Galaxy populations in groups and clusters are characterized by redder colours, lower star formation rates (SFRs) and more elliptical morphologies compared to field galaxies. Segregation in galaxy properties with halo-centric radius within large halos could help determine the dominant processes driving galaxy evolution. Studies have found segregation in properties such as luminosity, colour, SFR etc. This topic of debate has led to various studies focusing on the role of halo mass in these properties. Segregation in galaxy properties with halo mass has been observed, with lower star formation rates (SFR) in higher mass halos and more elliptical morphologies compared to lower mass halos.

**Introduction**

Galaxy analogues are identified in the dark matter simulation at z=0, starting with the most massive halo of the volume. Dense cluster regions are eliminated. Halo finding using MUSIC[10] and AHF (Halo finder for large volume). Dashed lines represent different lower mass cuts in (log(M_halo) to show the effect of excluding low mass galaxy analogues. The results were also examined in bins of parent halo mass, as shown in Fig. 6. Mass segregation results are strongest in small and large groups with nearly no trend seen in massive clusters.

**Simulation**

N-body simulation of a cosmological volume using the SPH code ChaNGa[10]. Initial conditions created using MUSIC[10]. 100 Mpc box; highest resolution contains 1024^3 particles, m_{dm} = 3.7×10^7 M_{☉}. Halo finding using AHF[12]: spherical overdensity algorithm and ROCKSTAR[13]: phase-space FOF algorithm.

**Selecting Galaxy Analogues**

Galaxy analogues are identified in the dark matter simulation at z=0, starting with the most massive halo and applying the following criteria:

- If M_{dm}<10^{10} M_{☉}, halo and subsequent branches are eliminated.
- If M_{dm}>10^{12} M_{☉}, halo is eliminated, but each subhalo is considered as candidate.
- If 10^{10}<M_{dm}<10^{12} M_{☉} and halo has no subhalos with M_{dm}>10^{10} M_{☉}, halo is included as galaxy analogue and subsequent branches are eliminated.
- If 10^{10}<M_{dm}<10^{12} M_{☉} and halo has at least one subhalo with M_{dm}>10^{10} M_{☉}, we calculate M_{max,2M_{subhalo}}; if residual mass is also within 10^{10}<M_{dm}<10^{12} M_{☉}, halo is included as analogue and each subhalo is also considered as candidate.

A schematic of the selection process is shown in Fig. 2.

**Results**

The radial distribution of galaxy analogues by number and mass fractions are shown in the top panels of Fig. 3. The results from the two halo finders agree well outside 0.5 R_{vir}, although there are significant differences within 0.5 R_{vir}. The bottom panels of Fig. 3 show the significantly different levels within the subhalo hierarchy of the galaxy analogues detected by the two halo finders. These differences at small radii can also be seen in more detail in Fig. 4, which shows an example group halo and its substructure. The results highlight the need for velocity information (as used by ROCKSTAR) in identifying galaxy analogues in the inner regions of halos, in agreement with previous work.[3,4,14]

**Mass Segregation**

Using the galaxy analogues identified by ROCKSTAR, we study mass segregation.

- For the total sample (solid purple), a significant negative trend is found within 0.5 R_{vir}, and a mild positive trend beyond R_{vir}.
- We examine the effect of excluding low mass haloes (dashed green & dotted pink). The trends are similar with a lower mass limit of 10^{10.5} M_{☉} but no significant trend is detected for high-mass analogues (M_{halo}>10^{11} M_{☉}).
- The results were also examined in bins of parent halo mass, as shown in Fig. 6. Mass segregation results are strongest in small and large groups with nearly no trend seen in massive clusters.

**Summary**

We find significant mass segregation in the inner regions of group-mass halos and the trends are stronger when considering low-mass analogues. Since dynamical friction is expected to be more efficient for more massive analogues, our results suggest that it is not the dominant factor at work. Instead, the results are likely driven by the accretion histories of the galaxy analogues and their host halos.

We are following up this work by examining segregation in mass at accretion and peak analogue mass, as well as with zoom-in hydrodynamical simulations to study in detail the various processes affecting galaxy evolution in galaxy groups.

**References**