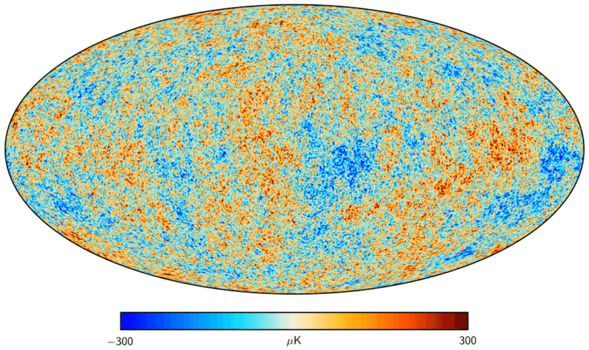
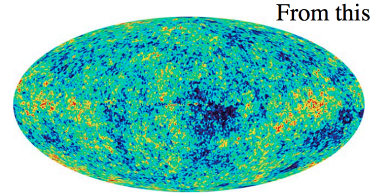
Start with fluctuations in density after the Big Bang…



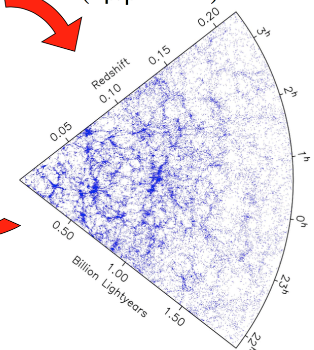
Planck measurement of the CMB - $\Delta T/T \sim 10^{-6}$

Structure Formation and Evolution

From this ($\Delta\rho/\rho \sim 10^{-6}$)



to this
($\Delta\rho/\rho \sim 10^{+2}$)



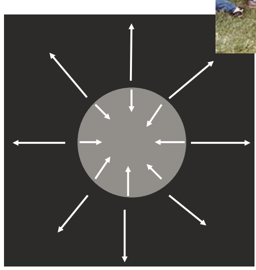
to this
($\Delta\rho/\rho \sim 10^{+6}$)

2

Formation of Structure: LCDM

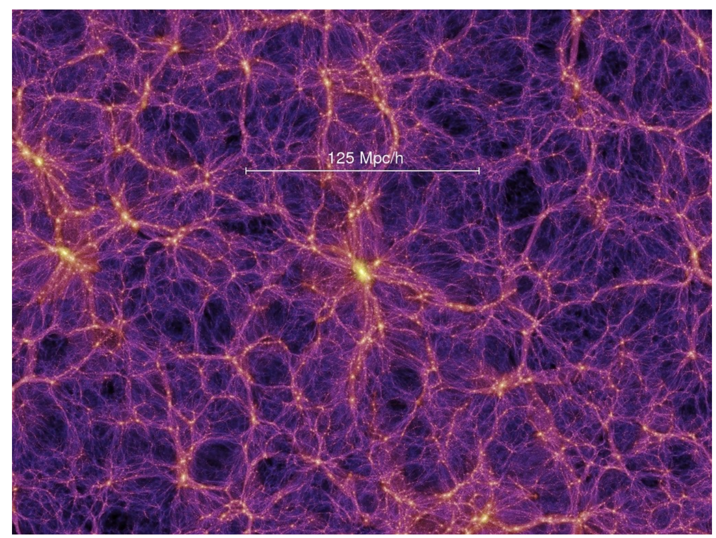
Cosmological expansion

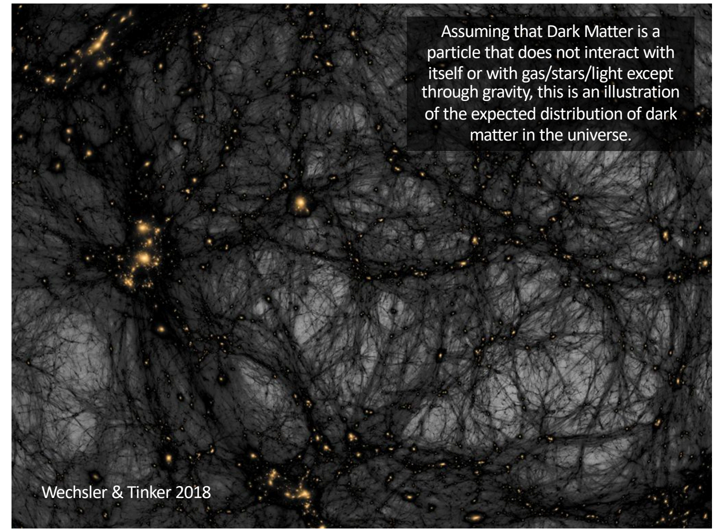
Gravity/dark matte



Overdensities grow into gravitationally bound structures once they overcome the expansion.

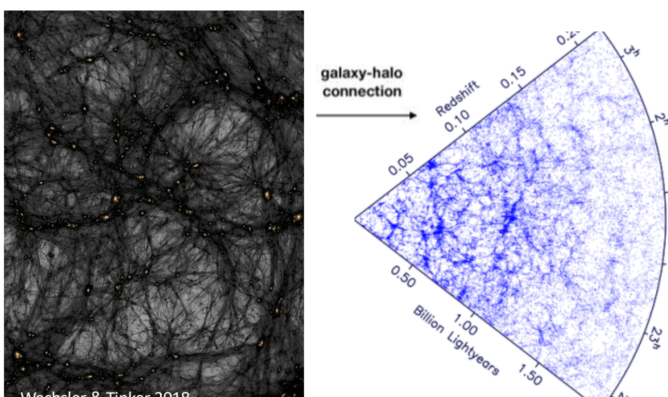
Space between bound overdensities expands.



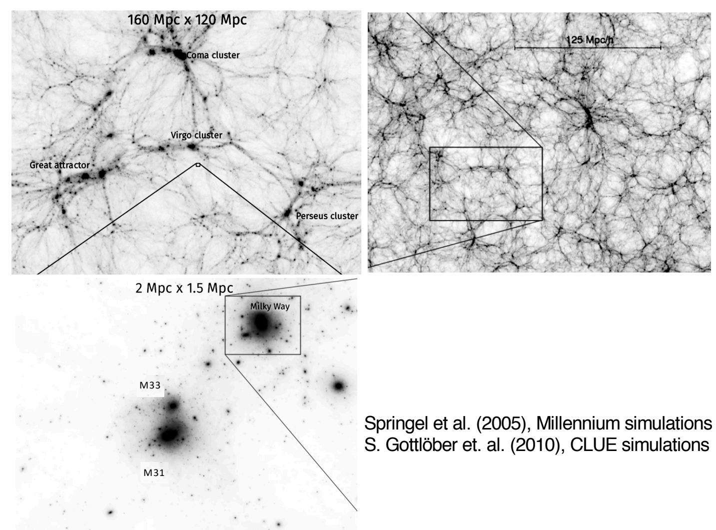


6

Simulated “web” matches the observed distribution of galaxies

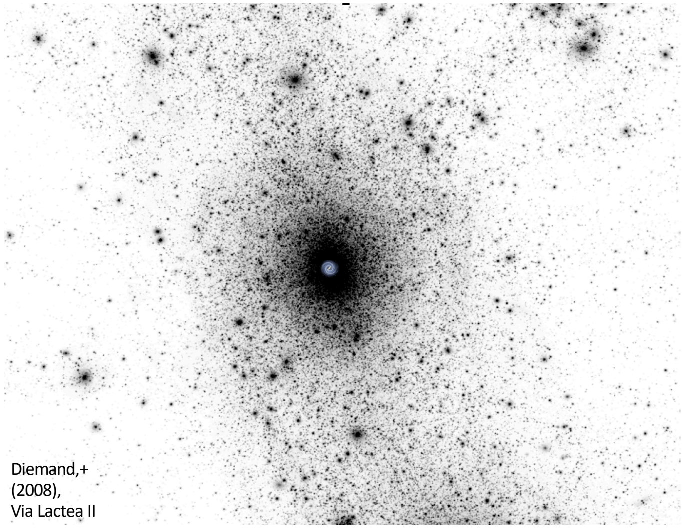


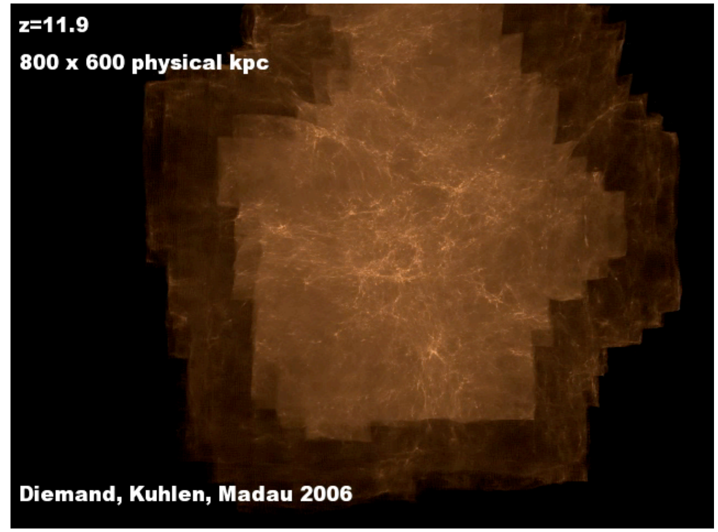
2dF Galaxy Redshift Survey

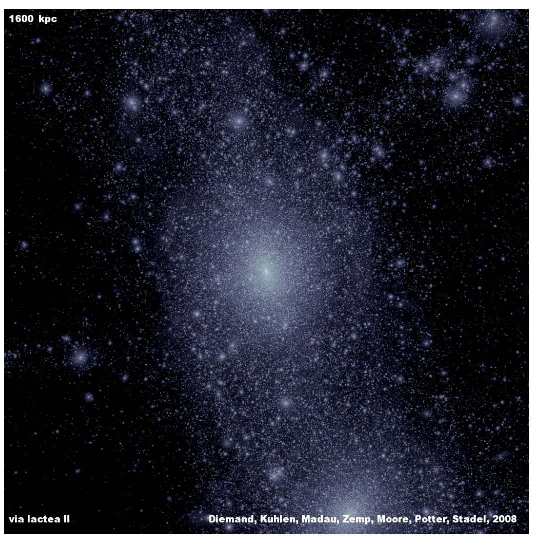


Springel et al. (2005), Millennium simulations
S. Gottlöber et. al. (2010), CLUE simulations

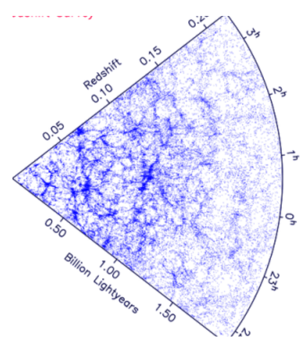
8







Galaxy Luminosity Function



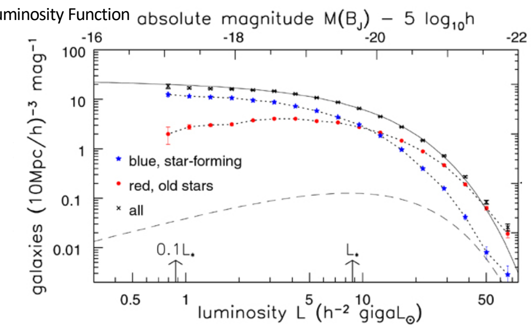
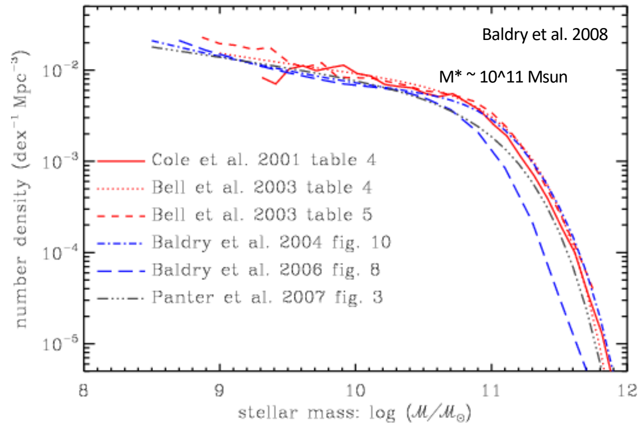


Fig 1.16 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

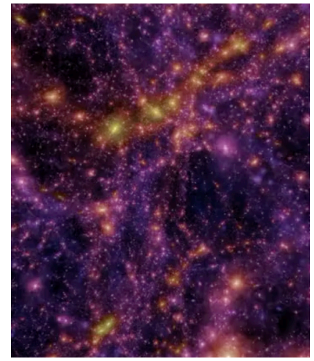
Fig. 1.16. Number of galaxies per 10 Mpc cube between absolute magnitude $M(B_J)$ and $M(B_J)+1$ (crosses). Dotted lines show numbers of blue (stars) and red (filled dots) galaxies making up this total; vertical bars indicate errors. The solid line shows the luminosity function of Equation 1.24; the dashed line gives $\Phi(M) \times L/L_\star$, the light from galaxies in each interval of absolute magnitude. The blue bandpass B_J is matched to the photographic plates used to select the galaxies – 2dF survey, D. Croton.

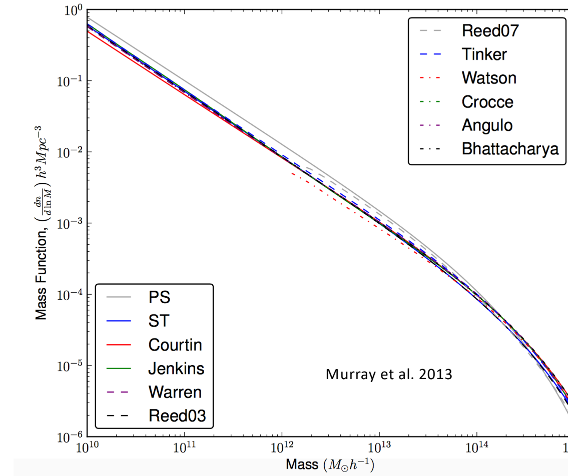
Sparke & Gallagher CI

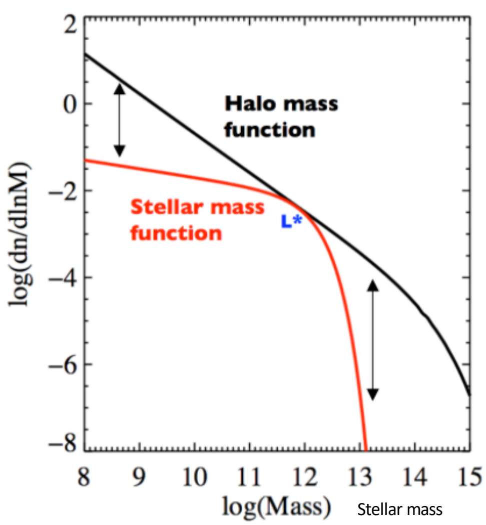
If we can determine each galaxy's mass-to-light ratio (M/L) we can construct a **galaxy stellar mass function**

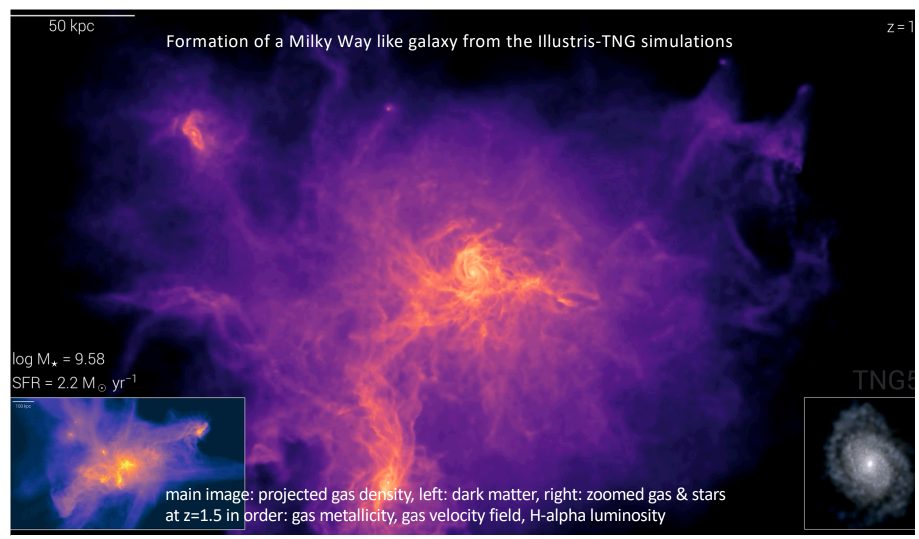


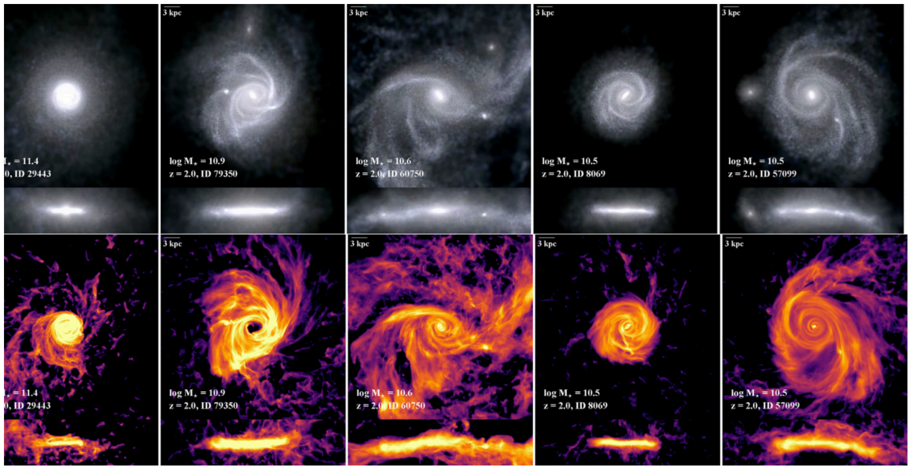
From dark matter-only simulations, we can find the mass function of dark matter halos.





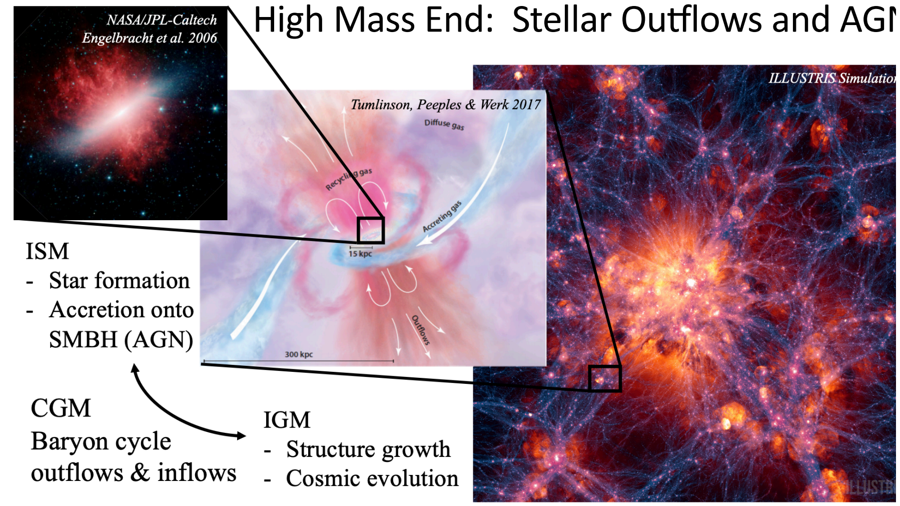






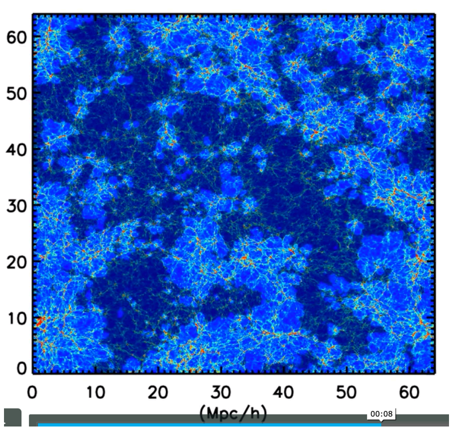
Illustris Collaboration: Pillepich+MNRAS 490 2019

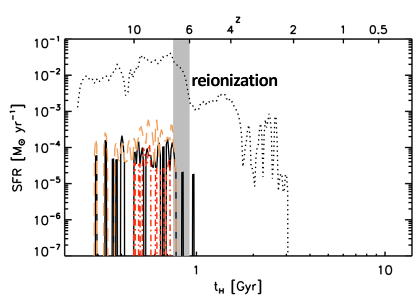
High Mass End: Stellar Outflows and AGI



Low Mass End: Stellar Feedback & Reionization

ttps://www.olcf.ornl.gov/2016/03/08/illuminating-the-universes-ignition/

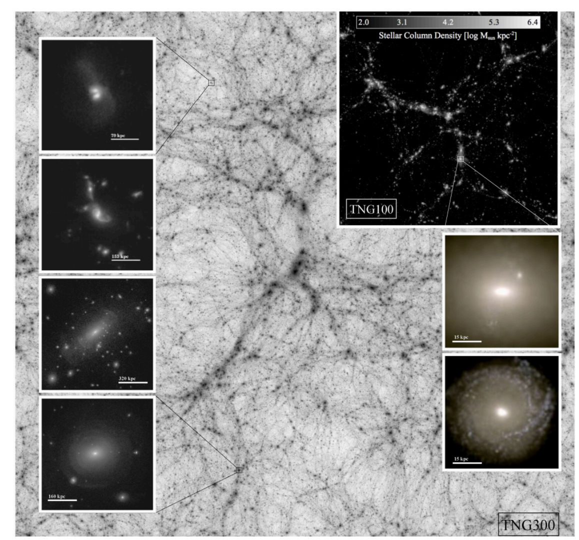




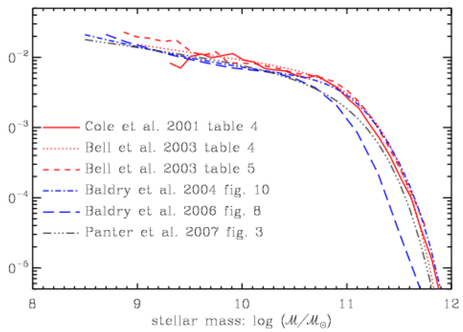
Jeon, Besla & Bromm 2017

How do we put the right stellar mass galaxy into the right halo ?

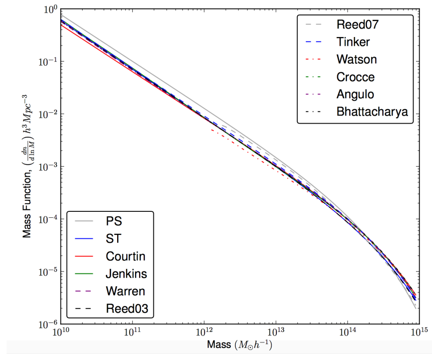
Pillepich+
MNRAS 475, 2018



Galaxy Stellar Mass Function



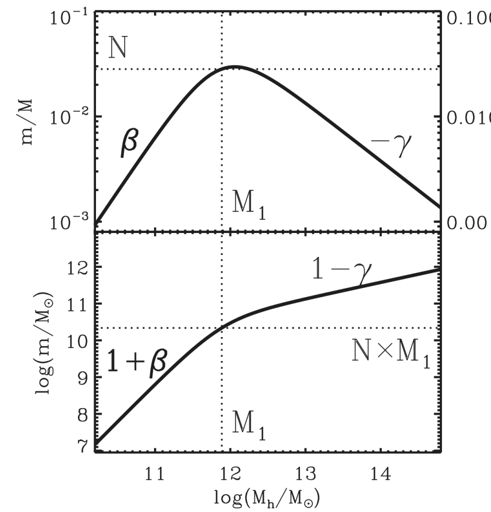
Dark matter halo mass function



Halo Mass to Stellar Mass Relation

$$\frac{m}{M} = 2N\left[\left(\frac{M}{M_1}\right)^{-\beta} + \left(\frac{M}{M_1}\right)^{\gamma}\right]^{-1}.$$

Moster + 2013 MNRAS 428, 3121



Moster+2013 eqns 11-14, Table 1

$$\log M_1(z) = M_{10} + M_{11}(1-a) = M_{10} + M_{11}\frac{z}{z+1}$$

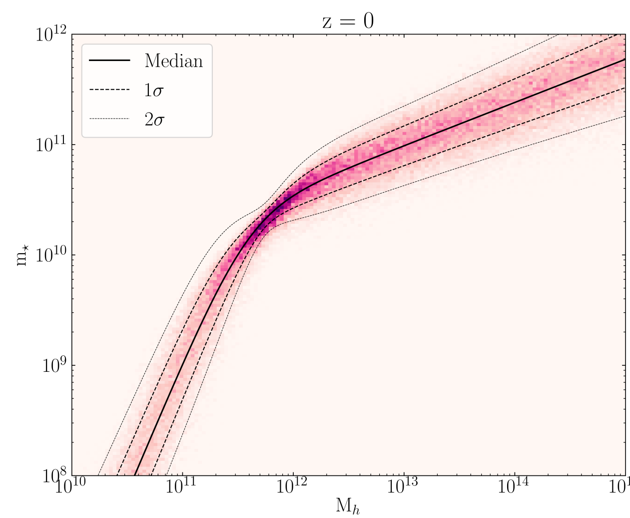
$$N(z) = N_{10} + N_{11}(1-a) = N_{10} + N_{11}\frac{z}{z+1}, \quad \gamma(z) = \gamma_{10} + \gamma_{11}(1-a) = \gamma_{10} + \gamma_{11}\frac{z}{z+1}.$$

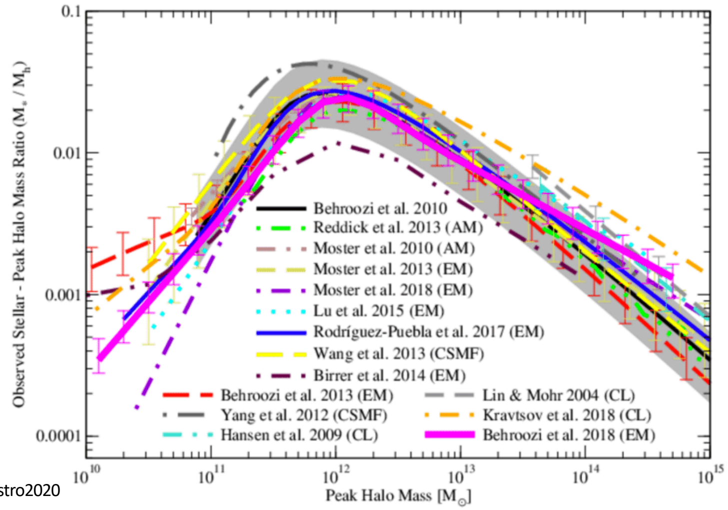
$$\beta(z) = \beta_{10} + \beta_{11}(1-a) = \beta_{10} + \beta_{11}\frac{z}{z+1},$$

Table 1. Fitting results for the redshift-dependent SHM relationship.

	M_{10}	M_{11}	N_{10}	N_{11}	β_{10}	β_{11}	γ_{10}	γ_{11}
Best fit	11.590	1.195	0.0351	− 0.0247	1.376	− 0.826	0.608	0.329
Range ±	0.236	0.353	0.0058	0.0069	0.153	0.225	0.059	0.173

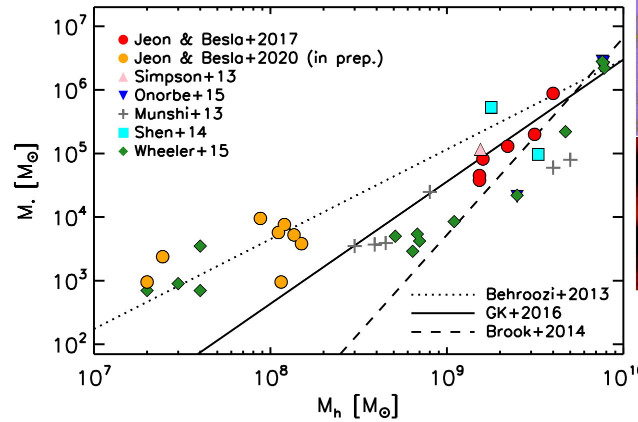
Notes. All masses are in units of $M_\odot$.

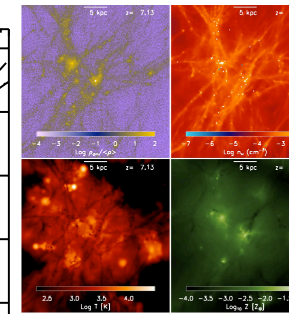




ehroozi Astro2020

Testing the halo mass – stellar mass relation





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$M_{Dynamical}$ /L Ratios at the Faint End

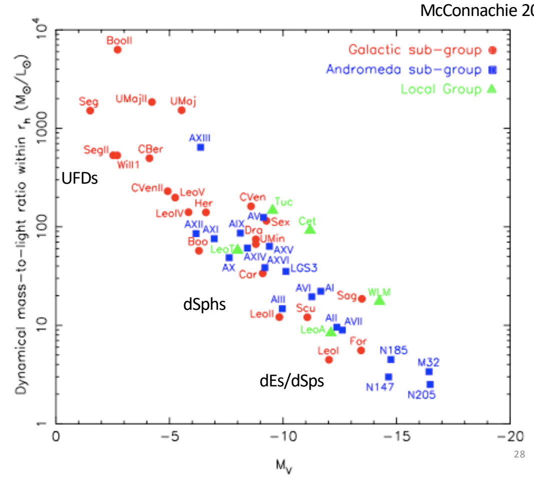
Wolf et al. 2010

$$M(< r_{1/2}) = 3\, G^{-1}\, \sigma^2_{\rm los}\, r_{1/2}$$
$$= 4\, G^{-1}\, \sigma^2_{\rm los}\, R_e\, .$$

$$r_{1/2} \approx 4R_e/3.$$

Re = 2D radius that contains half the stellar mass

McConnachie 2012



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