The Environments of Massive Galaxy Mergers in the Local Universe

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STScI Workshop on Galaxy Mergers: From the Local Universe to the Red Sequence

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Image: Seyfert's Sextet (HST, NASA)
Evolution of Massive Galaxies

**A growing** but “dead” red sequence

**A star-forming but static** blue sequence

Bell, Naab, McIntosh et GEMS 2006; Lotz et al 2006; van Dokkum 2005

Growth secure below $10^{11} M_{\odot}$

merging is important

w/ and w/out dissipation

Evolution above $10^{11} M_{\odot}$ difficult to measure

some direct evidence of assembly

but how are giant Es really made?

Role of environment?

What is the importance of major (1:1, 4:1) mergers involving massive (>3x10^{10} M_{\odot}) galaxies in a complete sample of massive (>2.5x10^{13} M_{\odot}) groups?
Massive Mergers as a Function of Environment
McIntosh, Hertzberg, Guo, van den Bosch, Katz, Mo & Yang (in prep.)

Data: SDSS galaxies grouped by common dark-matter halos
Yang et al. 2005; Weinmann et al. 2006

Physical environment: parent halo mass; central vs. satellite

Why search for major galaxy mergers in massive groups?
1. big spheroids: formation (mergers), home (dense environs)
2. D-M halo MF expected to evolve thru hierarchical merging
3. is there a special environment for building giant galaxies?

Visually inspect the 60x60 kpc region around massive group members (centrals and satellites) from complete sample:

- volume-limited: $0.06<z<0.12$ ($0.01<z<0.06$)
- halo-mass-limited:
  $N>2$ members $\rightarrow \log(M_{\text{halo}}/M_{\text{sun}})>13.8$ ($>13.4$)
**Major Pairs/Mergers in Massive Groups**

**Massive centrals sample**

- $r_{\text{primary}} < 16.27 \text{ mag}$; find companions with $\Delta r < 1.5 \text{ mag}$; $R_{\text{proj}} < 30 \text{ kpc}$

**Massive satellites sample**

- $r_{\text{primary}} < 16.27 \text{ mag}$; find companions with $\Delta r < 1.5 \text{ mag}$; $R_{\text{proj}} < 30 \text{ kpc}$
Major Mergers in Massive Groups

Naab et al. 2006
Major Mergers in Massive Groups

interacting spectroscopic pairs ★ ★
interacting 1-redshift pairs ● ○
major mergers (single detection) ★
Major Mergers in Massive Groups

- interacting spectroscopic pairs ★★★
- interacting 1-redshift pairs ● ○
- major mergers (single detection) ★

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Major Mergers at Centers of Massive Groups

1. 2%-5% frequency at all group mass scales probed
2. 85% red-red ("dry merging") $\equiv$ high-mass red fraction
3. central mass growth rate is 25%-100% since $z=1$ ($T_m=200-800\text{Myr}$)

Major SAT-SAT mergers less important:
Building Giant Galaxies: Summary

1. When? Mass assembly above $10^{11}M_{\text{sun}}$ continues to present time:
   - direct evidence at $0.1<z<0.7$ and $z<0.12$,
   - argues against massive population being all in place by $z=1$.

2. Where? Have first constraints on assembly environment:
   - more important at centers of group-to-cluster-sized DM halos,
   - centers may have doubled in mass since $z=1$.

3. How? Major galaxy-galaxy merging plays an important role:
   - dry merging important at high-mass end,
   - gas-rich mergers likely important at lower halo masses as part of redistribution of stars from blue disks $\rightarrow$ red spheroids.
SDSS Group Catalog Construction

Details in Yang et al. 2005; Weinmann et al. 2006

1. FoF to define initial groups; leftover = isolated groups
2. estimate group mass $M_{\text{group}}$ from group luminosity $L_{\text{group}}$ and $M/L$
3. calculate virial radius and velocity dispersion
4. select group members from #3
5. repeat process until membership converges

Method tested/confirmed with mock galaxy redshift catalogs.

Dark-matter halo mass $M_{\text{halo}}$ estimate:
1. final $L_{\text{group}}$ (using empirically normalized scale $L_{19.5}$)
2. match number density of all groups with $L>L_{19.5}$ to $M_{\text{halo}}$ with same number density using $\Lambda$CDM halo mass function