THE EVOLUTION OF STAR FORMATION ACTIVITY IN CLUSTER GALAXIES OVER $0.15 < z < 1.5$

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ABSTRACT

We explore 7.5 billion years of evolution in the star formation activity of massive ($M_\star > 10^{10.1}\,M_\odot$) cluster galaxies using a sample of 25 clusters over $0.15 < z < 1$ from the Cluster Lensing And Supernova survey with *Hubble* and 11 clusters over $1 < z < 1.5$ from the IRAC Shallow Cluster Survey. Galaxy morphologies are determined visually using high-resolution *Hubble Space Telescope* images. Using the spectral energy distribution fitting code CIGALE, we measure star formation rates, stellar masses, and 4000 Å break strengths. The latter are used to separate quiescent and star-forming galaxies (SFGs). From $z \sim 1.3$ to $z \sim 0.2$, the specific star formation rate (sSFR) of cluster SFGs and quiescent galaxies decreases by factors of three and four, respectively. Over the same redshift range, the sSFR of the entire cluster population declines by a factor of 11, from 0.48 ± 0.06 Gyr^{-1} to 0.043 ± 0.009 Gyr^{-1}. This strong overall sSFR evolution is driven by the growth of the quiescent population over time; the fraction of quiescent cluster galaxies increases from 28^{+8}_{-19}% to 88^{+5}_{-4}% over $z \sim 1.3 \rightarrow 0.2$. The majority of the growth occurs at $z \gtrsim 0.9$, where the quiescent fraction increases by 0.41. While the sSFR of the majority of star-forming cluster galaxies is at the level of the field, a small subset of cluster SFGs have low field-relative star formation activity, suggestive of long-timescale quenching. The large increase in the fraction of quiescent galaxies above $z \sim 0.9$, coupled with the field-level sSFRs of cluster SFGs, suggests that higher redshift cluster galaxies are likely being quenched quickly. Assessing those timescales will require more accurate stellar population ages and star formation histories.

❖ Introduction

- z~1のclusterはfieldに比べてquiescent fractionが大きい
- 1<z<1.5でのcluster ETGsのfraction増加とSFR(~7 $M_\odot yr^{-1}$)はmajor mergerが活発であることを示唆 (Wagner+15)
- 0.15<z<1.5のcluster銀河の星形成を調べることで、redshiftごとの主要なquenching mechanismを知りたい
  - strangulation (several Gyr)
  - ram pressure stripping (~1 Gyr)
  - AGN feedback (a few Myr)

❖ Sample

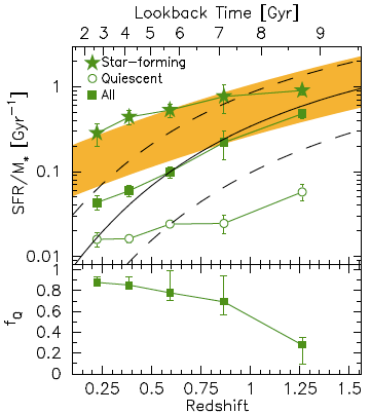
1. CLASH (Postman+12) のcluster 24個(0.15<z<1)
2. ISCS (Eisenhardt+08) のcluster 11個(1<z<1.5)

ハロー質量の進化シミュレーションから、ISCS clusterはCLASH clusterのprogenitorだと思っている

final sampleは$\log(M_*/M_\odot)>10.1$の銀河1386個

- HST imageによりmorphologyを決定(late/early)
- BCG, AGNを除外
- SED fittingにより質量とSFRを算出
  - double declining exponential SFHを仮定
- $D_n(4000)$の値でSFGとquiescentを分離

❖ Result



sSFR & quiescent fraction

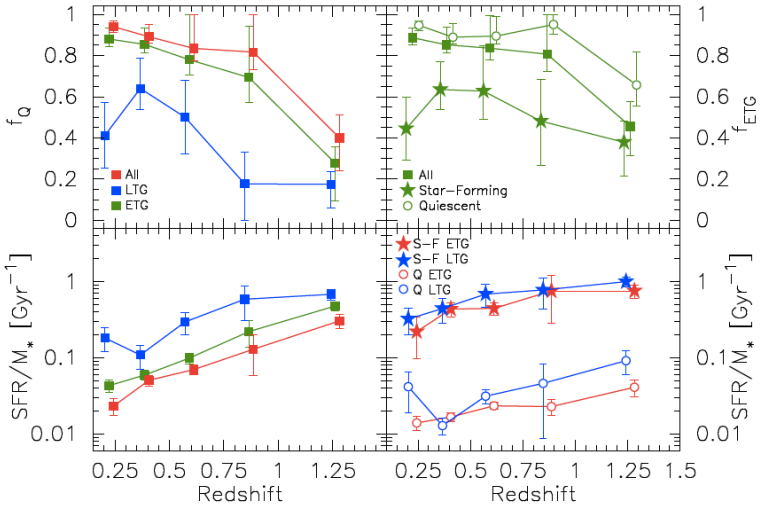
- sSFR進化はfield銀河のものと良く合う

→ strangulationによるquenchingは支配的ではない(もしそうならfieldより小さくなるはず)

- SFGs, quiescentのsSFR減少(約1/3)に比べて銀河全体のsSFR減少が大きい(約1/11)
- quiescent fractionは0.5<z<1.25で大きく増加

→ 個々の銀河種族のsSFR進化よりも、SFGからquiescentへのtransitionが大きく寄与

Morphology dependence



- SFGs, quiescentともに、sSFR進化のmorphology依存性は見られない
- 0.9<z<1.3 (~1.5 Gyr) の間のquiescent fractionの増大(0.41)は、clusterでのquenchingが素早く起こることを示唆
- 同時期にearly type fractionも増加している

→ merger-driven AGN quenching が支配的である可能性を示唆

- low-zにおいてもSFGsのある程度の割合はearly type