THE SPECIAL GROWTH HISTORY OF BRIGHTEST CLUSTER GALAXIES

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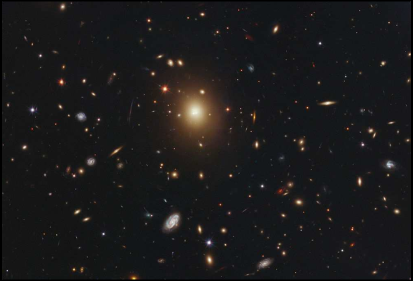
Nipoti (2017, MNRAS, 467, 661)

Nipoti, Giocoli et al. (2017, in prep.)

Two-phase mass assembly of BCGs

$\approx 50\%$ before cluster virialization ($z \gtrsim 1$)

$\approx 50\%$ via cannibalism ($z \lesssim 1$)



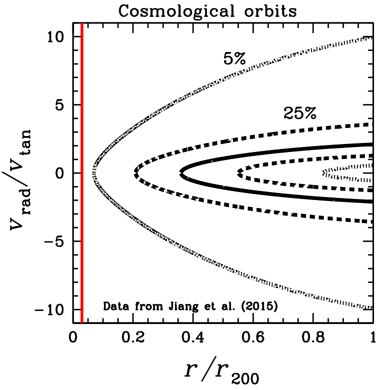
Abell 2261 (Postman et al. 2012)

(Merritt 1985, Tremaine 1990, Dubinski 1998, De Lucia & Blaizot 2007, Lauer et al. 2014, Shankar et al. 2015, Vulcani et al. 2016)

Cannibalism = accretion of companion cluster galaxies

(Ostriker & Tremaine 1975, White 1976, Hausman & Ostriker 1978)

(Vulcani, Treu, CN et al. 2017; GLASS VIII)



→ Cosmological orbits do not plunge down to the BCG

→ Cannibalism is driven by dynamical friction

→ Mainly dry ''not-so-minor'' mergers

Cannibalism-driven growth of BCGs

$z \simeq 0.6$ (Nipoti et al. 2003)

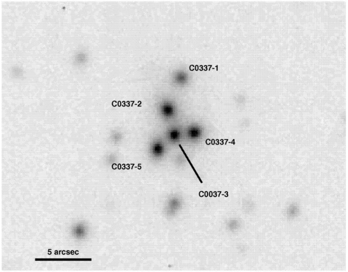


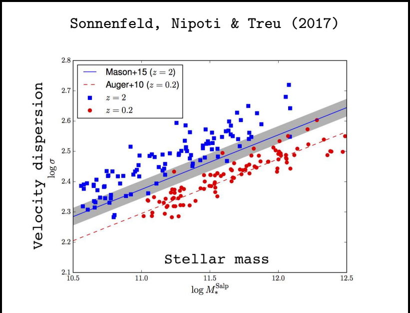
Figure 1. VLT-FORS1 *I*-band image of the galaxy cluster C0337-2522

Evolution of M_*, R_e & σ depends on:

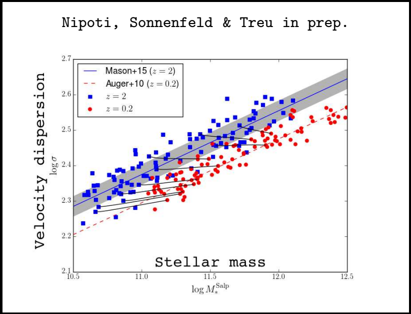
- $\rightarrow$ merger rate
- $\rightarrow$ properties of cannibalized galaxies
- $\rightarrow$ merging orbital parameters

M_*-σ: effect of merging orbital energy

Parabolic orbits ($E_{\rm orb} = 0$)



Elliptic orbits ($E_{\rm orb} < 0$)



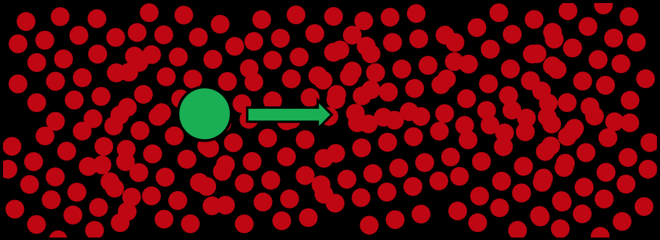
(see also Nipoti et al. 2003; Boylan-Kolchin et al. 2006; Nipoti et al. 2009; Posti et al. 2014)

Questions I'll try to address

→ How are BCG-satellite mergers?

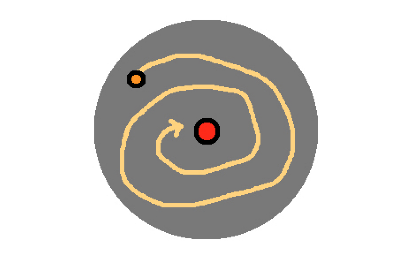
→ Different from cosmological halo-halo mergers?

→ How does dynamical friction reshape the orbits?

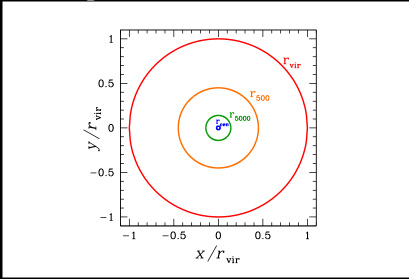


N-body simulations

Isolated cluster (Nipoti 2017)



Cosmological (Nipoti, Giocoli et al. 2017)



→ Rigid satellite starts from apocentre

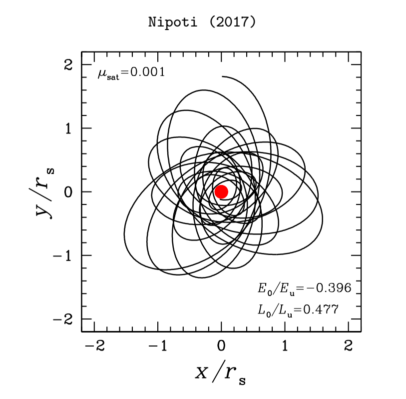
→ Initial conditions from distribution function

→ Measuring merger orbital parameters at different radii

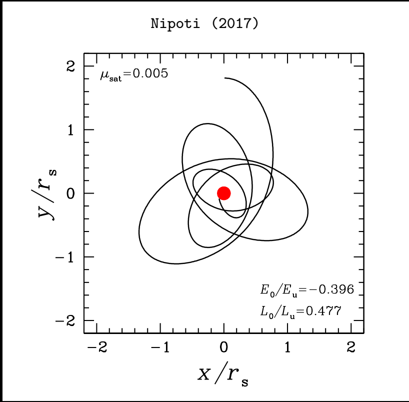
→ Simulations: LE SBARBINE (Despali et al. 2016)

Satellite's orbit: trajectory

$M_{sat}/M_{cen} \simeq 1/8$

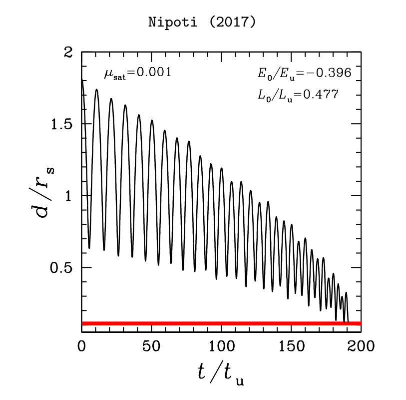


$M_{sat}/M_{cen} \simeq 2/3$



Satellite's orbit: radial distance vs. time

$M_{\rm sat}/M_{\rm cen} \simeq 1/8$



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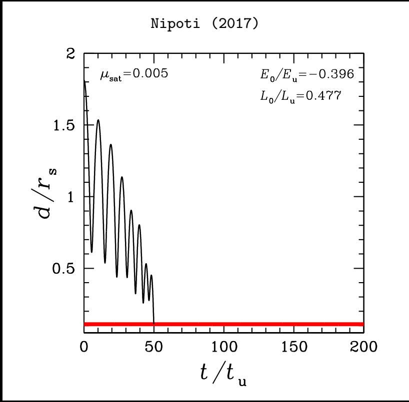
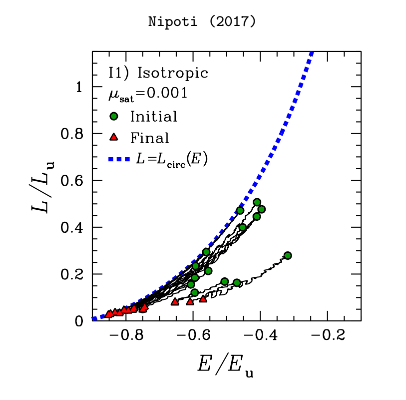


Angular momentum vs. energy (Lindblad diagram)

Isotropic

$M_{\rm sat}/M_{\rm cen} \simeq 1/8$



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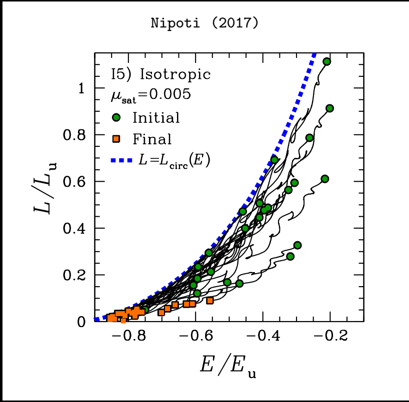
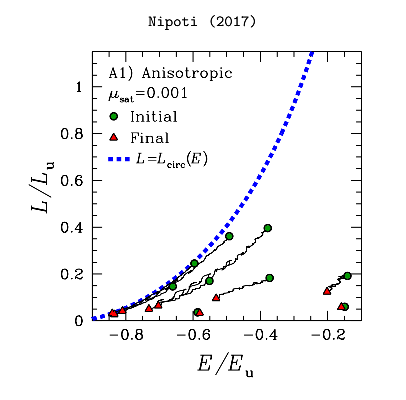


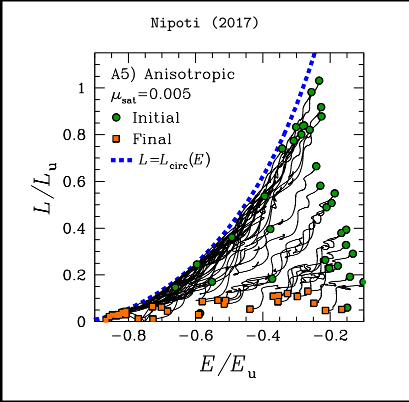
Angular momentum vs. energy (Lindblad diagram)

Radially anisotropic

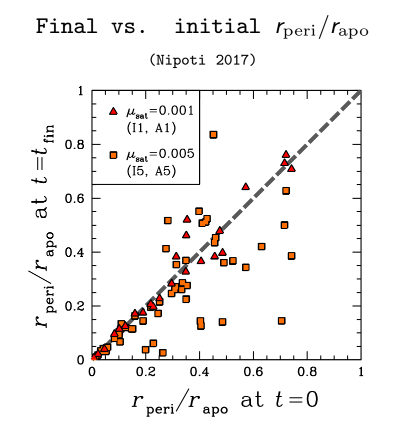
$M_{\rm sat}/M_{\rm cen} \simeq 1/8$



$M_{\rm sat}/M_{\rm cen} \simeq 2/3$



No evidence of orbit circularization



→ Effect of dynamical friction depends on both orbit and host properties

→ Host makes satellite conform to its orbital structure

(see also Bentekoe & van Albada 1987, Casertano et al. 1987, Statler 1991, van den Bosch 1999, Tsuchiya & Tsumada 2000, Arena & Bertin 2007)

Two-body (satellite-BCG) orbital parameters

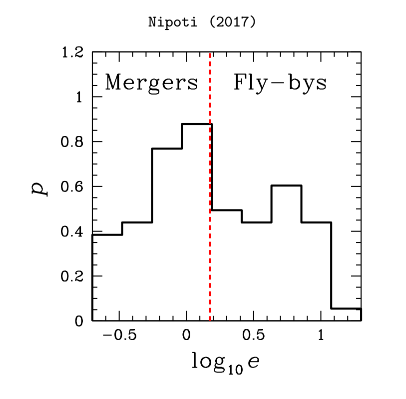
$\rightarrow$ (E_{2b}, L): energy & angular momentum

$\rightarrow$ $(e, r_{\mathrm{peri,2b}})$: eccentricity and pericentric radius

$\rightarrow$ $(\eta, r_{\mathrm{peri,2b}})$: circularity and pericentric radius

$\rightarrow$ $(v/v_{\mathrm{circ}}, v_r/v)$: relative speed and radial velocity component at a given radius

Classification of encounters



Eccentricity:

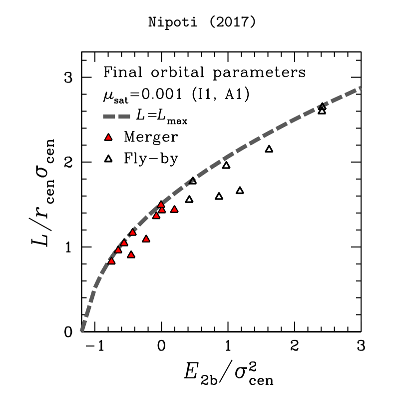
$$e = \sqrt{1 + \frac{2E_{2b}L^2}{G^2 M_{2b}^2}}$$

$e < 1.5$: mergers

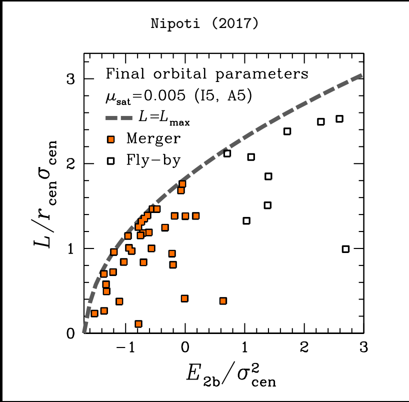
$e > 1.5$: fly-bys

Mergers and fly-bys in Lindblad diagram

$M_{\rm sat}/M_{\rm cen} \simeq 1/8$

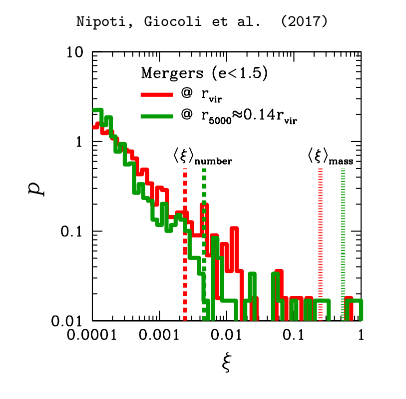


$M_{\rm sat}/M_{\rm cen} \simeq 2/3$

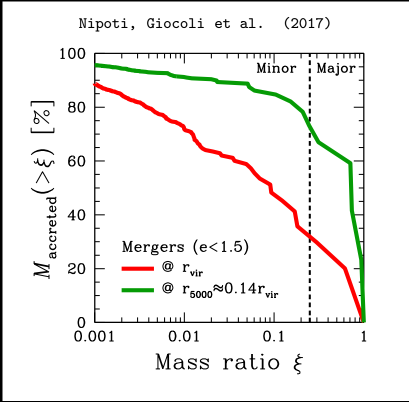


Merger mass ratio ξ: cosmological simulations

Dsitribution of ξ



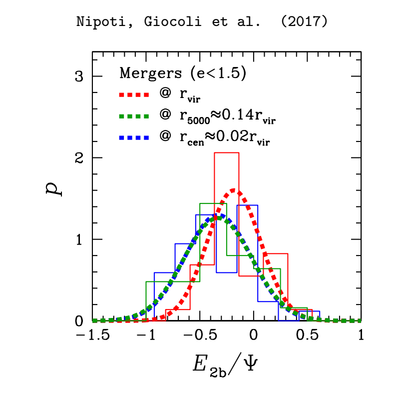
Mass$(>\xi)$



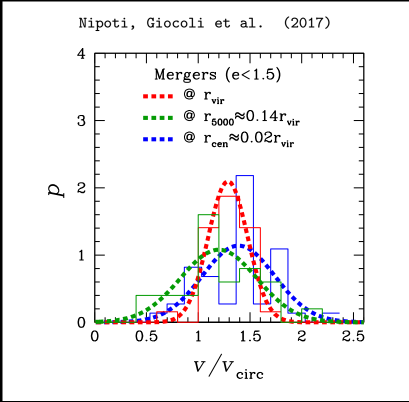
Major mergers more important for BCGs than for accretion at $r_{\rm vir}$

BCG-satellite and cosmological orbits have similar binding energy

Energy

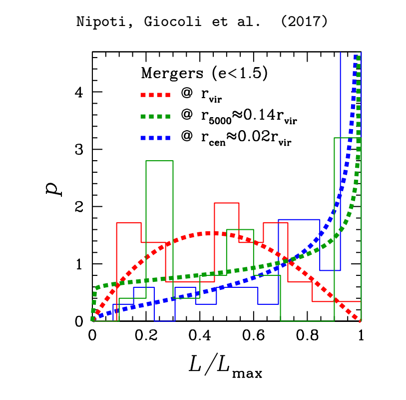


Relative speed

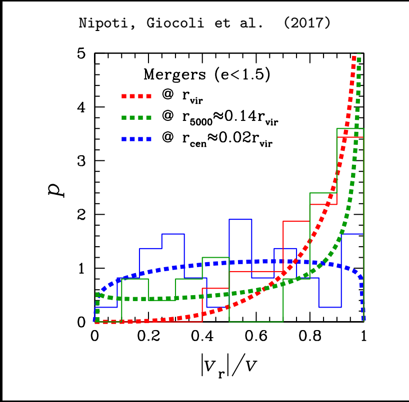


BCG-satellite orbits are more tangential than cosmological orbits

Angular momentum

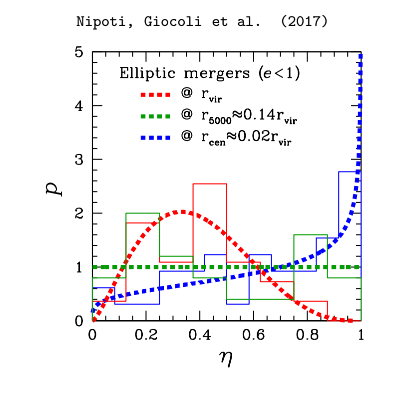


Radial velocity component

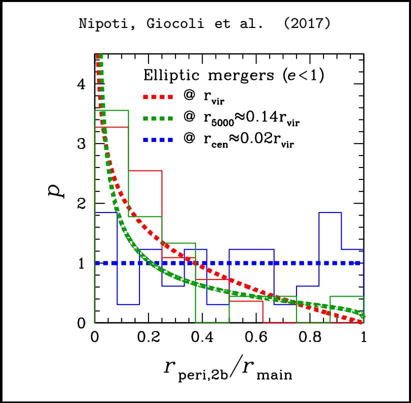


Bound mergers: less eccentric for BCGs

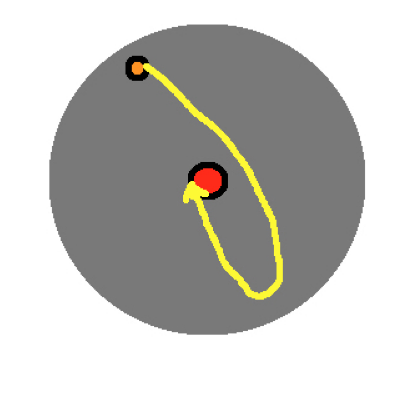
Circularity



Pericentric radius



No circularization, but ‘‘grazing’’ orbits



→ Cluster viewpoint: radial orbit

→ BCG viewpoint: tangential orbit

→ Satellite ‘‘grazing’’ the BCG

(see also Boylan-Kolchin et al. 2008)

Conclusions

- Dynamical friction does not necessarily lead to orbit circularization
- BCG-satellite mergers have
  - $\rightarrow$ larger mass ratios
  - $\rightarrow$ similar binding energy
  - $\rightarrow$ more tangential orbits

  compared to halo-halo mergers at $r_{\rm vir}$
- Follow-up: implications for scaling laws of BCGs

THANKS!