Subaru Users Meeting FY2022

SED fitting analysis of massive galaxies in a protocluster of LAEs at z=2.4 near the radio galaxy 53W002

P17

Naoki Yonekura, Masaru Kajisawa (Ehime U.), Ken Mawatari (NAOJ), Toru Yamada (ISAS)

ABSTRACT

We report results of a search for massive galaxies in a large-scale high-density structure of Lyman Alpha Emitters (LAEs) at z=2.4 near a radio galaxy 53W002 by using *B*-, *V*-, *i'*-, *J*-, *H*-, *Ks*-band imaging data taken with Suprime-Cam and MOIRCS on the Subaru telescope. Massive member galaxy candidates were selected by JHKs-band color cuts and an additional criterion from SED fitting analysis. We estimated their Ms, SFRs, and sSFRs from SED fitting and compared them with those of field galaxies selected by the same selection method. We found significant number density excesses of massive galaxies with log Ms/Msun ≳11 and massive quiescent ones with log Ms/Msun ~ 10.5-11 and log sSFR/yr < -11 in the protocluster region. We also compared spatial distribution of the member galaxy candidates with that of LAEs. The Massive galaxies with log Ms/Msun > 11 are not located at the density peak of LAEs but widely distributed along similar direction to the structure of LAEs. On the other hand, the quiescent galaxies with log sSFR/yr < -11 show clearly avoiding the structure of LAEs. These results indicate that massive galaxies with log Ms/Msun≳11 and quiescent ones exist in this protocluster and star-formation activities of member galaxies depend on their location in the protocluster (Yonekura et al. 2022, ApJ, 930, 102).

1. INTRODUCTION

-Background-

- ✓ It is well known that massive early-type galaxies with little SF activities dominate galaxy clusters at local universe.

  How have those massive galaxies formed in high-density regions?

  ➡ Direct observations for massive galaxies in protoclusters at their formation epoch of z>2 are important.

- ✓ NB observations of LAEs successfully discovered protoclusters. However, the LAE selection could miss massive and/or quiescent galaxies.

  ➡ Rest-frame optical observations are needed to search for them.

- ✓ Although several previous studies discovered massive galaxies in protoclusers, they focused on only rich protoclusters such as SSA22[1].

  ➡ **It is unclear whether massive galaxies have already been formed in more typical protoclusters.**

-This study-

- ✓ We focused on a protocluster of LAEs near a radio galaxy 53W002 at z=2.4 (Fig.1), which is thought as a typical protocluster[2].

  ➡
  - ✓ **We examine whether massive galaxies have already been formed in this typical protocluster.**
  - ✓ **We investigate their physical properties if they exist.**

2. DATA & ANALYSIS

-Data and Photometry-

Table 1. summary of the used data

Band	*B*	*V*	*i'*	*J*	*H*	*Ks*
Equip.	Suprime-Cam			MOIRCS		
Depth*	27.3	26.6	25.9	23.6	23.4	23.3

*5σ limiting AB magnitude.

Effective area is ~70.2 arcmin^2 (red line of Fig.1).

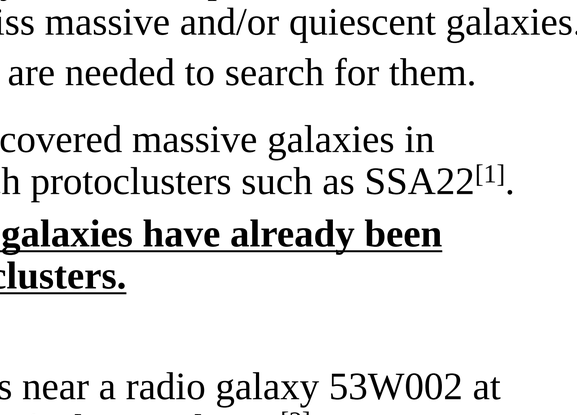

Fig.1 Fields of view of Suprime-Cam (blue line) and MOIRCS (red line). Gray-scale contour shows the LAE number density[2]. Yellow pentagon is the radio galaxy 53W002.

-Member Candidate Selections-

Objects with K_s<23.3 AB mag

(i) JHKs-band color cuts[3] based on Blmer/4000Å break at z~2.4

$$\begin{cases} (J-K_s)_{\rm AB} > 0.581 \text{ and} \\ (J-K_s)_{\rm AB} > 2(H-K_s)_{\rm AB} + 0.541 \end{cases}$$

80 objects were selected.

(ii) A criterion from SED fitting

$$\Delta\chi^2 \equiv \chi^2_{\rm best} - \chi^2_{z=2.39} < 2.71$$

($\chi^2_{\rm best}$ and $\chi^2_{z=2.39}$ are minimum χ^2 at best-fit redshift and z=2.39.)

Model spectra for SED fitting
- GALAXEV models[4]
- Chabrier IMF[5]
- Calzettie extinction law[6]

Contaminants from other redshifts have higher $\Delta\chi^2$ values (Fig.3).

18 objects were removed.

Finally, 62 candidates are selected in the protocluster region.

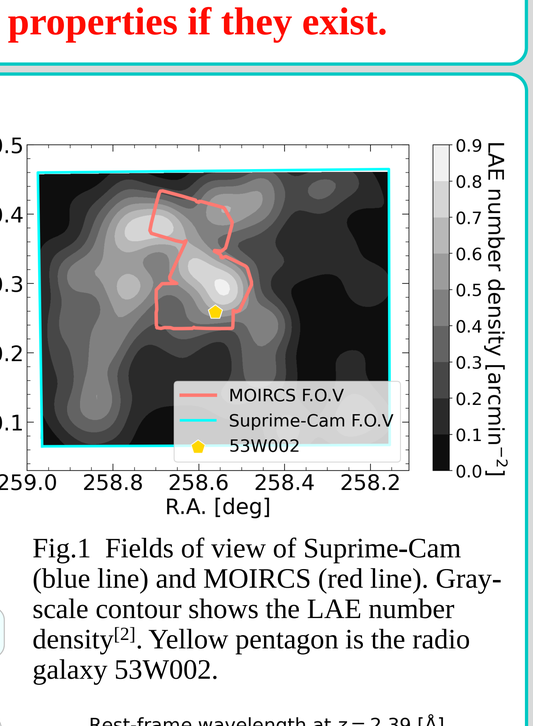

Fig.2 Transmission curves of used filters (color solid lines). Dashed grey line show a model spectrum at z=2.39.

Fig.3 χ^2 of SED fitting vs. redshift (black line) of an object which is removed by selection (ii). Red solid and blue dashed lines show z=2.39 and best-fit redshift. Red shade region shows the range of $\Delta\chi^2$ < 2.71.

-Field Sample for Comparisons-

- ✓ We used *B*-, *V*-, *i'*-, *J*-, *H*-, *Ks*-band data from COSMOS2015 catalog[7].
- ✓ Effective Area is ~1230 arcmin^2.

➡ 896 objects are selected by the selection (i) and (ii) as the field sample.

3. sSFR vs. Ms

Specific Star formation rate (sSFR) and Stellar mass (Ms) are estimated by SED fitting with fixing redshift to z=2.39.

-Density Excess in the Protocluster-

- ✓ We made a density excess map of the protocluster region on sSFR vs. Ms by subtracting density map of the field from that of the protocluster (top panel of Fig.4).
- ✓ Massive galaxies with Ms≳10^{11} M$_\odot$ and massive quiescent ones with Ms~10^{11} M$_\odot$ and sSFR<10^{-11} yr^{-1} show significant density excesses.

  ➡ **Massive and/or quiescent galaxies have already been formed in the typical protocluster.**

-SF Activities of Massive Galaixes-

- ✓ Massive galaxies with Ms>10^{11} M$_\odot$ show intermediate sSFRs of 10^{-11}-10^{-10} yr^{-1} (bottom panel of Fig.4).

  ➡ Their SF activities have not yet stopped completely?

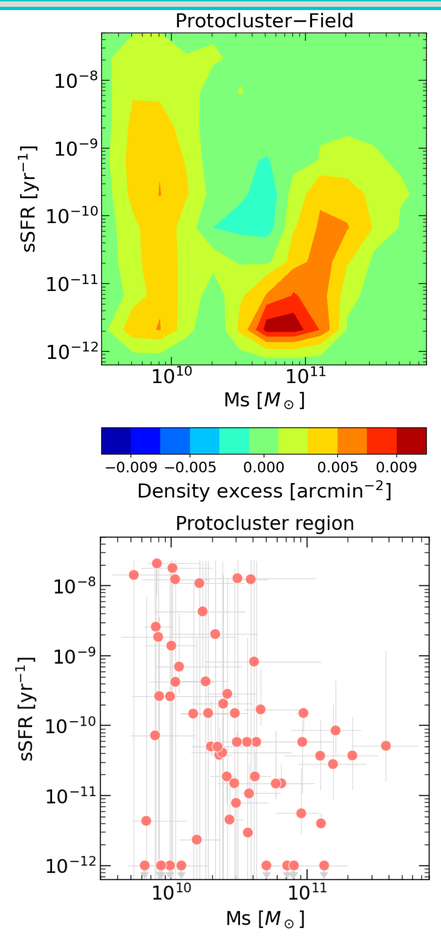

Fig.4 **Top**: probability density excess map on sSFR vs. Ms. **Bottom**: sSFR vs. Ms for the member candidates in the protocluster region.

4. SPATIAL DISTRIBUTION

-Distribution of Massive Galaxies in the Protocluster-

Left panel of Fig.5 shows the distribution of massive galaxies with Ms>10^{11}M$_\odot$.

- ✓ Not concentrated at the density peaks of LAEs.
- ✓ A wide distribution along the large-scale structure of LAEs.

-Dependence on sSFR-

Star-forming galaxies with sSFR>10^{-11} yr^{-1} are located near the density peaks of LAEs. (middle panel of Fig.5)

⟷

Quiescent galaxies with sSFR<10^{-11} yr^{-1} clearly avoid the structure of LAEs. (right panel of Fig.5)

➡ **SF activities depend on their location in the protocluster.**

-What Caused This Trend?-

Large-scale cold gas supply along the structure of LAEs could be related with this trend.

If such cold gas supply occurs,

- ✓ Galaxies are newly formed along the large-scale gas filaments.

  ➡ Construction of the large-scale structure of LAEs.
- ✓ Cold gas can be supplied to existing massive galaxies.

  ➡ Sustaining/rejuvenating their SF activities.

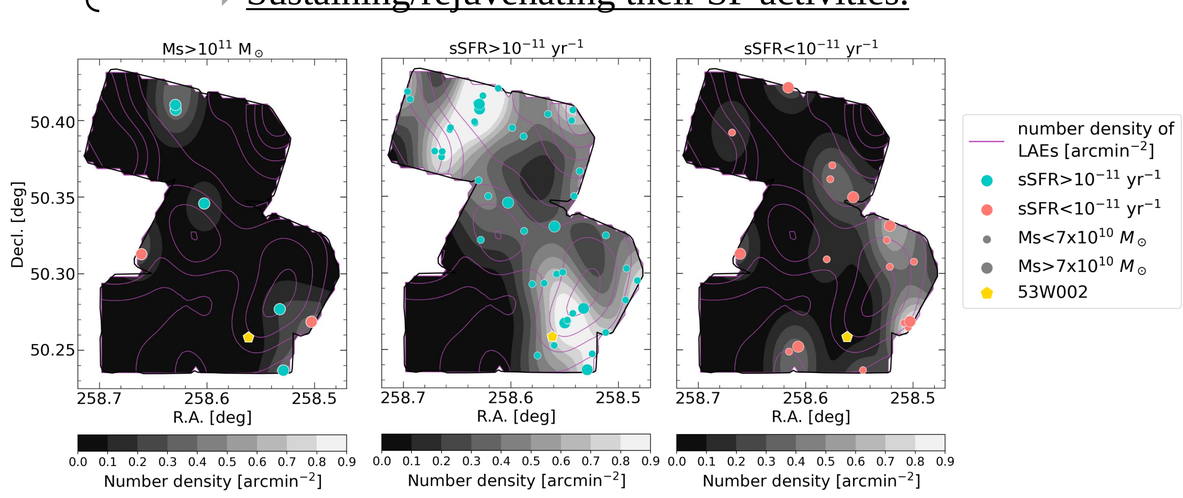

Fig.5 Spatial distributions of member galaxies with Ms>10^{11} M$_\odot$ (left), those with sSFR>10^{-11} yr^{-1} (middle), and those with sSFR<10^{-11} yr^{-1} (right). Different sizes and colors indicate different Ms and sSFR, respectively. Gray-scale and purple line contours show number densities of member galaxies and LAEs, respectively. Yellow pentagon is the radio galaxy 53W002.

REFFERENCE

[1] Kubo et al. 2013, ApJ, 778, 170
[2] Mawatari et al. 2012, ApJ, 759, 133
[3] Kajisawa et al. 2006, MNRAS, 371, 577
[4] Bruzual & Charlot 2003, MNRAS, 344, 1000
[5] Chabrier 2003, PASP, 115, 763
[6] Calzetti et al. 2000, ApJ, 533, 682
[7] Laigle et al. 2016, ApJS, 224, 24