The environmental dependence of rapidly-quenching and rejuvenating galaxies

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Background

- The reasons for galaxies to stop forming stars ('quench') are not fully understood.
- Here, we look at the environmental effects on galaxy quenching. If a galaxy is a member of a group of galaxies, it is called a satellite galaxy. If a galaxy is on its own, or at the centre of the group, it is called a central galaxy. Satellite galaxies feel environmental effects more than centrals.
- The emission line H-alpha can identify star-formation that occurred within the last 10 million years, while UV light can identify star-formation that occurred within the last 100 million years.
- This means if a galaxy that has strong UV, but negligible H-alpha, it must have stopped forming stars in the last 100 million years or so. We call these galaxies that have recently quenched 'transient' galaxies.
- We explore properties of transient galaxies to try determine which factors are dominant in galaxy quenching.

Data

- The main elements in this analysis are the H-alpha flux, which is taken from the Sloan Digital Sky Survey (SDSS) and the UV flux, which is taken from the GALEX-SDSS-WISE Legacy Catalog Medium-Deep 2 (GSWLC-M2).
- We also obtain stellar masses, group halo masses, redshifts, satellite/central designations, and other line emission fluxes for each galaxy.
- Star formation rates are derived directly from the H-alpha and UV luminosities. Group properties, such as the group-centric radius and the line-of-sight velocity dispersion are also calculated.

Results

- We define transient galaxies as those with sSFR(UV) >= $10^{-11.1}$ yr^{-1}, and EW(Ha) <= 3 Å. We define rejuvenating galaxies - galaxies that have recently begun star-forming after a passive period - as the inverse of this.

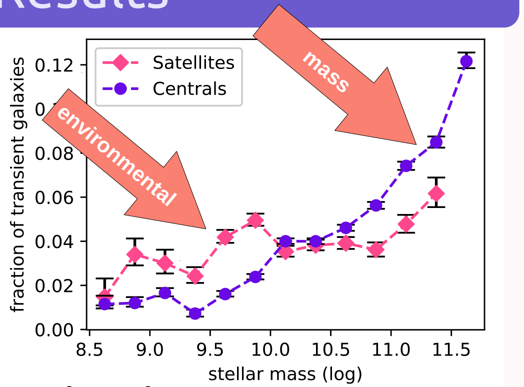

Fig. 1: fraction of transient galaxies.

- The main results are as follows:
  - **At low mass, the fraction of transient satellites is higher than that of centrals (see Fig. 1). This implies that the environmental factor is what causes the quenching. At high mass, the increase in mass is the more important factor.**
  - Higher group mass haloes cause more galaxies to quench than low group mass haloes. This effect is stronger for low stellar mass galaxies, again showing the importance of the environmental factor.
  - We find very few rejuvenating galaxies (see Fig. 2), and no difference in centrals or satellites. This shows that when transient galaxies quench, they do not tend to rejuvenate periodically. The quenching event is one-off.
  - The environment does not act alone, as the distributions of transients and star-forming galaxies with respect to group-centric radius and velocity offset are almost identical.

Discussion

See Slide 2 for more figures.

- At low mass, we see an increased transient fraction in satellites compared to centrals, of about 1% (5 sigma sig.) across all low stellar masses (< $10^{10.5}$ M_{sun}). This implies that at low stellar mass, satellites quench predominantly by environmental processes.
- This suggests that as a satellite galaxy enters a group, the intragroup medium prevents the satellite from accreting new gas. This is reflected by the fact that more transient galaxies are found close to the group centre (see Fig. 3). We also see that the transient fraction increases with group halo mass. This implies a larger group imparts a stronger gravitational pull on satellite galaxies, which would increase the possibility of ram-pressure stripping or violent mergers.
- In Fig. 4, we see that low stellar mass transients are distributed towards low group radii with a gentle slope, whereas high stellar mass transients have a steep slope, closer to the group centre. This implies that low stellar mass satellites are more easily quenched by the environment, but high stellar mass satellites only quench after spending some time in the group.
- We find that satellites in groups of higher mass have larger velocity offsets compared to the velocity of the group (see Fig. 5). This supports the possibility that higher mass groups would have a higher chance of causing ram-pressure stripping.
- It seems plausible that it is sufficient to say that environmental processes are dominant for low stellar mass satellites and high halo mass groups in particular. However, we also find that the transient distributions are identical to the star-forming distributions. If environmental processes were dominant, then those star-forming galaxies would also be starting to quench. This leaves one (or a combination) of two possibilities: the group isn't totally efficient at quenching, or the properties of the satellite are involved in the quenching. This is the topic of future research.

References: Abazajian et al. 2009; Baldry et al. 2004; Bell et al. 2004; Blanton et al. 2005; Brinchmann et al. 2004; Doi et al. 2010; Faber et al. 2007; Gabor et al. 2010; Gunn and Gott 1972; Kennicutt 1998; Martin et al. 2005; McGee et al. 2011; McGee et al. 2014; Morrissey at al. 2007; Omand et al. 2015; Salim et al. 2016, 2018; Smethurst et al. 2017; Strateva et al. 2001; Wetzel et al. 2012; Yang et al. 2007; Ziparo et al. 2014.

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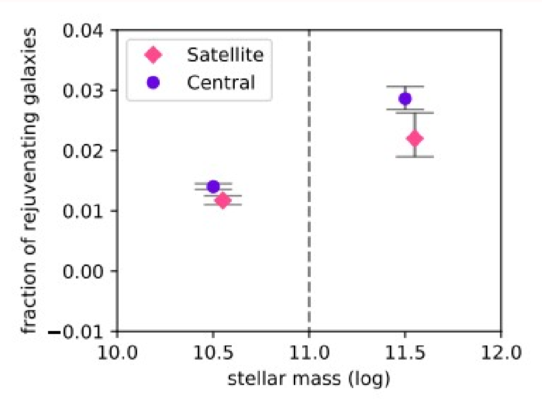


Figure 2: fraction of rejuvenating satellite galaxies and central galaxies in two stellar mass bins, low mass and high mass.

Note that in both bins the fractions are close to zero, and that the central and satellite fractions are very similar.

Figures

Figure 3: (Left) Fraction of transient galaxies over star-forming galaxies as function of radius, binned by halo mass. (Right) Fraction of transient galaxies over quenched galaxies as function of radius, binned by halo mass.

Note the increasing fraction in the left panel, and that the most massive halo (orange diamond) has the largest fractions.

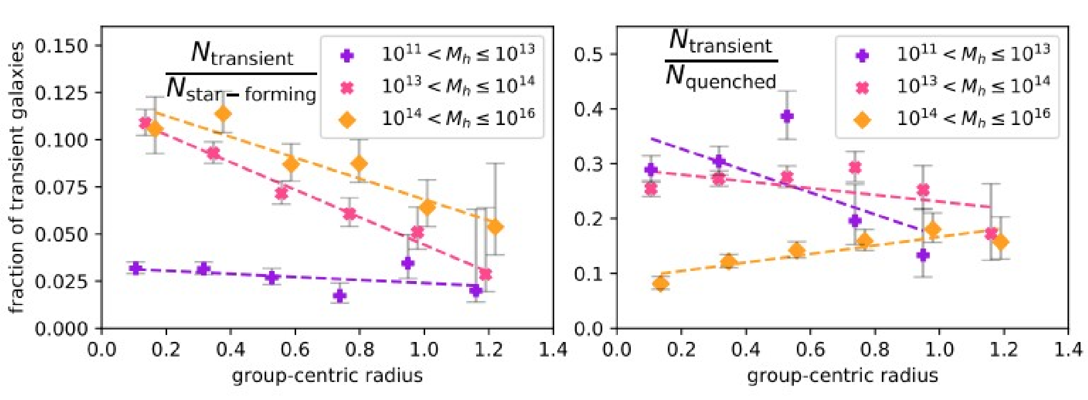


Figure 4: (Left) Histograms of low stellar mass transient and star-forming galaxies as function of radius. (Right) Histograms of high stellar mass transient and star-forming galaxies as function of radius.

Note the similarity in shape of the transient and star-forming distributions.

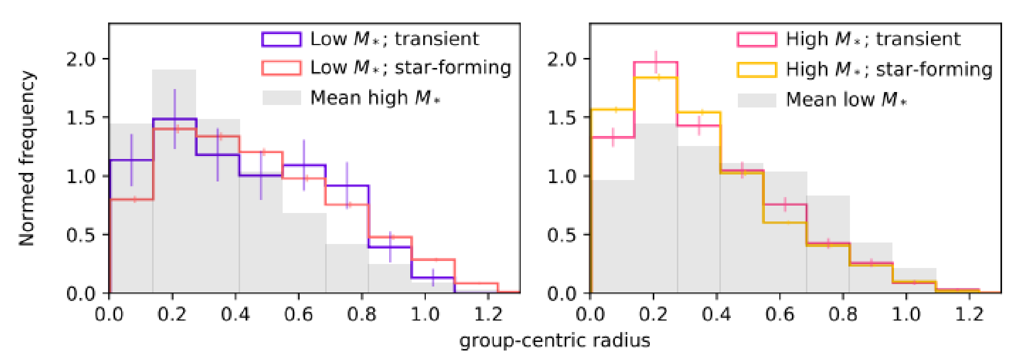
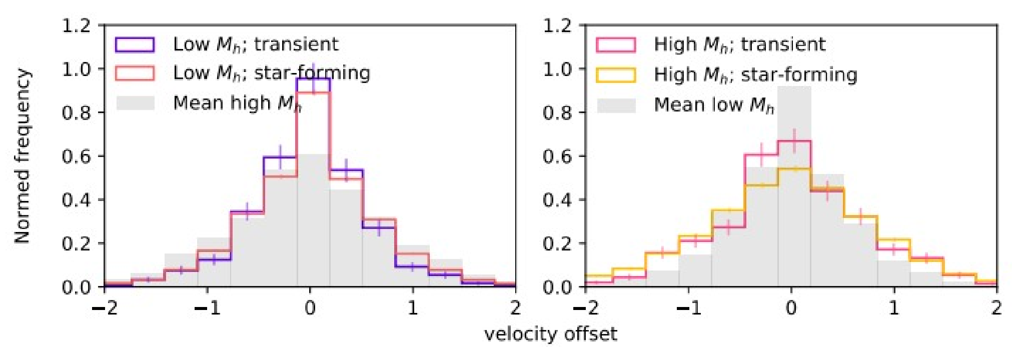


Figure 5: (Left) Histograms of low group halo mass transient and star-forming galaxies as function of velocity offset. (Right) Histograms of high group halo mass transient and star-forming galaxies as function of velocity offset.

Note the similarity in shape of the transient and star-forming distributions.



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