Star formation activities in a cluster and its surrounding structure at z=1.46

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Abstract

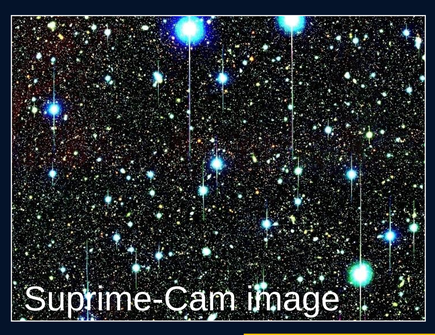
We present a panoramic [OII] emission survey in and around a cluster XMMXCS J2215.9-1738 at z=1.46 with Suprime-Cam/Subaru, and the follow-up NIR spectroscopy of 16 [OII] emitting galaxies in the cluster core with MOIRCS/Subaru. With NB912 narrow-band filter (λ=9139 Å, $\Delta\lambda$=134 Å), we identify 380 [OII] emitting galaxies down to 1.4x10^{-17} erg s^{-1} cm^{-2} in a 32x23 arcmin^2 area. We find that the [OII] emitting galaxies are distributed even in the cluster core, and further along filamentary large-scale structures around the cluster, which are among the largest structure of star-forming galaxies ever identified at 1.3<z<3.0. The discovery of such structures in this cluster enables us to investigate the dependence of properties of star-forming galaxies on the environment at z=1.46. The star formation activities and mass-matallicity relation for the [OII] emitters indicate that this cluster has experienced active star formation comparable to those in its surrounding regions. On the other hand, a significantly higher fraction of [OII] emitters is seen on the red sequence in the cluster core compared with those in the other environments. These red galaxies are more likely to be nearly passively evolving galaxies which host [OII] emitting AGN, rather than dust-reddened star-forming [OII] emitters. Our results all suggest that there is apparently no longer a strong environmental variation in the galaxy properties at z~1.5, except for the excess of the red emitters. AGN feedback may be one of the critical processes to quench star formation in massive galaxies in high density regions.

Introduction

- Star forming activity of local galaxies is strongly dependent on environment. Local ellipticals prefer to be in higher density region. (e.g., Dressler+97)
- Unveiling star formation activities as a function of environment and time would provide us important clues to understanding galaxy formation and evolution.

Our ongoing project (PI: T. Kodama):
MAHALO-Subaru (**MA**pping **HA**lpha and **L**ines of **O**xygen with **Subaru**)
This project aims to map out the star formation activity in clusters and fields at 0.4<z<2.5 by narrow-band imaging.
(Related presentations: Kodama's talk, and Koyama and Tadaki's posters)

Target



- **XMM XCS J2215.9-1738 cluster @ z=1.46**
- One of the very distant clusters with a detection of X-ray emission
- kT=4.1 +0.6/-0.9 keV (Hilton+10)
- Lx=2.92 +0.24/-0.35 10^{44} erg/s (Hilton+10)
- σ=720 km/s (Hilton+10)

Our data set

- Imaging data

  NB912 narrow-band filter (λ_c=9139 Å, $\Delta\lambda$=134 Å)

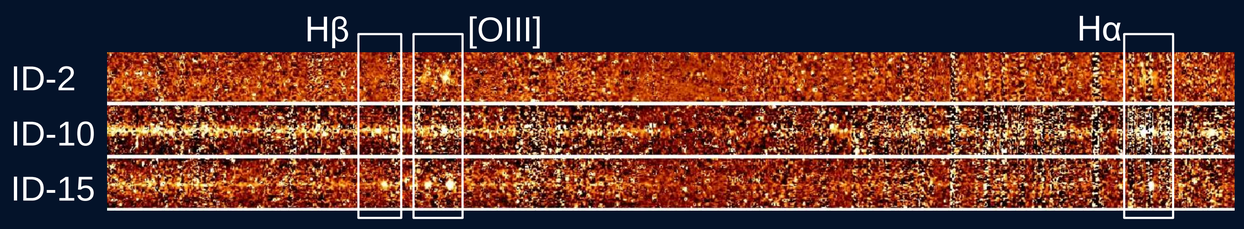
  $\Delta\lambda$=134 Å ⇔ Δv= -2800 ~ +1600 km/s @ z=1.46

Filter	Effective area (arcmin^2)	Net integration (min)	Limiting mag. (3σ)	Instrument	Observation date
B	32 × 23	140	27.6	Subaru/Suprime-Cam	2008 July 30–31†
R_c	32 × 23	88	27.1	Subaru/Suprime-Cam	2009 July 20
i'	32 × 23	90	26.8	Subaru/Suprime-Cam	2009 July 20
z'	32 × 23	80	25.8	Subaru/Suprime-Cam	2008 July 30–31†
NB912	32 × 23	260	25.8	Subaru/Suprime-Cam	2008 July 30–31†
J	6 × 6	32.5–92.3	23.8–24.6	Subaru/MOIRCS	2007 August 07†, 2008 June 29–30†
K	32 × 23	123	23.4	UKIRT/WFCAM	2010 July 30–31

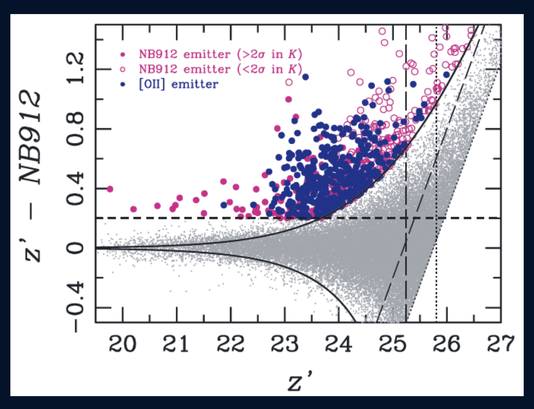
† Hayashi et al. (2010); ‡ Hilton et al. (2009).

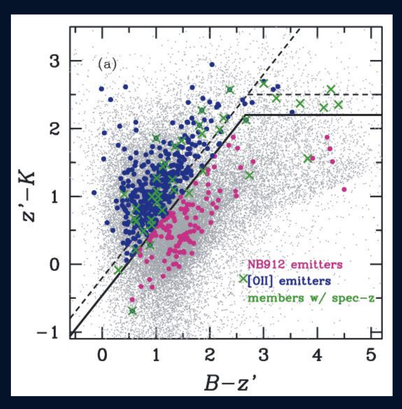
- Near-infrared spectroscopic data by MOIRCS/Subaru

  For 16 [OII] emitters in the cluster core, some emission lines are detected.
  Many [OII] emitters are confirmed to be a cluster member at z~1.46.



[OII] emitters in and around XCS2215 cluster

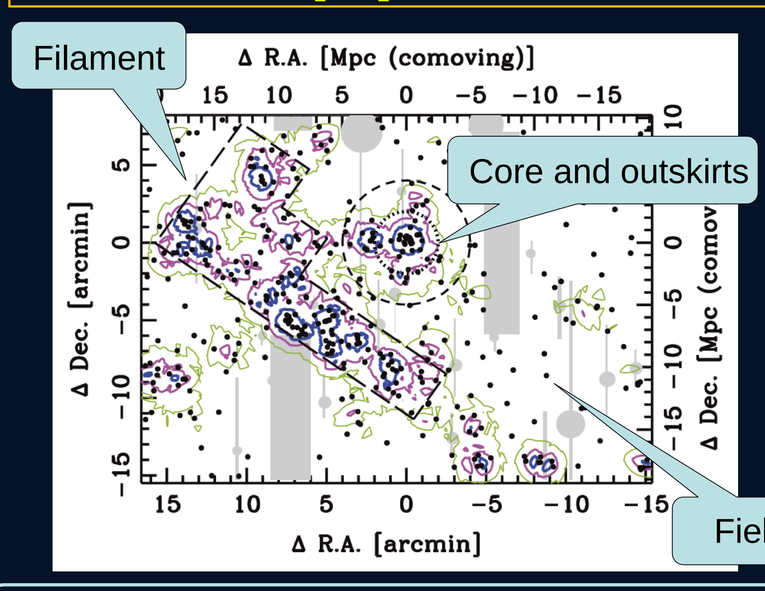




(1) Emitters are selected as objects with 3σ excess of NB912 to z'.
(2) Cluster member candidates are selected by their BzK colors,
(z'-Ks)>(B-z')-0.46 or (z'-Ks)>2.2 ・・・ (i)
Objects that meet both (1) and (2) are selected as [OII] emitters in the cluster.

380 [OII] emitters down to dust free SFR>3Msun/yr

Distribution of [OII] emitters in and around the cluster



Black dots: [OII] emitters

Contours: local densities calculated from the [OII] emitter sample

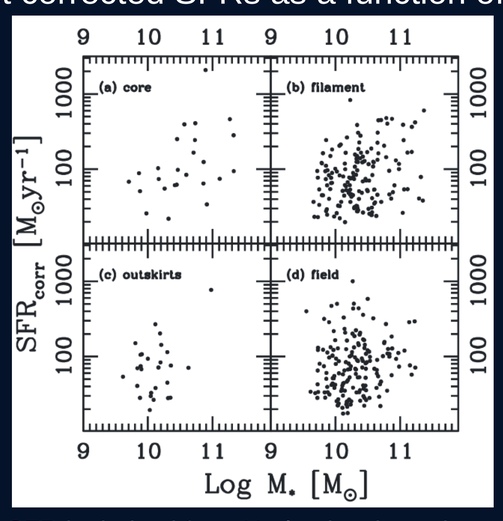
Grey areas: masked

Four environments, core, outskirts, filament, and field, are defined based on the distribution of [OII] emitters.

Map of [OII] emitters at z=1.46 shows a concentration in the cluster core and a large scale structure from east to south of cluster.

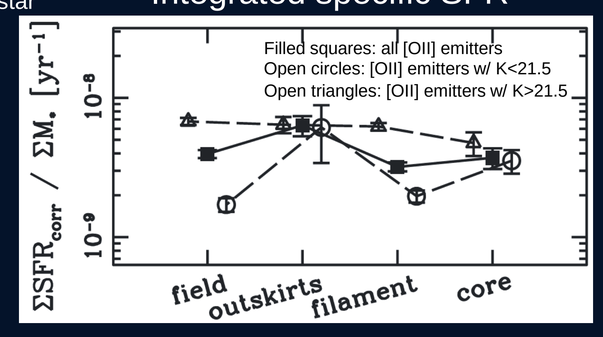
Star formation activity as a function of environment

Dust corrected SFRs as a function of M_{star}

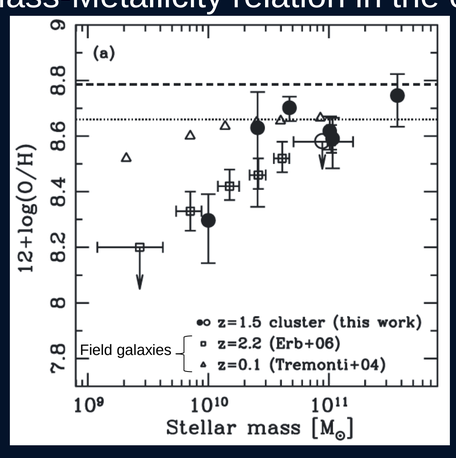


SFR is derived from Hα luminosity estimated from observed [OII] flux, and dust extinction is estimated from Garn et al. (2010) equation.

Integrated specific SFR



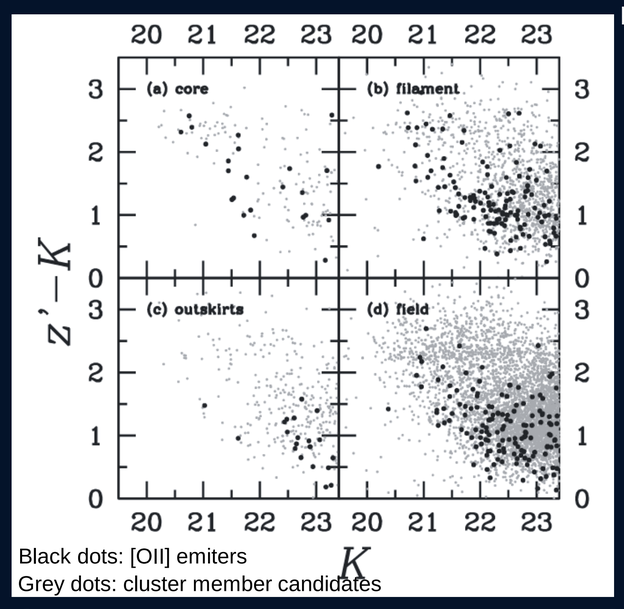
Mass-Metallicity relation in the core



Metallicity is derived from [NII]/Hα ratio.
(N2 method: Pettini & Pagel 2004)

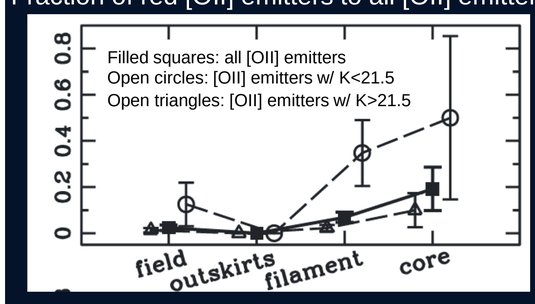
SFR, specific SFR and metallicity for [OII] emitters in the high density regions are similar to those for the field galaxies. Thus, it seems that there is no longer a strong environmental variation in the galaxy properties at z~1.5

Fraction of red [OII] emitters with $(z-K)_{AB}$ > 2.2

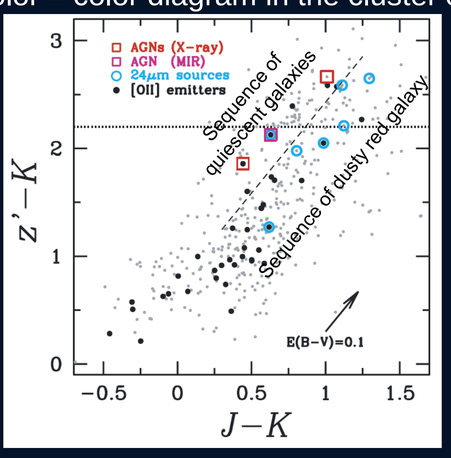


Black dots: [OII] emiters
Grey dots: cluster member candidates

Fraction of red [OII] emitters to all [OII] emitters



Color – color diagram in the cluster core



Most of red [OII] emitters which prefer to be located in higher density regions are likely to be passively evolving galaxies with AGN activity.

The results in this poster are published in **Hayashi et al., 2011, MNRAS, in press (arXiv: 1104.2121)**, and see also **Hayashi et al., 2010, MNRAS, 402, 1980**.