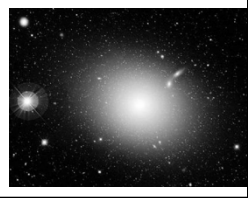
FORMATION AND EVOLUTION OF GALAXIES

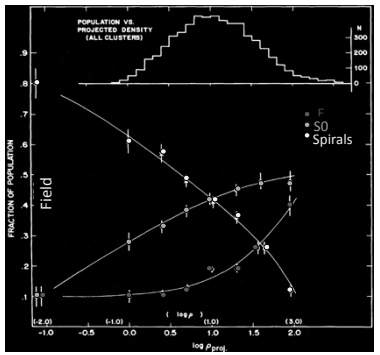
Lecture 20

- Galaxy transformations
  - Ram pressure stripping
  - Strangulation
- Galaxy formation in an expanding Universe



Somak Raychaudhury

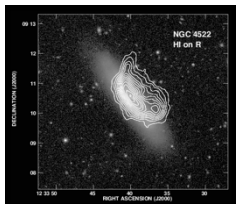
Morphology–Density Relation



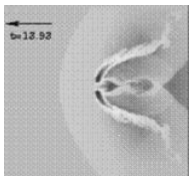
Dressler 1980

Additional physics?

- Ram-pressure stripping
- Collisions / harassment
- "Strangulation"



Kenney et al. 2003

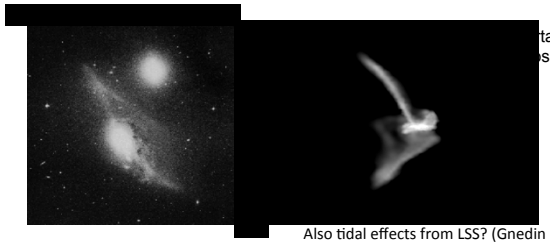


short timescale

Quilis, Moore & Bower 2000

Additional physics?

- Ram-pressure stripping
- Collisions / harassment
- "Strangulation"



tant in
s?

Also tidal effects from LSS? (Gnedin 2003)

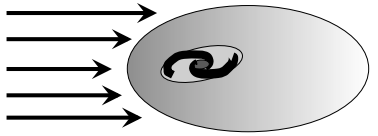
Additional physics?

- Ram-pressure stripping
- Collisions / harassment
- "Strangulation"
  - Either through tidal disruption, or shock-heating to level at which it can't cool (e.g. Springel & Hernquist 2001)

long timescale

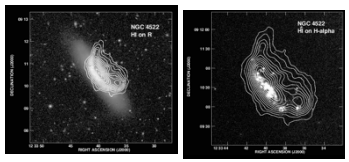
Additional physics?

- Ram-pressure stripping (Gunn & Gott 1972)
- Collisions / harassment (Moore et al. 1995)
- "Strangulation" (Larson et al. 1980; Balogh et al. 2000)
  - Either through tidal disruption, or shock-heating to level at which it can't cool (e.g. Springel & Hernquist 2001)



long timescale

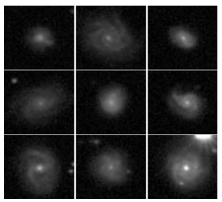
S to S0 transformation?



Kenney et al. 2003
Vollmer et al. 2004

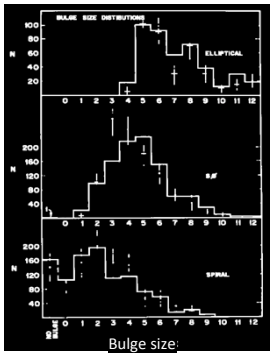
• Ram pressure stripping of the disk could transform a spiral into a S0 (Gunn & Gott 1972; Solanes & Salvador-Solé 2001)

• Strangulation may lead to anemic or passive spiral galaxies (Shiyoa et al. 2002)



Non-SF spiral galaxies from SDSS (Goto et al. 2003)

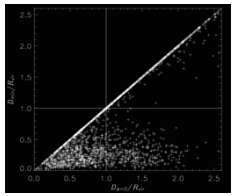
S to S0 transformation?



Bulge size

Dressler 1980

- But bulges of S0 galaxies larger than those of spirals
- Requires S0 formation preferentially from spirals with large bulges perhaps due to extended merger history in dense regions

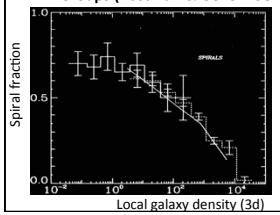


Gill et al. 2004

Arguments against ram pressure stripping:

1. S0 galaxies found far from the cluster core
   - Galaxies well beyond R_{virial} may have already been through cluster core (e.g. Balogh et al. 2000; Mamon et al. 2004; Gill et al. 2004)

Groups (Postman & Geller 1984)



2. Morphology-density relation holds equally well for irregular clusters, centrally-concentrated clusters, and groups

   - but may be able to induce bursts strong enough to consume the gas

When did galaxies form: a rough estimate (1)

Consider a small ($\delta\rho/\rho$ <<1) spherical perturbation of radius r:

$$M(r) \cong (4\pi/3) r^3 \bar{\rho}_{matter} = (4\pi/3) r^3 (3H^2/8\pi G)\Omega_{matter}$$

For H_0=100h km/s/Mpc,

$$M(r)/M_{sun} \cong 1.16\times10^{12} h^2 \Omega_{matter} r^3_{Mpc}$$

For h=0.7 and Ω_{matter}=0.25,

$$M(r)/M_{sun} \cong 1.4\times10^{11} r^3_{Mpc}$$

i.e. an ~L* galaxy coalesced from matter within a comoving volume of roughly ~ 1-1.5 Mpc radius