Testing Web Feeding Model for Star Formation in Galaxy Clusters in the COMOS Field

Eunhee Ko[1], Myungshin Im[1], Seong-Kook Lee[1] and Minhee Hyun[1]

Contact: eunheeko@astro.snu.ac.kr
Github: https://github.com/eunheeko

[1]SNU Astronomy Research Center, Astronomy Program, Dept. of Physics & Astronomy, Seoul National University

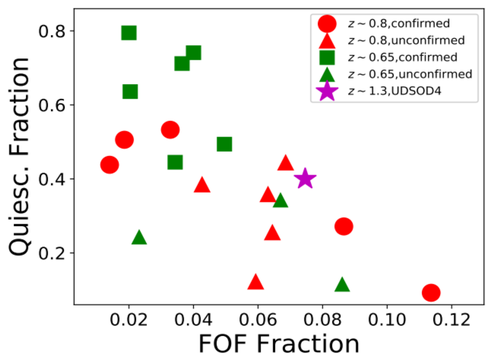
Introduction

■ Cluster-by-Cluster Variation in star formation activity at z ~ 1

- Several mechanisms explain how the galaxies evolve. However, what plays the main role of controlling the star formation activity is not clearly investigated.
- Galaxy clusters at z ~ 1 are important probes to investigate the diverse star formation activities.

Is star formation activity in clusters at z ~ 1 affected by large-scale structure?
And How can we quantify the dependence of large-scale structure?

■ Web Feeding Model



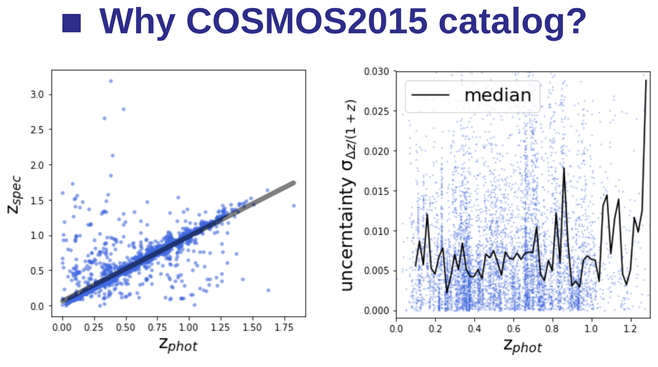
► Definition:

- **Quiescent galaxy fraction F_q**, the number of quiescent galaxies divided by the total number of galaxies in galaxy clusters, is used as an indicator of star formation activity
- **Friends-of-Friends fraction, F_{FoF},** is calculated as the area of 2-σ level overdense area over circular area within 10Mpc radius.
- F_q and F_{FoFs} are strongly anti-correlated in galaxy clusters in UDS field which implies **"More connected, More active"**

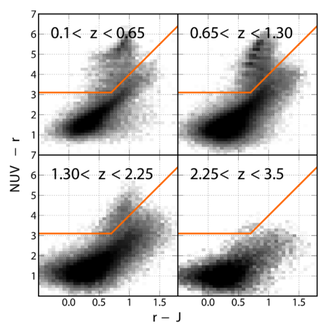
- **Web Feeding Model** explains the variety of star formation activities in clusters with the suggestion that enhanced star forming activities in overdensities are due to the inflow of gas and star-forming galaxies to localized overdense areas. *(Lee et al. 2019)*
- According to Web Feeding Model, large-scale structure might be the main reservoirs of gas and star-forming galaxies to keep galaxy clusters fresh and extended in size at z ~ 1

Data & Sample Selection

■ Why COSMOS2015 catalog?



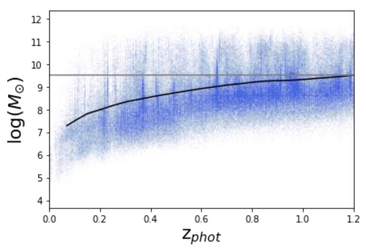
► **Left**: Photometric redshift comparison with spectroscopic redshift(*Lilly et al. 2007*). **Right**: photometric redshift uncertainty as a function of redshift. Photometric redshift accuracy is $\Delta z/(1+z_{spec})$ ~ 0.007 with a catastrophic failure fraction of only 0.5 to z ~ 1



► NUV-r / r-J galaxy distributions. Quiescent galaxy lies in the top-left corner(*C. Laigle et al. 2016*)

- COSMOS field is $1.4 * 1.4 \sim 2\ deg^2$ area including deep multi-wavelength data over 30 filters.
- COSMOS2015 catalog provides the **reliable photometric redshift**

■ Mass complete sample

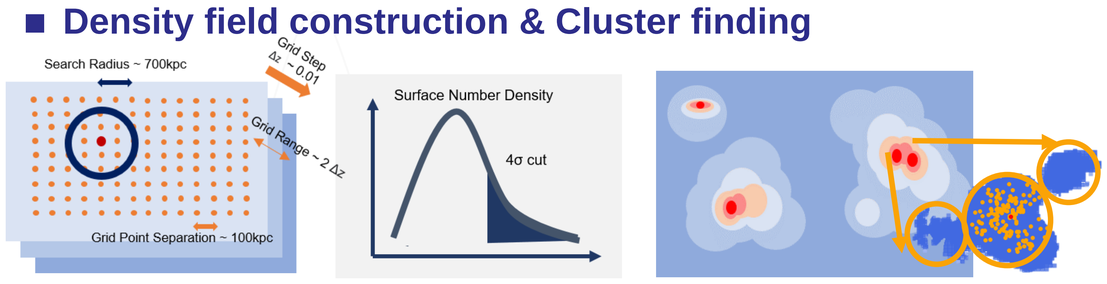


- Photometric redshift range: 0.6 < z < 1.2
- Mass complete sample using K_s band:

$$\log\left({}^{M_{limit}}/_{M_\odot}\right) = \log\left({}^{M}/_{M_\odot}\right) + 0.4(K_s - 24)$$

Mass complete limit is the stellar mass for which 90% of galaxies

■ Density field construction & Cluster finding

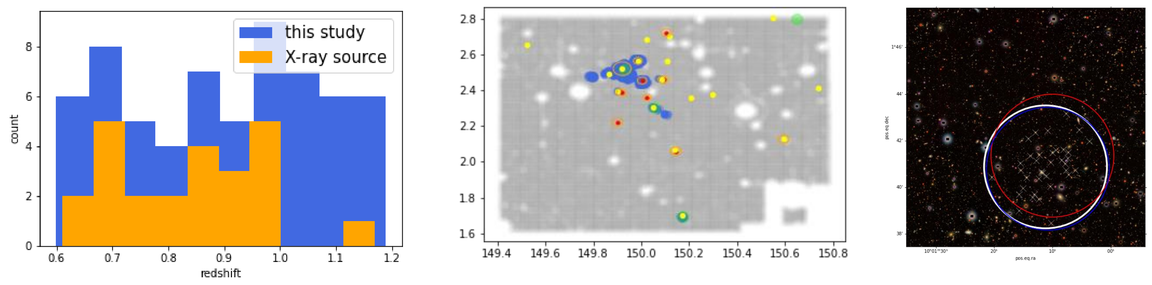


Step 1: Divide the redshift bins : $0.6 < z < 1.2$ (z step size ~ 0.01)
Step 2: Measure the number density within 0.7 Mpc for all grid points in each bin
Step 3: Select overdense area exceeding 4σ-level as galaxy cluster candidates

- Overdense area with more than 10 connected grid points are included and when the number of grid points exceed 50, we find the substructure again .

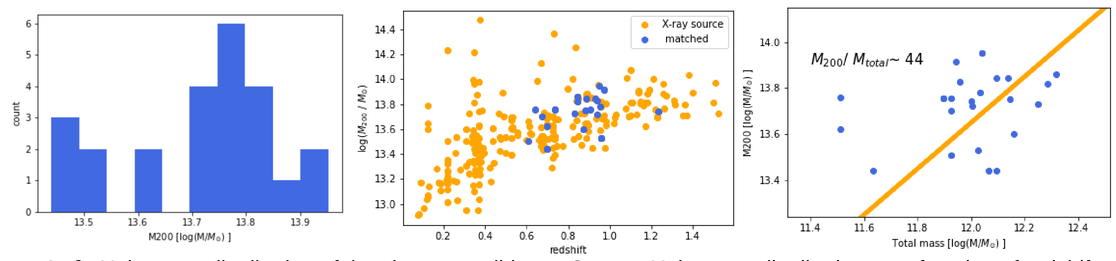
Preliminary Results

■ Characteristics of 4- σ overdense area



▲ **Left**: Redshift distribution of 4-σ level overdensities and matched X-ray source catalogs. **Center**: Crossmatch 4-σ overdensities(blue) with X-ray(red) and Weak lensing(yellow) catalog. **Right**: r', i', g' composite image of galaxy cluster candidates. White, blue, and red circle corresponds to the galaxy clusters in this study, X-ray source cluster, and weak lensing catalog respectively.

- By applying 4-σ level selection cut, total 63 overdense area are found.
- 24 galaxy cluster candidates are matched with x-ray catalog(*Gozalislet al. 2018*), and 20 with optical & weak lensing catalog(*bellagamba et al. 2011*)

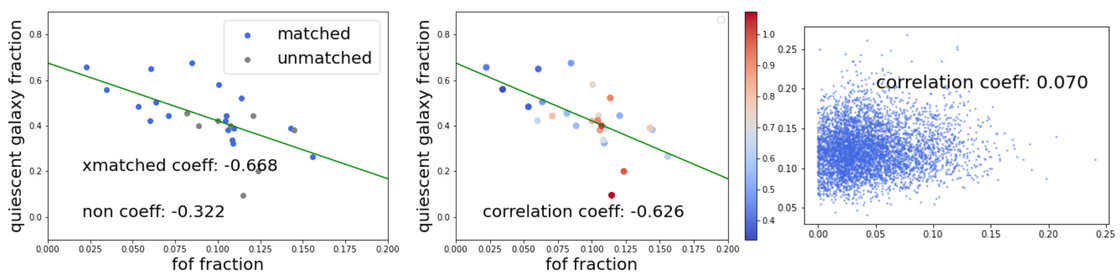


▲ **Left**: Halo mass distribution of the cluster candidates. **Center**: Halo mass distribution as a function of redshift. **Right**: we determine the member galaxies based on R_{200} from the relationship between total mass and M_{200} in X-ray catalog. The M_{halo}/M_{total} shows the linear relationship, and the ratio is calculated as 44

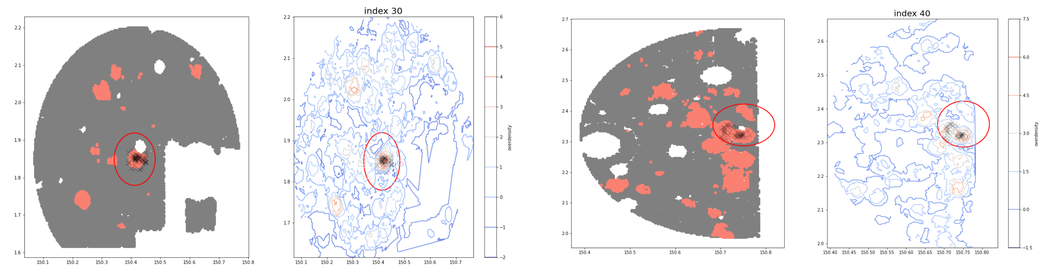
- Center of coordinates, and redshifts of galaxy cluster candidates are calculated as weighted mean.

$$M_{total} = \sum_i M_i * w_i \ where\ w_i = {}^{N_{photo-z\ only}}/_{N_{total}}$$

■ Large-scale structure dependence on star formation activity



- F_q and F_{FoFs} show the **intermediate anti-correlation** which might indicate the star formation activity dependence on large-scale structure. The Pearson coefficient between F_q and F_{FoFs} is calculated as **-0.668** While it is **0.070** at randomly chosen 1000 points



▲F_{FoFs}~ 0.123, F_q~ 0.28 ▲ F_{FoFs}~ 0.03, F_q~ 0.46

- More connected area within 10Mpc have lower quiescent galaxy fraction while more isolated one shows higher quiescent galaxy fraction

Summary & Further study

- We found 63 galaxy cluster/group candidates at 0.6 < z < 1.2 in COSMOS field.
- We also found the anti-correlation between friends-of-friends fraction and quiescent galaxy fraction which might indicate the large-scale structure dependence on star formation activity in galaxy clusters/groups.
- Less strong correlation was found, However, the cluster detection based on photometric redshifts has intrinsic uncertainties compared to the spectroscopic redshifts.
- The role of cosmic web will be investigated by applying cosmic web extraction algorithm in the future study.