Revealing the impacts of stellar mass and environment on galaxy quenching since z~1

Zhiying Mao, Tadayuki Kodama, Jose Manual Perez Martinez, Kouta Adachi, Naoaki Yamamoto
Tohoku University

TOHOKU UNIVERSITY

GPPU 宇宙創成物理学 国際共同大学院

Abstract

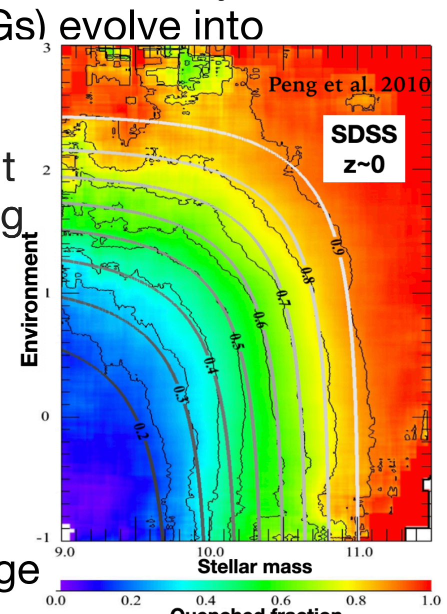
We analysed member galaxies of 14 clusters from COSMOS field at z~0.5-1.0 and used rest-frame UVJ diagram to classify them into star-forming, recently-quenched and quiescent population. We define quenching efficiency and quenching stage to quantify quenching process and confirmed mass and environmental quenching. We also found that environmental effects are stronger for low mass galaxies. Then we use model evolutionary tracks to distinguish fast and slow quenching galaxies. It turned out that ram pressure stripping is dominating quenching of low mass galaxies in dense region and AGN feedback dominates quenching of massive galaxies in low density region.

1. Introduction

This study focus on redshift 0.5-1.0, after cosmic noon, to study quenching process where star-forming galaxies(SFGs) evolve into quiescent galaxies(QGs).

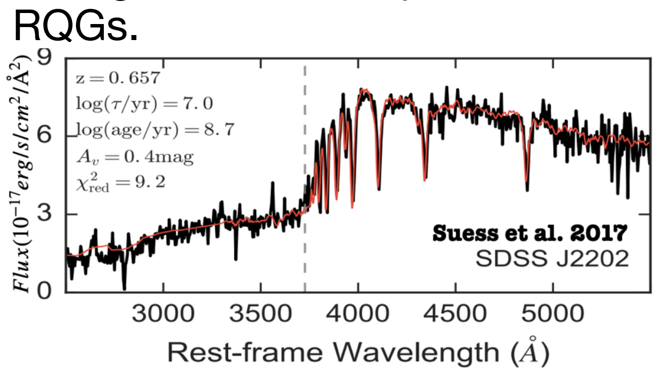
1.1 Galaxy quenching

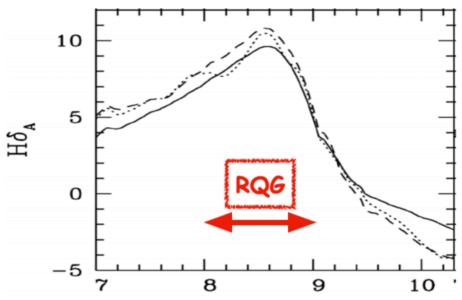
Galaxy quenching is mainly affected by environment and stellar mass. Therefore we can divide quenching mechanisms into mass and environmental effects. Different mechanisms have different timescales. Hence we can use quenching timescale to distinguish physical mechanism behind it.



1.2 Recently-quenched galaxy (RQG)

RQG is a transitional population between SFG and QG that are shortly after quenching. RQGs have large fraction of A type stars, which makes them have strong Balmer absorption features. These features can be used to identify RQGs.



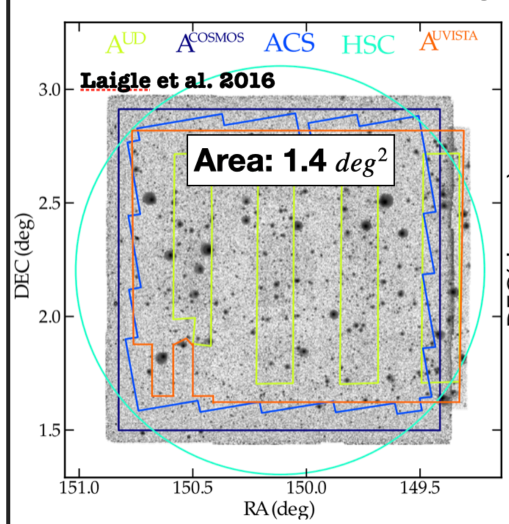


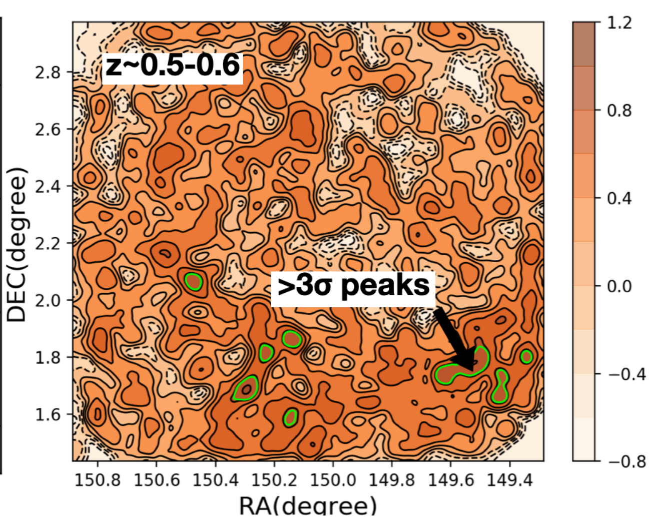
Hδ line strength evolution with galaxy age

2. Dataset and method

2.1 Sample construction

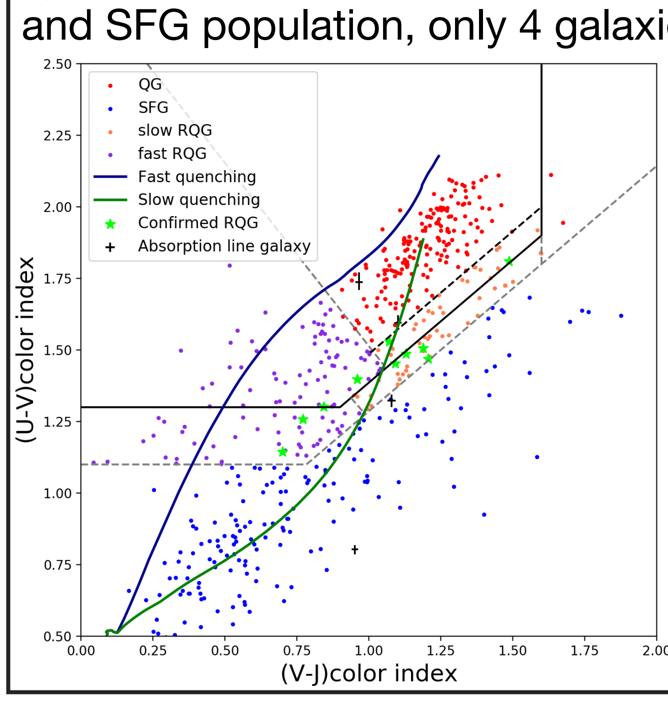
We use data from the central 1.4deg^2 COSMOS2015 catalog to have both optical and NIR coverage. This will enable us to estimate rest-frame UVJ colour indices of our targets. These colours are used to classify galaxy populations. Next, we put our galaxy sample into $\Delta z \sim 0.1$ width redshift bins. For each bin, we calculate local density Σ_5 and pick out >3σ peaks of local density. Peaks with reasonable member galaxy redshift distribution are defined as galaxy clusters. Final sample is selected from cluster centre out to cluster outskirts to include galaxies from different environments.





2.2 Galaxy classification

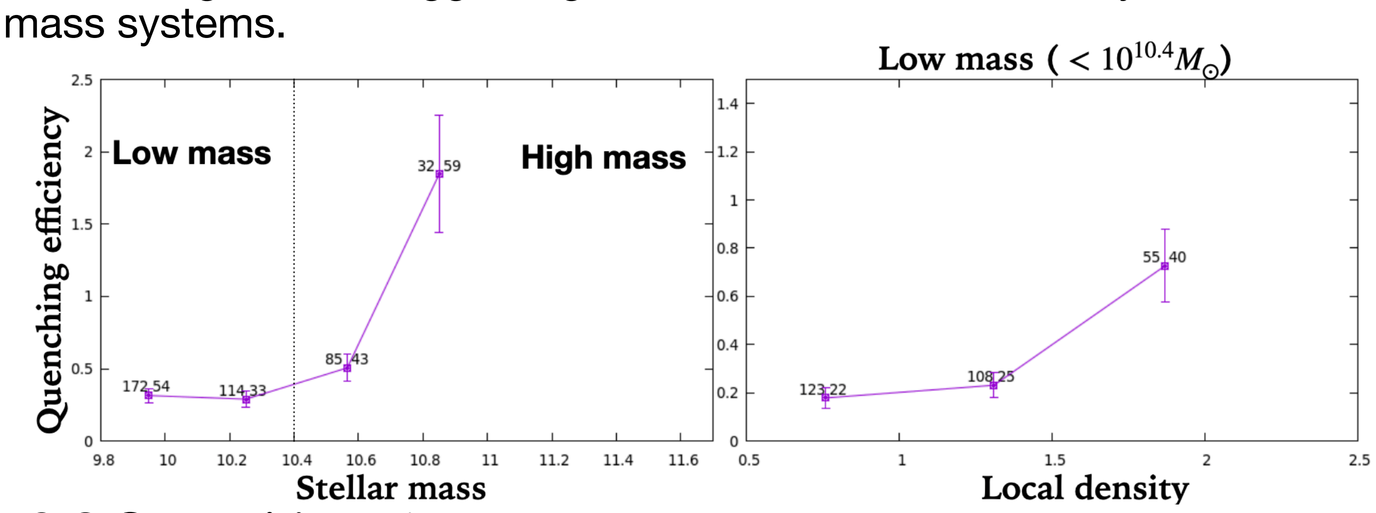
We use UVJ diagram to classify galaxies into QG, RQG and SFG. To confirm our results, we matched our sample with DEIMOS 10K spectroscopic survey catalog. For UVJ-selected RQGs with high quality spectra, ~70% are confirmed with strong Balmer absorption lines. For QG and SFG population, only 4 galaxies have RQG features, and 2 of them lie near the RQG boundaries, another is affected by AGN. In this way we confirm UVJ selection is reliable. Then we apply fast and slow evolutionary models with quenching timescale 1Gyr and 0.1Gyr respectively. These two model galaxies' evolutionary tracks on UVJ diagram go through different regions. Hence, we can use UVJ diagram to robustly separate fast quenching galaxies and slow quenching galaxies.



3. Results

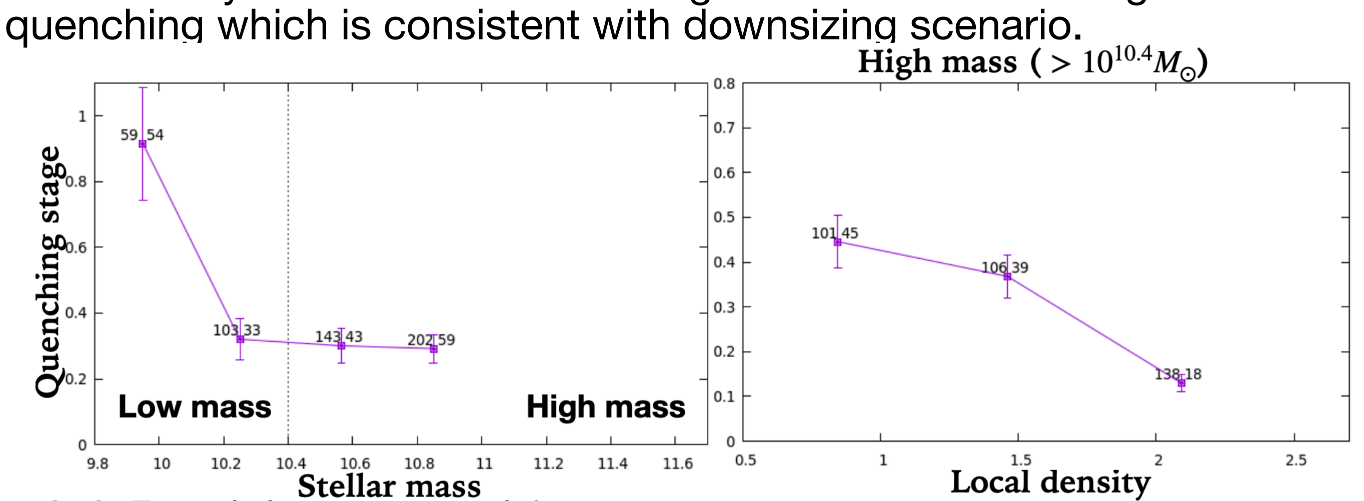
3.1 Quenching efficiency

Quenching efficiency is defined as $Q.E. = N_{RQG}/N_{SFG}$, which can quantify the efficiency SFGs turn into RQGs. Q.E. increases with both mass and local density, confirming the existence of mass and environmental quenching. For its dependence on local density, it is only significant for low mass galaxies, suggesting environmental effects mainly affect low mass systems.



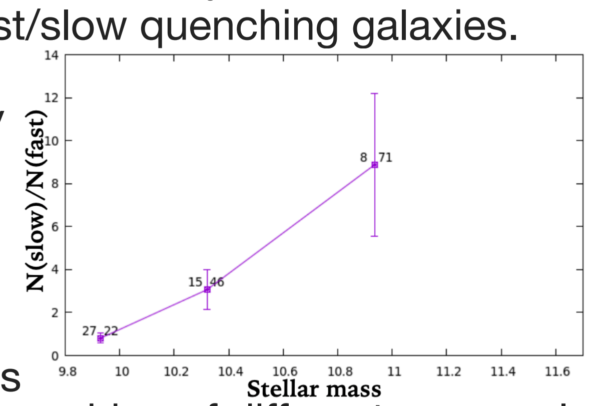
3.2 Quenching stage

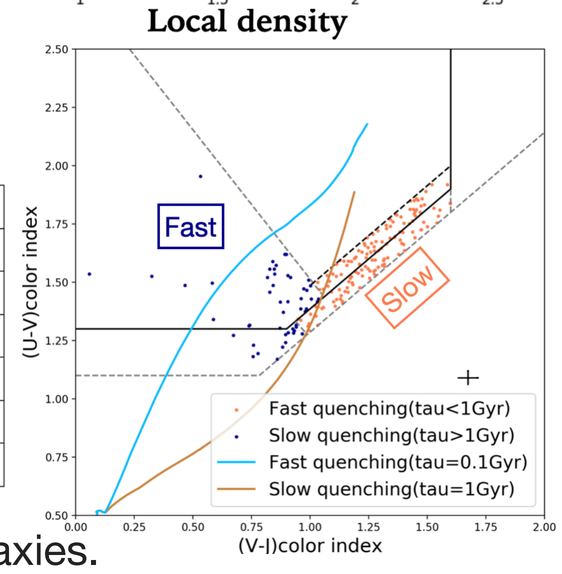
Quenching stage is defined as $Q.S. = N_{RQG}/N_{QG}$. When Q.S. value is large, this region is in early stage of quenching, because most galaxies haven't finished quenching process. Q.S. decreases with both stellar mass and local density. It shows that massive galaxies are in later stage of quenching which is consistent with downsizing scenario.



3.3 Fast/slow quenching

Use model evolutionary tracks, we can separate fast/slow quenching galaxies. Their ratio significantly increases with stellar mass. It shows different mechanisms are ruling quenching of different mass galaxies.





For massive galaxies in sparse environment, slow quenching is playing dominant role. This is likely due to AGN feedback, since AGNs are hosted exclusively by massive galaxies and this mechanism has long timescale (~1Gyr).

For low-mass galaxies in dense environment, fast quenching is more dominant. This is likely due to ram pressure stripping that happens only in dense cluster core region. And this mechanism has short timescale (~100Myr).

	N(slow)/N(fast)	Errorbar
high mass + low local density	5.400	1.859
low mass + high local density	1.286	0.374

4. Future prospects

- ❖Use joint-HSC catalog to expand analysis field to SXDS and ELAIS field
- ❖Include IRAC data and expand redshift range to 0.5-2.0
  - ➡ Increase sample size by 6 times
- ❖Spectroscopic confirmation of UVJ selection method and other result
  - ❖ Use FOCAS, DEIMOS etc. to carry out pilot project
  - ❖ Use PFS (2023) to conduct survey of RQGs
- ❖Put stronger constraint on quenching timescale