The Orbits of Infalling Satellite Halos

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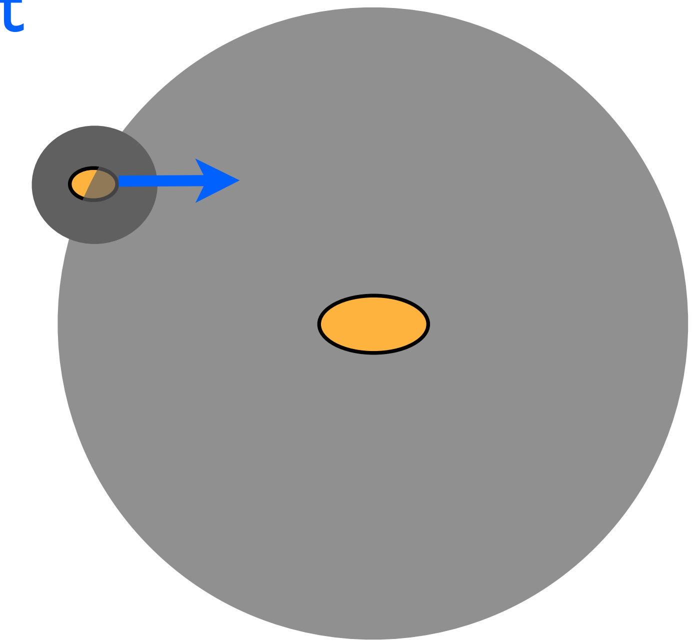
Orbital parameters at infall set the initial conditions for the subsequent evolution of subhalos/galaxies

Central galaxy

- angular momentum growth
- merger dynamics

Satellite galaxy

- survival times
- merger rate
- mass stripping
- star formation quenching
- morphological evolution



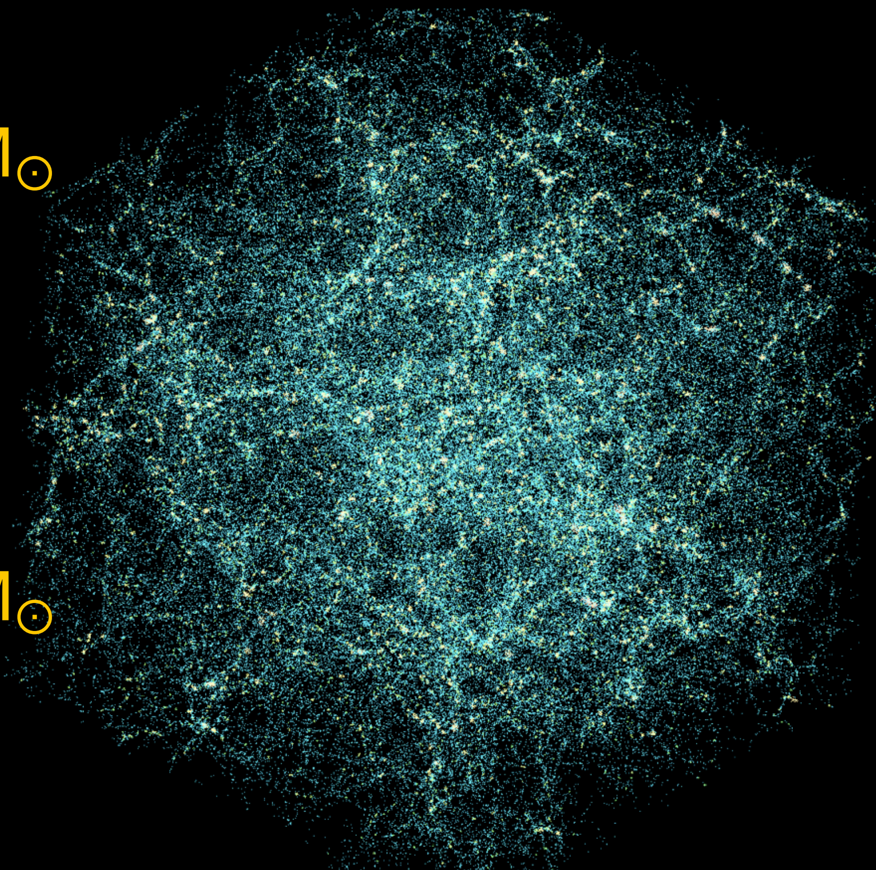
$$\tau_{\rm disrupt} \propto \tau_{\rm dyn} \frac{(M_{\rm host}/M_{\rm sat})^b}{\ln(1+M_{\rm host}/M_{\rm sat})} e^{\eta}$$

Boylan-Kolchin et al. 07

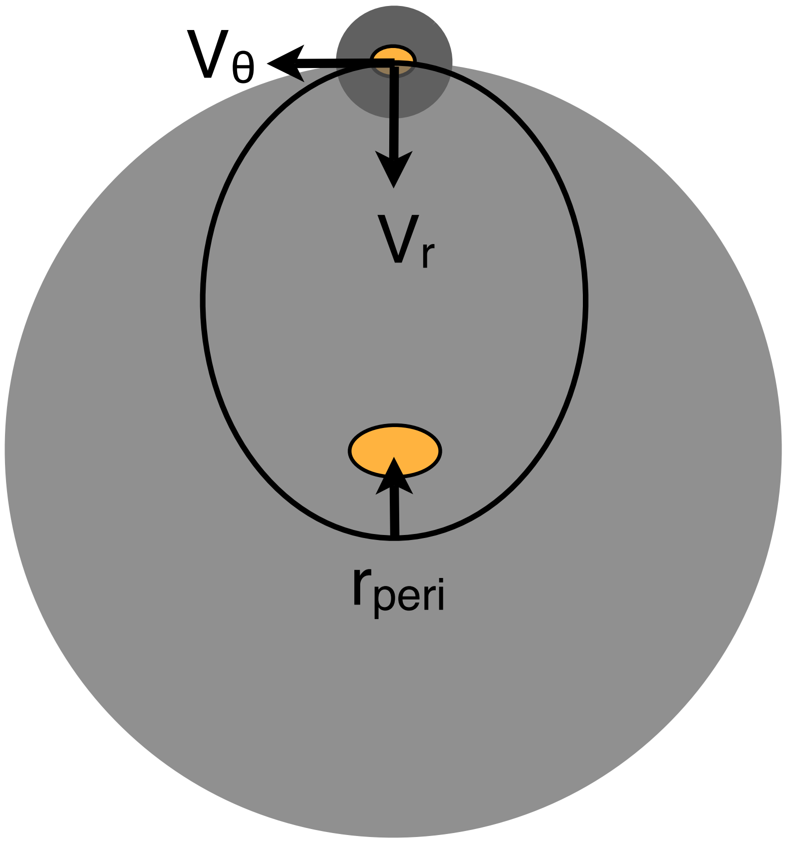
High-Resolution, Cosmological N-body Simulations

Box size	200 h^{-1}Mpc
Particle mass	$1.6 \times 10^8\ h^{-1} M_\odot$
Force resolution	3 h^{-1}kpc
Particle count	3.4 billion

Box size	250 h^{-1}Mpc
Particle mass	$1.4 \times 10^8\ h^{-1} M_\odot$
Force resolution	2.5 h^{-1}kpc
Particle count	8.6 billion



Calculating Orbital Parameters

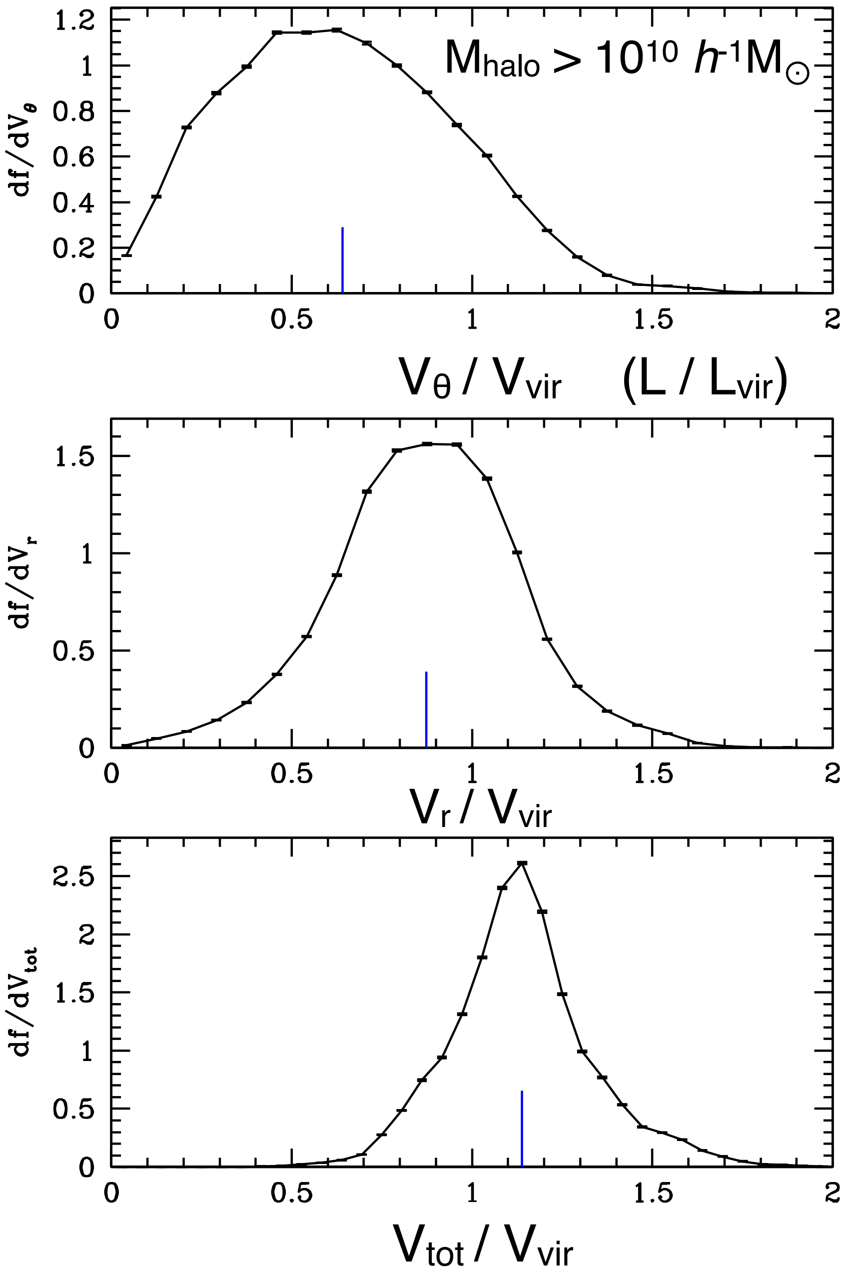


circularity

$$\eta = \frac{j(E)}{j_c(E)} = \sqrt{1 - e^2}$$

pericenter

$$r_{\rm peri} = \frac{L^2}{(1+e)GM_{\rm sat}M_{\rm host}\mu}$$



Infall Velocities at z=0

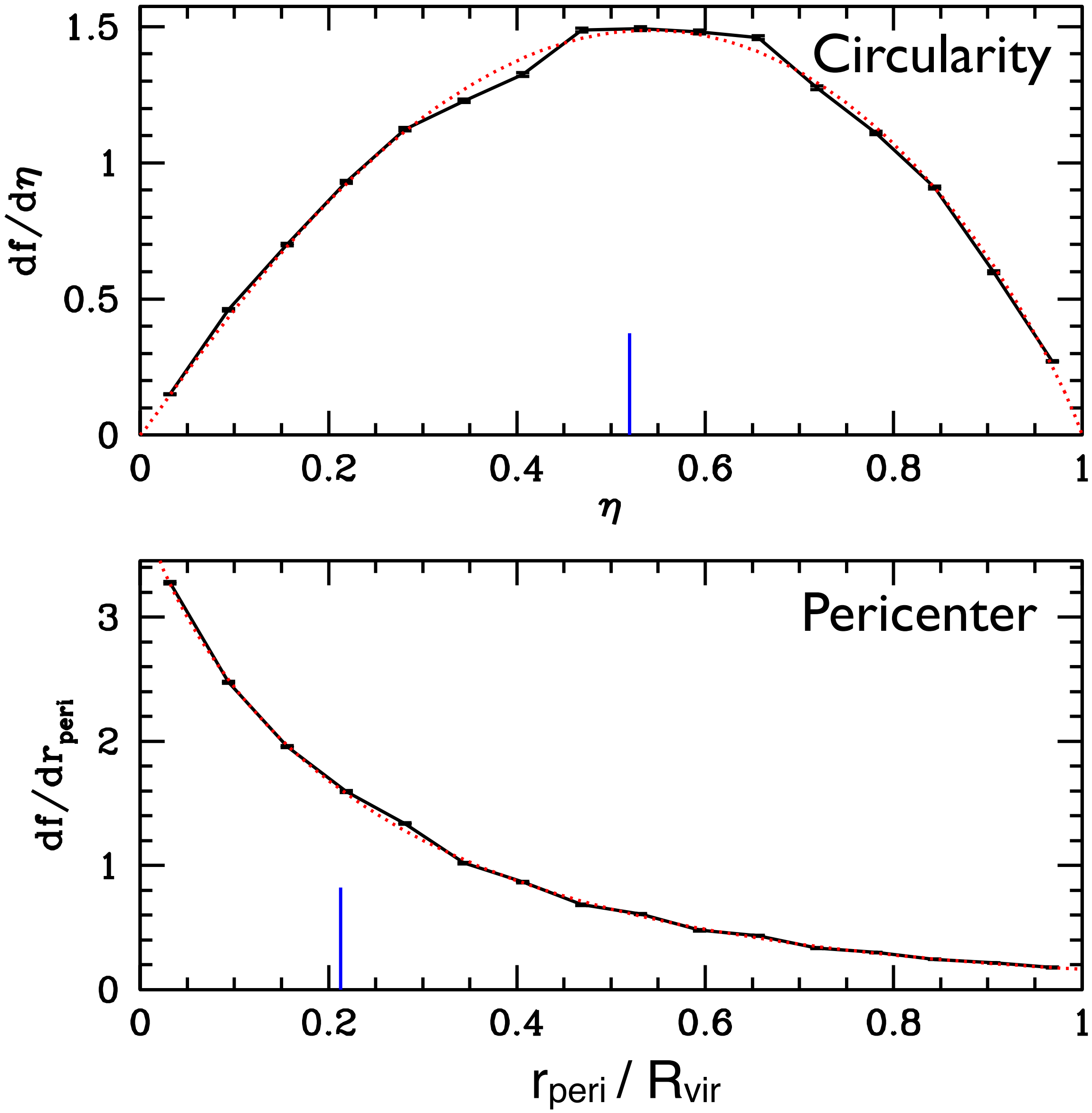
Maxwell-Boltzmann velocity distributions

$$\frac{df}{dV_\theta} \sim V_\theta \, e^{-(V_\theta - V_o)^2}$$

$$\frac{df}{dV_r} \sim e^{-(V_r - V_1)^2}$$

Satellites infall is faster than host halo virial velocity

Infall Circularity & Pericenter at z=0



$$\frac{df}{d\eta} = C_o \eta^{1.05}(1-\eta)^{0.8}$$

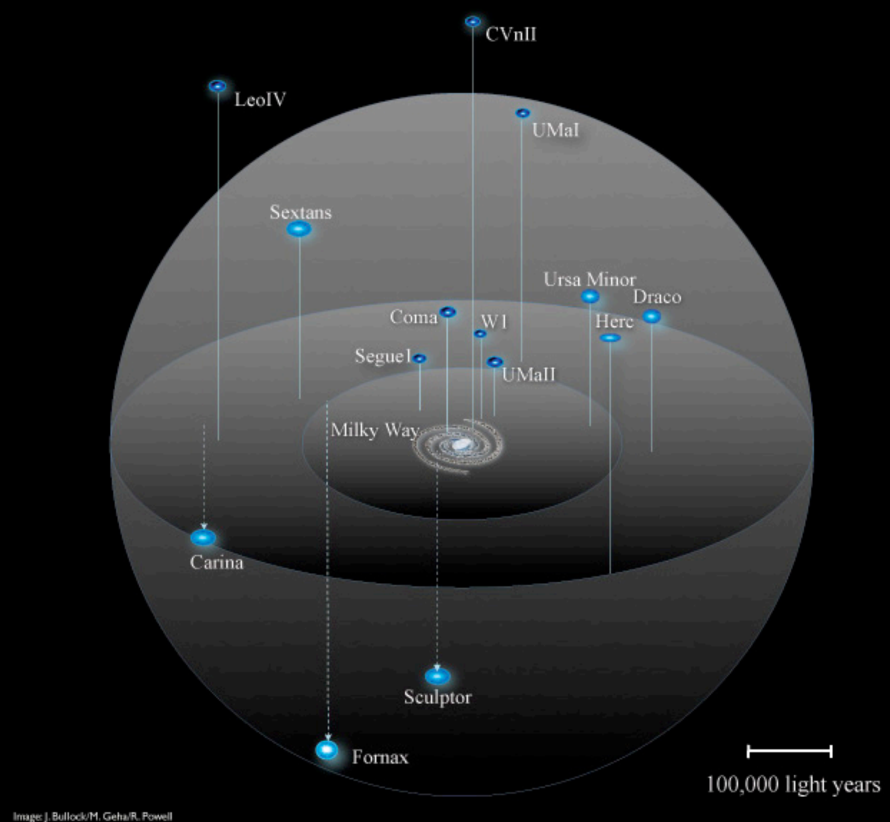
Few satellite orbits are highly radial or circular

$$\frac{df}{dr_{peri}} = R_o \exp\left\{-\left(\frac{r_{peri}}{0.27}\right)^{0.85}\right\}$$

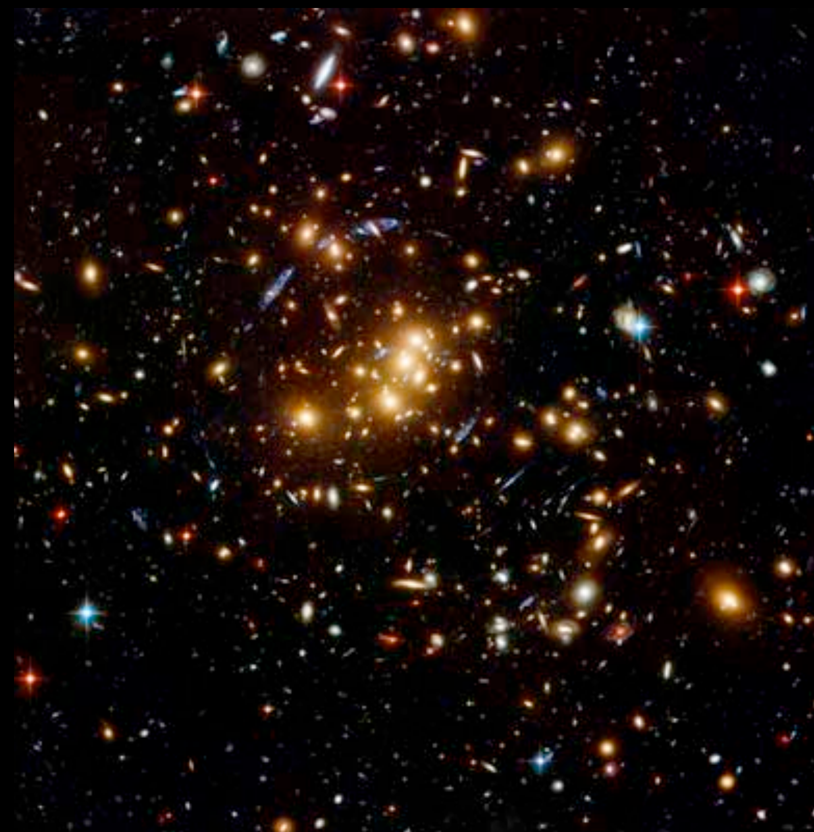
Most satellite orbits plunge deeply into their host halo

see also:
Vitvitska et al. 02, Zentner et al. 05, Benson 05, Wang et al. 05, Khochfar & Burkert 06

Milky Way
M~10^{12} $M_\odot$

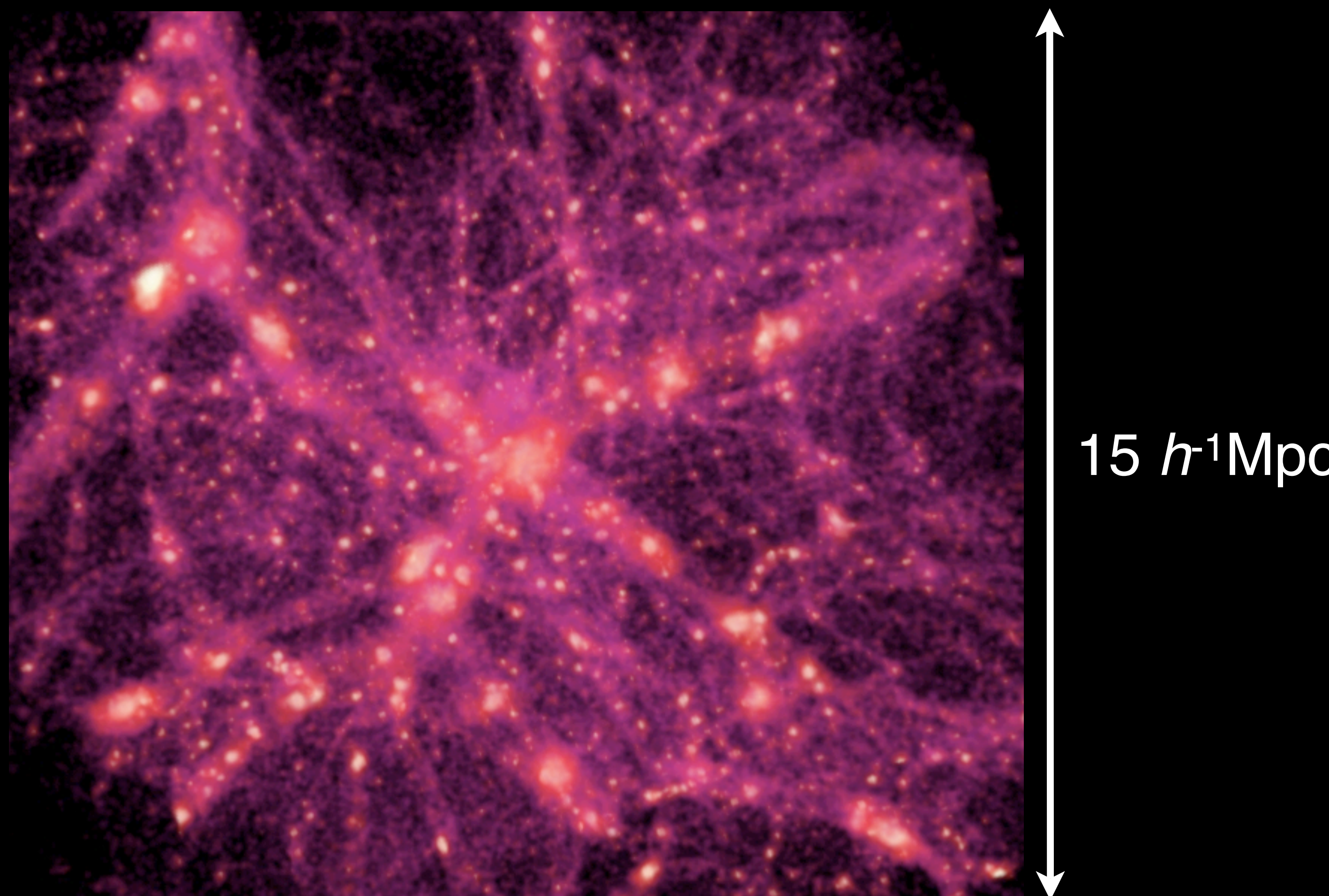


Galaxy Cluster
M~10^{14} $M_\odot$



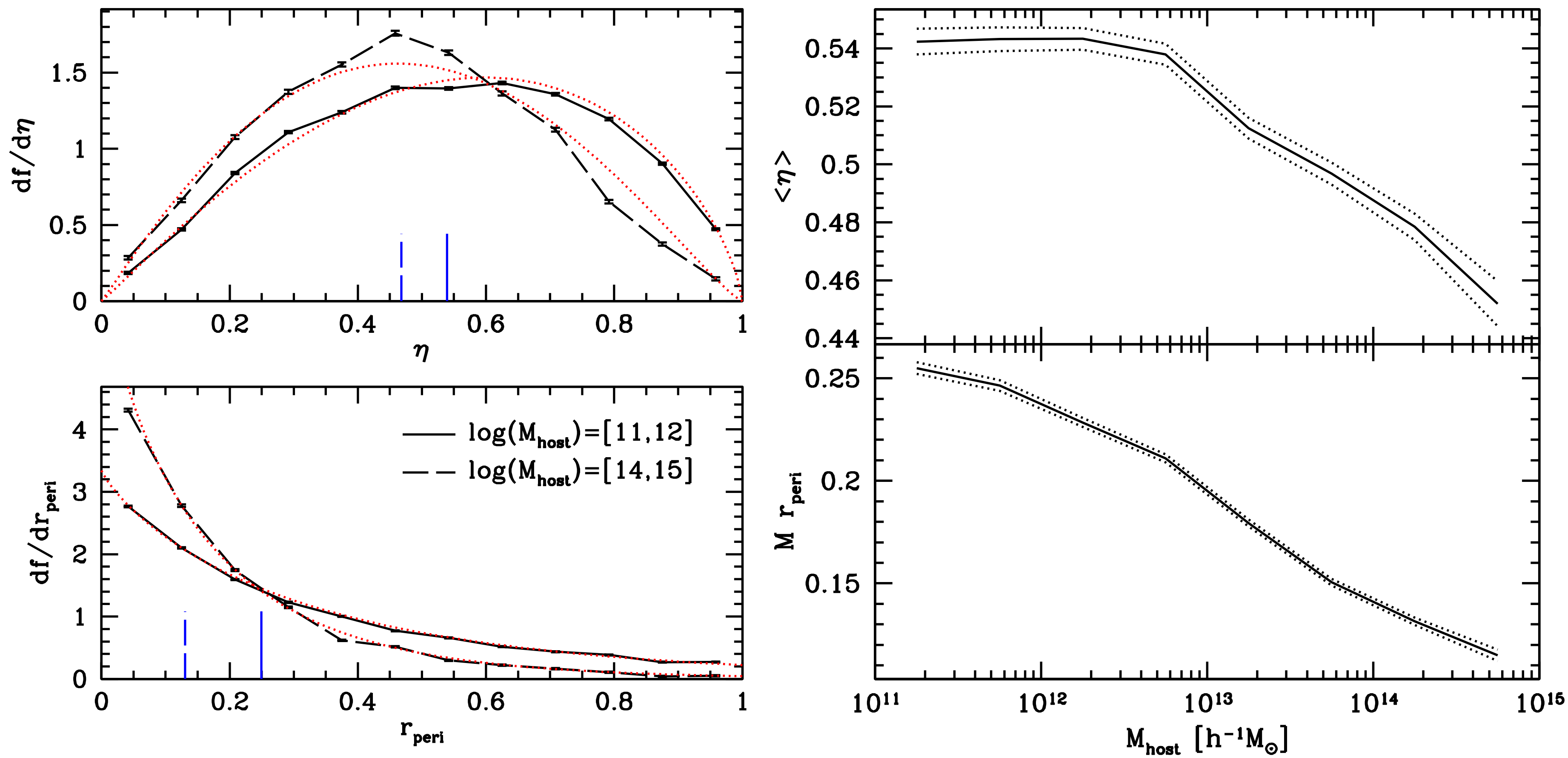
Self similar systems?

Does the nature of mass accretion change with halo mass?



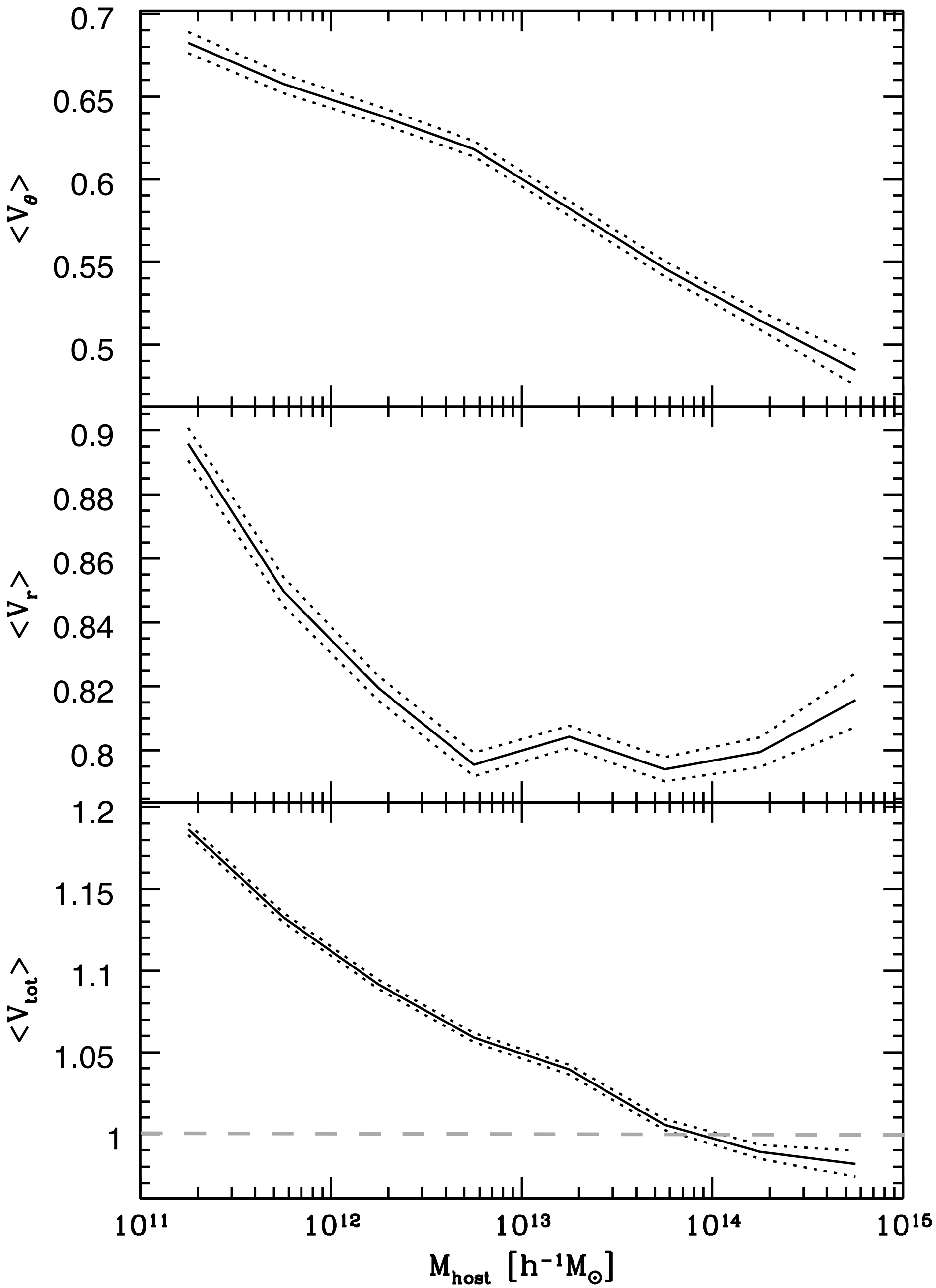
Galaxy clusters reside at intersection of filaments ($M > M_*$)
Low-mass galaxies reside within filaments ($M < M_*$)

Mass dependence of satellite circularity & pericenter



Satellite orbits are more radial & penetrate deeper at higher host halo mass

Mass dependence of satellite velocities



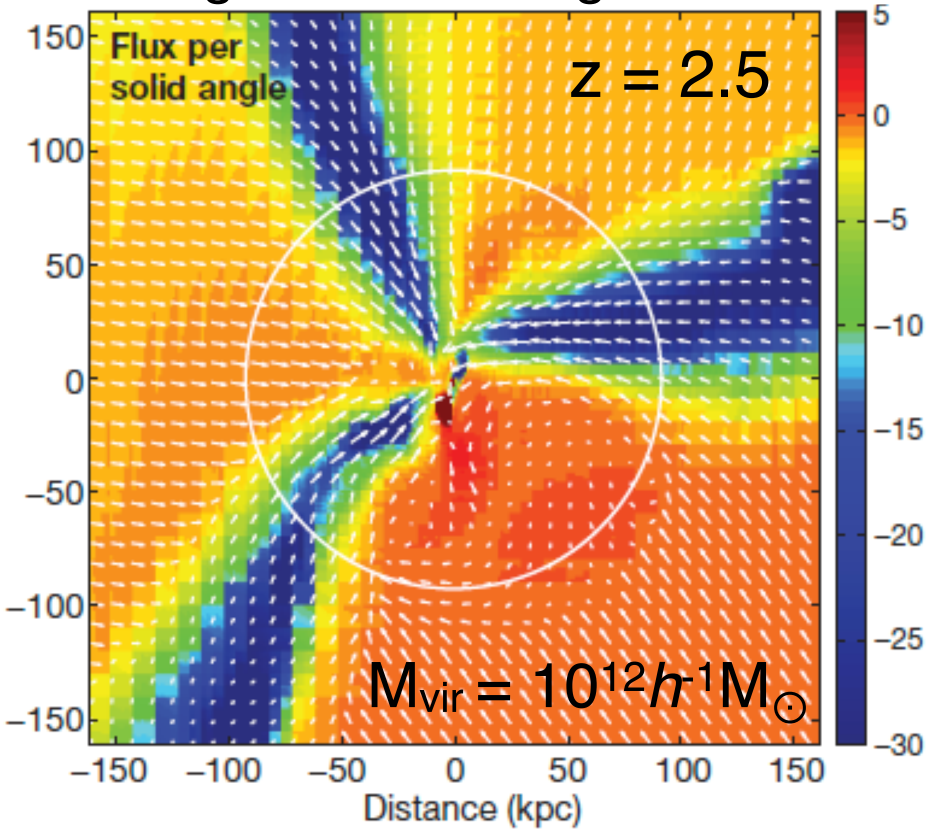
Less efficient angular momentum transport onto higher mass halos

Less radial orbits onto higher mass halos

Satellite/matter infall heats lower mass halos

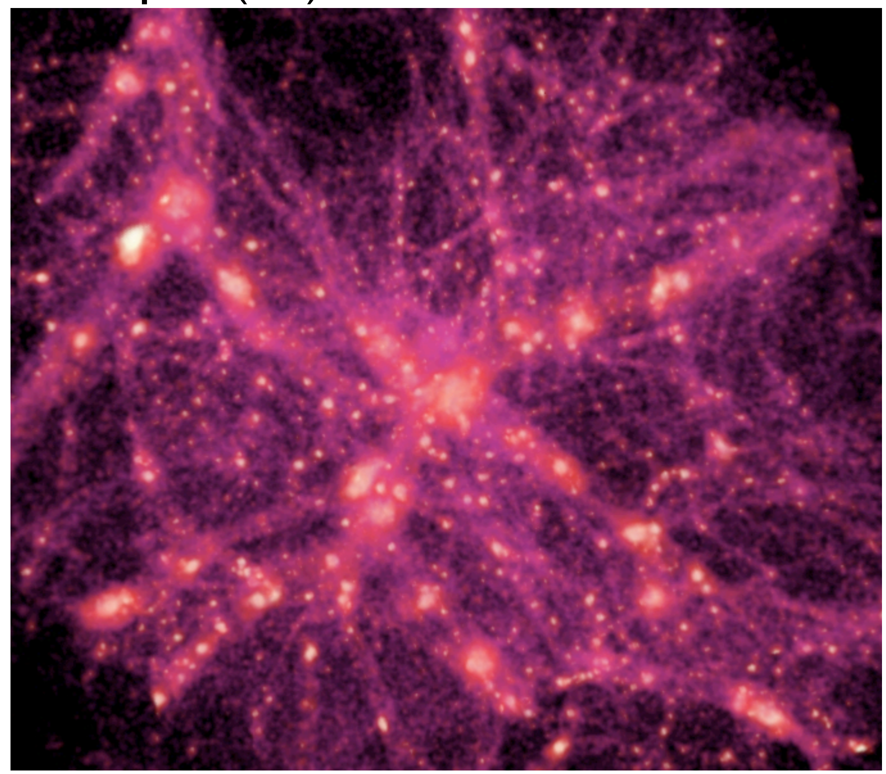
Does the nature of mass accretion change with redshift?

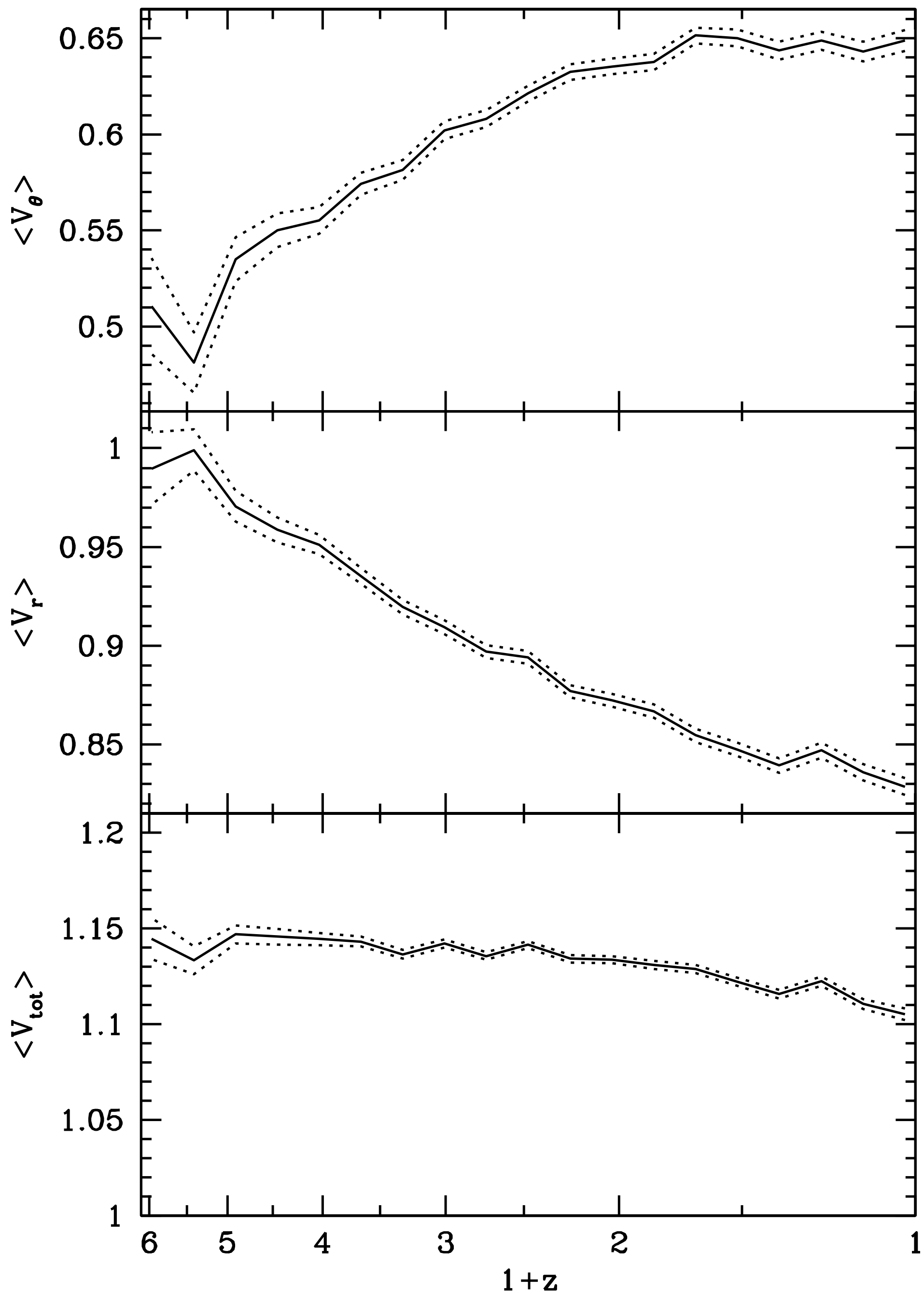
Galaxy formation via highly radial cold gas streams at high redshift



Dekel et al. 09

Characteristic halo mass scale of collapse (M_*) decreases with redshift





Redshift evolution of satellite velocities

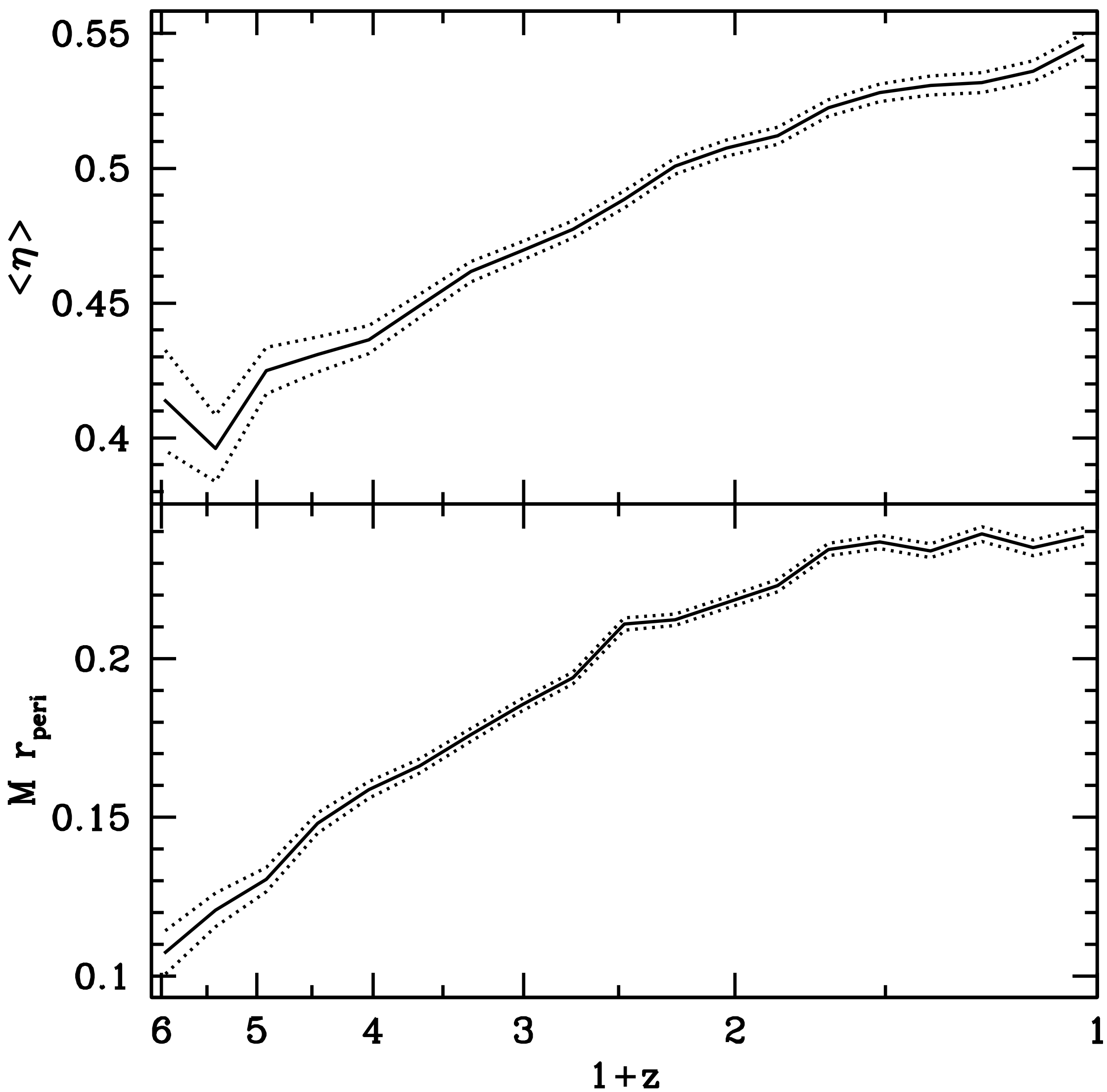
fixed mass
$M_{host} = 10^{12}h^{-1}M_{\odot}$

Less angular momentum transport onto halos at higher redshift

More radial velocities at higher redshift

No evolution in total velocity

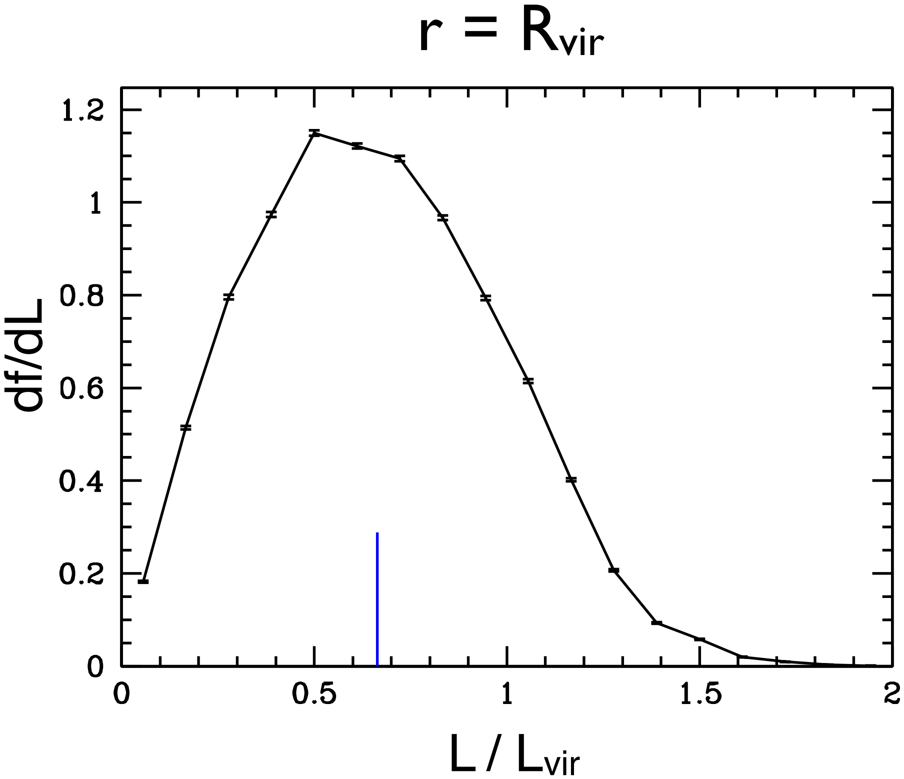
Redshift evolution of satellite circularity & pericenter

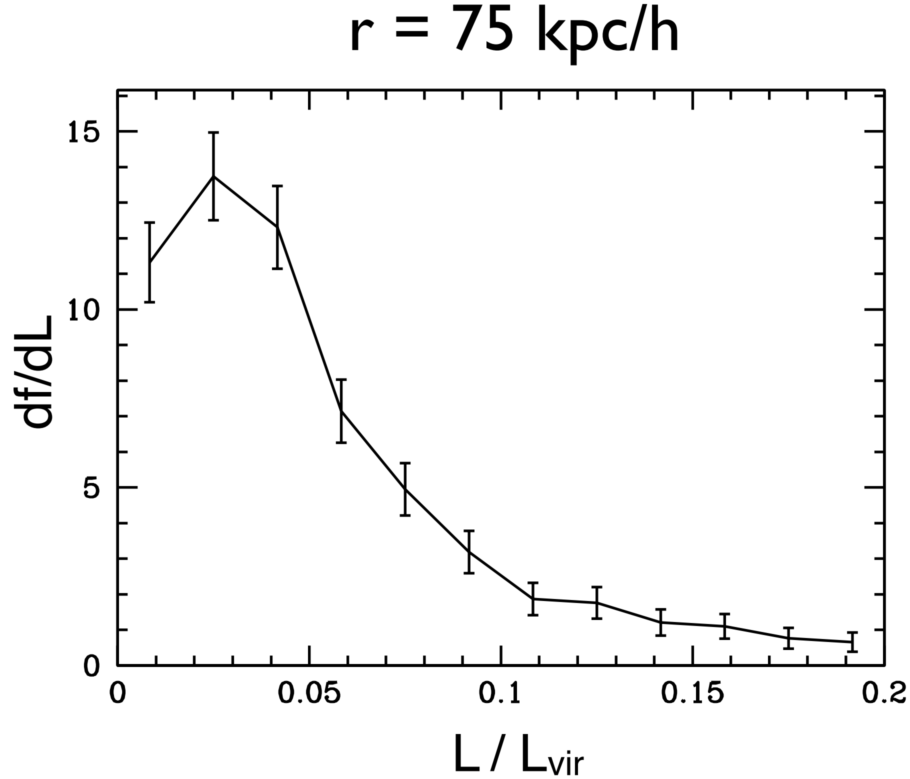


fixed mass
$M_{host} = 10^{12} h^{-1} M_{\odot}$

Satellite orbits are more radial & penetrate deeper at higher redshift

Satellite subhalo orbits near halo center (in prep.)





$M_{host} > 10^{11} h^{-1} M_{\odot}$

Orbits of Infalling Satellite Halos

- At z=0, typical satellite orbits have $\eta \sim 0.5$ and $r_{peri} \sim 0.2\ R_{vir}$
- Satellite infall velocity is higher than host halo virial velocity
- Satellite orbits are more radial & penetrate deeper at higher host halo mass
- Satellite orbits are more radial & penetrate more deeply at higher redshift
- Fits available: arxiv.org/abs/1001.4792