Environmental dependence of the structural evolution of early-type galaxies

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Evolving galaxies in evolving environments, Bologna, September 2014

Observed size evolution of ETGs

Cimatti, Nipoti & Cassata (2012)



| Sample | N | Redshift |
|-----------------|--------|-------------------|
| SDSS | 59 500 | 0 < z < 0.4 |
| COSMOS/2COSMOS | 950 | 0 < z < 1 |
| GOODS-N+S | 469 | $0 < z^{*} < 2$ |
| Literature | 465 | 0.2 < z < 2.7 |
| GMASS | 45 | $1.4 < z^* < 3$ |
| COSMOS | 12 | $1.4 < z^* < 1.8$ |
| XMMU J2235-2557 | 11 | z = 1.39 |
| K20-0055 | 9 | 0.7 < z < 1.2 |
| POWIR | 6 | $1.2 < z^* < 1.8$ |
| K20 | 4 | 1.6 < z < 1.9 |
| 1255-0 | 1 | z = 2.186 |
| FW-4871 | 1 | z = 1.902 |

see also Daddi+05, van Dokkum+08, Newman+12, Saracco+14, Morishita+14, van der Wel+14

Observed velocity-dispersion evolution of ETGs



see also Belli et al. (2014)

$R_{ m e}$ and σ vs. mass: dry-merger simulations





see also Hausman & Ostriker (1978); Hernquist+(1993); Ciotti & van Albada (2001); Naab+(2009)

Size evolution of ETGs: LCDM vs. observations

(see also poster by Lorenzo Posti)



ightarrow Observed pprox predicted at $z\lesssim 2$

ightarrow Observed evolution stronger than predicted by LCDM at $z\gtrsim 2$

σ evolution of ETGs: LCDM vs. observations

(see also poster by Lorenzo Posti)



ightarrow LCDM predictions consistent with current observations.

Evolution of ETGs in groups and clusters



- ightarrow COSMOS groups at z pprox 0.6 (George+11)
- ightarrow EDisCS clusters at $z \approx 0.6$ (White+05)
- ightarrow WINGS clusters at $z \approx 0$ (Fasano+06)

ightarrow Galaxies evolve: $M_*(z)$, $R_{
m e}(z)$, $\sigma(z)$ ightarrow Environment evolves: $M_{
m halo}(z)$ (group ightarrow cluster)

$R_{ m e}$ - σ - M_{*} : centrals vs. satellites at zpprox 0





 \rightarrow Observed clusters at $z \approx 0$ (WINGS) \rightarrow Large offset between centrals and satellites

see also Lauer+07, Bernardi 09, Hyde & Bernardi 09, Valentinuzzi+10

$R_{ m e}$ - σ - M_* : centrals vs. satellites at $z \approx 0.6$



Vulcani et al. in prep.

- ightarrow Observed groups at zpprox 0.6 (COSMOS)
- ightarrow No (or small) offset between centrals and satellites

see also Lauer+07, Bernardi 09, Hyde & Bernardi 09, Valentinuzzi+10

Modeling evolution of group ETGs: $R_{\rm e}$ - M_{*}



- ightarrow Initial conditions: COSMOS data (Vulcani et al. in prep)
- ightarrow Evolution of centrals: LCDM+dry mergers (Nipoti+12)
- ightarrow No evolution of satellites
- \rightarrow Predicted $z \approx 0$ offset smaller than observed in WINGS

Modeling evolution of group ETGs: $\sigma-M_*$



- ightarrow Initial conditions: COSMOS data (Vulcani et al. in prep)
- \rightarrow Evolution of centrals: LCDM+dry mergers (Nipoti+12)
- ightarrow No evolution of satellites
- \rightarrow Predicted $z \approx 0$ offset smaller than observed in WINGS

Modeling evolution of group ETGs: $R_{ m e}$ - σ



- ightarrow Initial conditions: COSMOS data (Vulcani et al. in prep)
- \rightarrow Evolution of centrals: LCDM+dry mergers (Nipoti+12)
- ightarrow No evolution of satellites
- \rightarrow Predicted $z \approx 0$ offset smaller than observed in WINGS

Evolution of halos: hosts vs. subhalos

(see poster by Lorenzo Posti)

Cosmological simulation of Posti et al. (2014)



- ightarrow No big difference between hosts and subhalos
- ightarrow Trend: hosts evolve more than subhalos
- ightarrow Dependence on halo mass?

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Lens ETGs: total density slope m{\gamma'} (
ho_{tot} \propto r^{-\gamma'})
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 $ightarrow \gamma'$ strongly influenced by environment

Evolution of γ' : dry mergers vs. observations



- ightarrow Model: Nipoti et al. (2012) + γ' (N-body)
- ightarrow Observations: SLACS+SL2S lenses (Sonnenfeld et al. 2013)
- ightarrow Evolution of γ' not explained by purely dry mergers

Evolution of γ' : wet mergers vs. observations



- \rightarrow Toy-model dissipation
- ightarrow Small amount of dissipation helps reproduce $\gamma'(z)$

Conclusions

- ▶ LCDM-merger models consistent with average $R_{
 m e}(z)$ and $\sigma(z)$ of ETGs at $z \lesssim 2$
- \blacktriangleright Observed $R_{
 m e}(z)$ stronger than predicted at $z\gtrsim 2$
- ▶ At $z \lesssim 1$ further challenges for LCDM-merger models:
 - \rightarrow Central ETGs in groups evolve much faster than satellites
 - \rightarrow Total density slope γ' strongly influenced by environment
 - \rightarrow Evolution of γ' not explained by purely dry mergers