Environmental effects on massive galaxy formation in most distant clusters

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Environmental effects on massive galaxy formation

The role of environment in massive galaxy formation/quenching remains unclear.

Baldry+2006

also see Koyama+2013 for high-z

Peng+2010

Invariant star forming main-sequence
The early assembly of massive (cluster) galaxies

Thomas+2010

Kawinwanichakij+2017
The early assembly of massive cluster galaxies:
The core of the most massive clusters are already dominated by quiescent galaxies at $z \sim 2$

Newman+2014

Strazzullo+2013, Wang+2016
Hunting for massive galaxy clusters in formation (starbursting galaxy clusters)

Herschel/SPIRE-selected extremely luminous infrared sources
“Discovery of a Galaxy Cluster with a Violently Starbursting Core at $z=2.506$”

Presence of both extended X-ray emission and a dominant population of massive SFGs

Narrow-band imaging of J1001 with Subaru/MOIRCS: Towards a complete census of star-forming cluster members

The massive cluster galaxies are heavily obscured.

Wang, Kodama, Tanaka, et al. in prep

Narrow band imaging of J1001 with Subaru/MOIRCS
J1001 bridges the gap from protocluster to mature clusters

A cluster-size, virialized halo yet a dominant population of massive star-forming galaxies

Umehata+2015
Galaxy Properties in J1001: CO(1-0) observations with VLA

With a single pointing from VLA, we detected 11 cluster members in CO(1-0), which nearly doubles the total number of CO(1-0)-detected normal galaxies at z>2

First evidence of environmental dependence of gas content at z>2:

Decreasing gas fraction towards the cluster core

Key: CO(1-0) observations of mass-complete samples of cluster members across different local environment!

also see Tadaki+2019
Dark galaxy clusters revealed by overdensities of HST-dark galaxies at $z>3$:

Current determination of the cosmic star formation rate density at $z>3$ is solely based on UV-bright galaxies.
Are the most massive $z>4$ galaxies missed by HST?  
(A complete H-dropout sample down to $[4.5] < 24$)
H-dropouts dominate the cosmic SFR density from massive galaxies, and are likely progenitors of today’s most massive galaxies in clusters.

Wang, T+2019, Nature, 572, 211
Dark galaxy clusters revealed by overdensities of HST-dark galaxies at z\(>3\):

Zhou+2019 (to be submitted) and GOODS-ALMA Wang+2019, 2020 (in prep)

Subaru archival data!

Zhou+2019 (to be submitted) and GOODS-ALMA
Massive galaxies at high-z are good tracers of galaxy (proto)clusters

Mass evolution of galaxies at constant number densities

Behroozi+2013

Increasing contribution from protoclusters to the cosmic SFR density at higher redshifts

Chiang+2015
Summary

- We reveal a novel population of young clusters with a dominate population of massive star-forming galaxies in the core, which bridges the gap between mature clusters and protoclusters.

- While most of the massive cluster galaxies locate on the main-sequence, strong cluster-centric radius dependence of molecular gas content (and SFE) is revealed in J1001, providing direct evidence on environmental dependence of massive galaxy formation at z>2.

- Subaru (MOIRCS, HSC) is critical to map the 3-D structures and obtain a complete census of member galaxies of young galaxy clusters in the early universe.