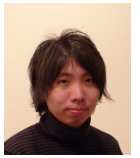


# Red Star Forming Galaxies in Distant Cluster Outskirts

~ A key population for understanding environmental effects at  $z < 1$  ~

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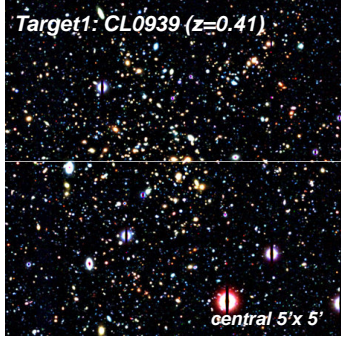


## ABSTRACT

We present our panoramic H $\alpha$  emitter survey for the two distant clusters of galaxies at  $z=0.4$  (CL0939+4713) and  $z=0.8$  (RXJ1716+6708), with narrow-band filters of Suprime-Cam and MOIRCS on the Subaru Telescope. Taking advantage of the wide-field capability of these facilities, we investigate in detail the star forming activity of galaxies along the large-scale structures at these high redshifts. In particular, **we report a discovery of a surprisingly large number of optically red H $\alpha$  emitters in the cluster surrounding environment such as groups and filaments**, where the colour-density relation shows an abrupt break (i.e. transitional environment). We revealed that a non-negligible fraction of such red H $\alpha$  emitters are indeed MIR-detected dusty starbursts, based on our wide-field 15 $\mu$ m imaging with the AKARI satellite. Thus, our results demonstrate that properties of galaxies are indeed changing "before" entering cluster environment accompanying strong dusty starbursts, and that the group-scale environment at  $z < 1$  has probably played a key role in shaping at least a fraction of the present-day cluster galaxies.

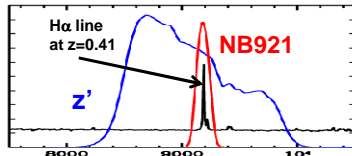
## Target 1. The CL0939+4713 Cluster at $z=0.41$

Koyama et al. 2011, ApJ, 734, 66



**main result 1**

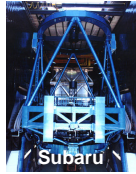
- A large number of H $\alpha$  emitters have been identified along the large-scale structure around the CL0939 cluster.
- A significant fraction (>30%) of H $\alpha$  emitters **in groups** show red colour (probably in transitional phase), suggesting an important role of the group environment for triggering/accelerating galaxy evolution.



### What we did ?

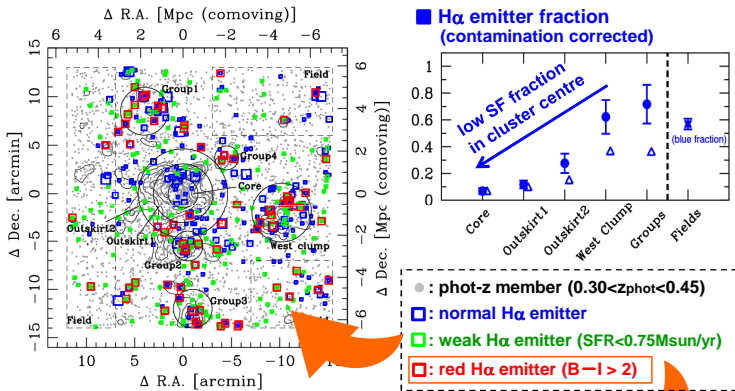
- We performed a wide-field H $\alpha$  emitter survey for the CL0939 cluster at  $z=0.41$  using NB921 filter of Suprime-Cam/Subaru.

- The purpose is to map out the star forming activity along the large-scale structure, and to understand the environmental effects acting on galaxies in the cluster surrounding regions (i.e. transitional environment).



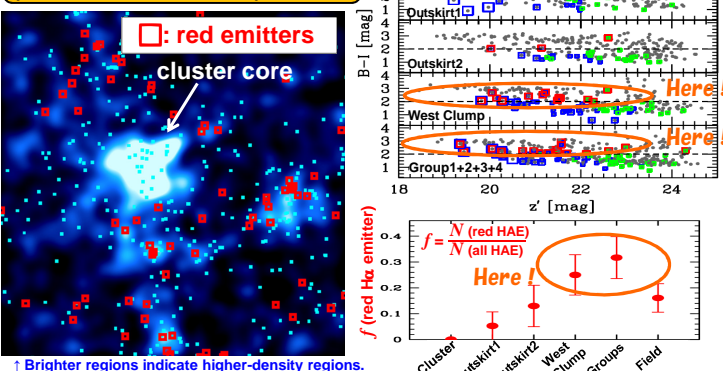
### Panoramic H $\alpha$ view of the CL0939 cluster

The H $\alpha$  emitters are distributed widely along the large-scale structure, and the number of H $\alpha$  emitters decreases towards the cluster centre.



### Red H $\alpha$ emitters in the group environment

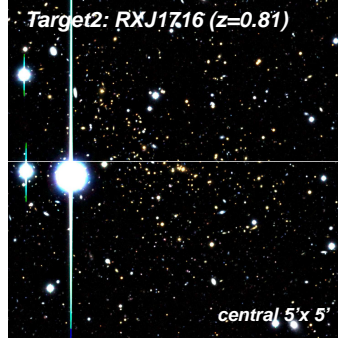
Obviously, the "red H $\alpha$  emitters" (transitional population) are most frequently seen in clump/groups (not in the cluster core!).



Brighter regions indicate higher-density regions.

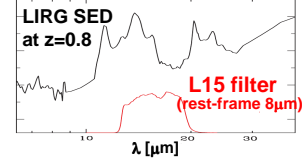
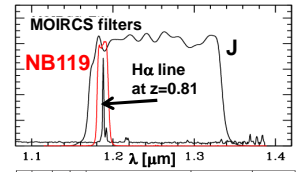
## Target 2. The RXJ1716+6708 cluster at $z=0.81$

Koyama et al. 2010, MNRAS, 403, 1611



**main result 2**

- At least a part of red emitters around the RXJ1716 cluster are indeed MIR-detected dusty starbursts (not just gradually fading their star formation).
- Highly obscured galaxies with  $\text{SFR}(\text{IR})/\text{SFR}(\text{H}\alpha) > 3$  are concentrated in the "medium-density" groups and filaments, supporting a link between dusty galaxies and such environment.



### What we did ?

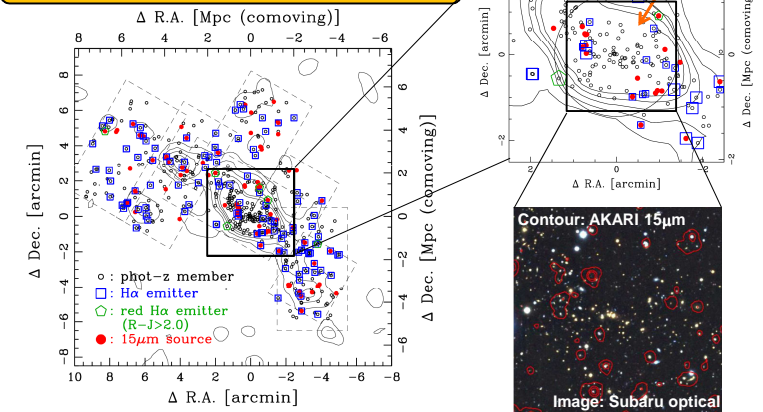
- We carried out the first wide-field H $\alpha$  and MIR mapping of a  $z \sim 0.8$  cluster with MOIRCS/Subaru and the AKARI satellite.

- These observation allowed us to study both unobscured/obscured star formation activity in various environments around the cluster.

### Panoramic H $\alpha$ +MIR view of the RXJ1716 cluster

Here !

The spatial distribution of the H $\alpha$  emitters and 15 $\mu$ m sources are very similar, and they avoid the cluster central region.



### Dusty galaxies around the RXJ1716 cluster

Dusty red SF galaxies (red H $\alpha$  emitters and/or MIR sources) are concentrated in the "medium-density" groups/filaments.

