the member of A851. Moreover, in 30×25 arcmin of field of view of Suprime-Cam, the 9 EIGs exist within 2.3 arcmin (750 kpc) from the center of the cluster. These results suggests that the EIGs exist in A851 and they are ionized hydrogen clouds.

Six of the nine parents show an emission out of stellar distribution (Fig. 1 top), which implies a ram-pressure stripping. We also used Hubble Space Telescope (HST) images to see the morphology. Four of the nine show asymmetry in the distribution of stars (Fig. 1 bottom), which implies a recent galaxy interaction. The spectrum and color of the parents shows that the parents are either starforming galaxy or post-starburst one.

Regarding kinematics, we found that 6 or 7 EIG parents belong to a subcluster of A851 which is now infalling onto the main cluster. Compared with CL0024, which has no EIGs, the infalling subcluster shows a higher fraction of EIG parents with a statistical significance. Our result resembles an example in a near cluster [3] that gas stripping is caused by the infall of subcluster.

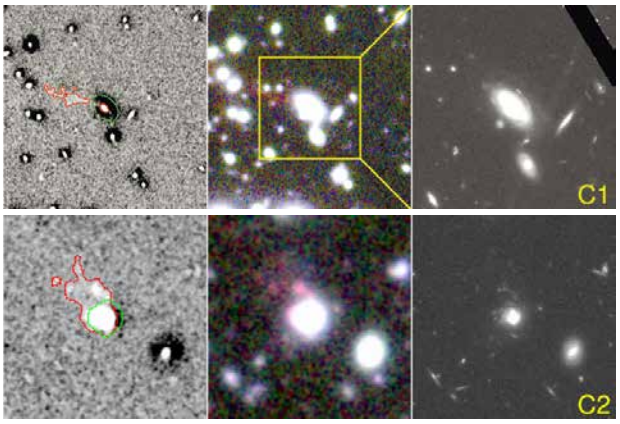

Figure 1: Examples of EIG in A851. Top-left and top-center are 50 arcsec (270 kpc) square, and the others are 25 arcsec (140 kpc) square. North is top, and east to the left. (Left) broad-band (z)-subtracted narrow-band (NB921) image from Subaru Suprime-Cam archived data. White shows strong emission in NB, and it corresponds to Hα at the A851 redshift. The red contour is 3σ isophote of NB-z, and the green contour shows 90 % flux isophote of the parent galaxy. The enclosed black ring around objects are artifacts caused by different seeing size of NB and z. (Center) Three color composite of NB921, z, and R. Hα is red in this color assignment. (Right) ACS/HST F816W image from the HST archive. The bottom galaxy (C2) shows asymmetric stellar distribution.

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