The effects of baryons on the halo mass function

Weiguang Cui

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Cui, W. et al. 2012, MNRAS, 423.2279C.
Cui, W. et al. 2013, MNRAS, to be submitted.

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10, Oct., 2013

Outline

HMF: How much do we know?

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- The two comment methods to identify halo: FoF and SO (e.g. White 2002).
- The difference between variance of halo finders (e.g. Knebe, 2011).
- The time evolution of halo (The universal of the HMF and the NFW profile).

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- The DE/MG models.
- The Massive Neutrinos. See Castorina & Villaescusa Navarro's talk.
- From dark-matter-only simulation halo to hydro-simulation halo: The effects of baryons.

The Simulations

Flat ΛCDM model parameters:
$\Omega_m = 0.24$; $\Omega_b = 0.04$; $h = 0.72$; $\sigma_8 = 0.8$; primordial power spectral index $n_s = 0.96$.
Simulation details: 2×1024^3 particles (DM: $3.54 \times 10^9\ h^{-1}\ M_\odot$ and Gas: $7.36 \times 10^8\ h^{-1}\ M_\odot$); Box size 410 Mpc/h; Redshift $z = 49$.

DM
Only collision-less dark matter particles, gas particles are treated as DM particles, but have smaller mass.

CSF
Sub-grid physics: Radiative gas cooling, star formation and kinetic feedback. Wind velocity 500 Km/s.

AGN
Besides CSF, AGN feedback is included, with some improvement with respect to Springel et al. (2005). Wind velocity 350 Km/s

FoF halo

On-fly FoF finder in Gadget-3.
Linking Length $b = 0.16$

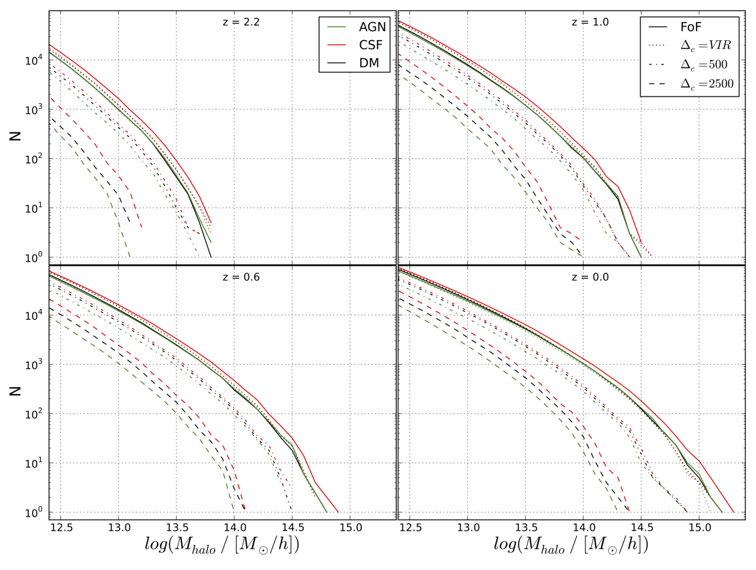
SO halo and Piao

Piao (Chinese character: 漂) is memory-controlled SO finder program. But it is not limit to do SO halo finding, it is designed to do post-processing analysis of very big simulation results (e.g. Tegabytes per snapshots) on small server or PC. It has very efficient RAM control and MPI paralleled.

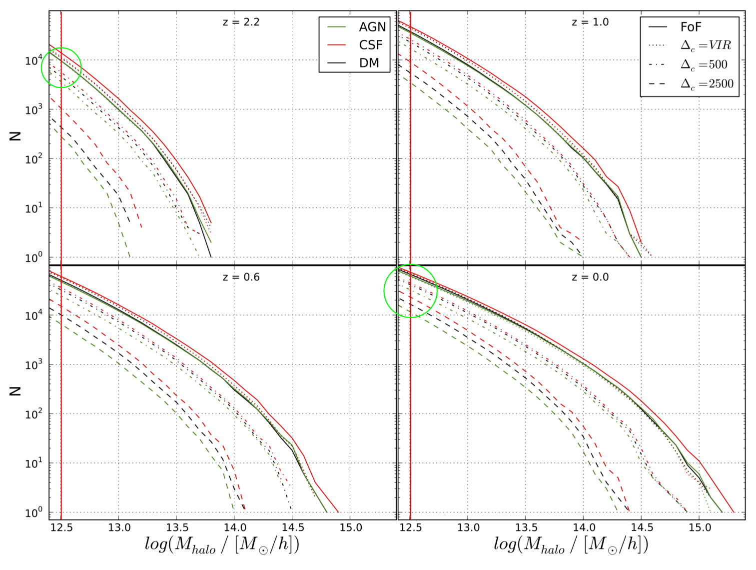
With Piao, we extract standard SO halos with three different overdensities $\Delta_c = 2500, 500, VIR$ from all three versions of simulations.

We used non-overlapping halos for the halo mass function.

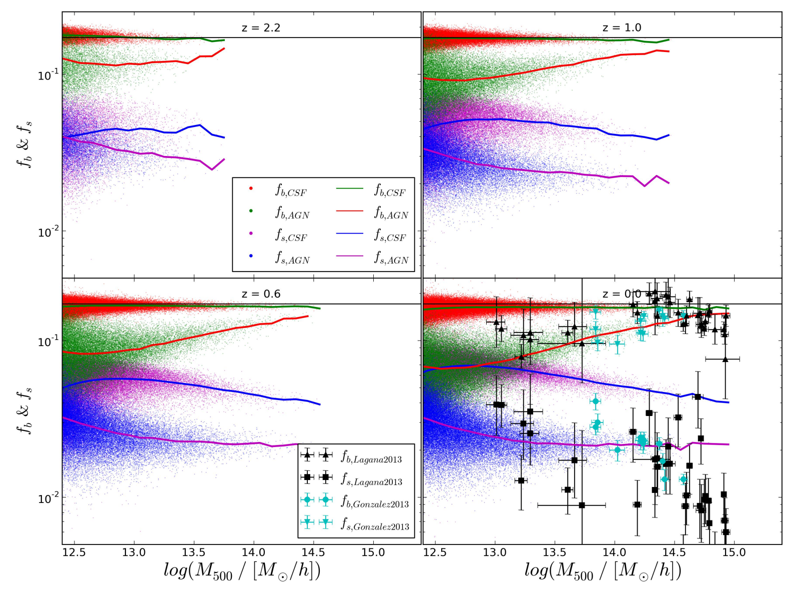
The accumulated HMF



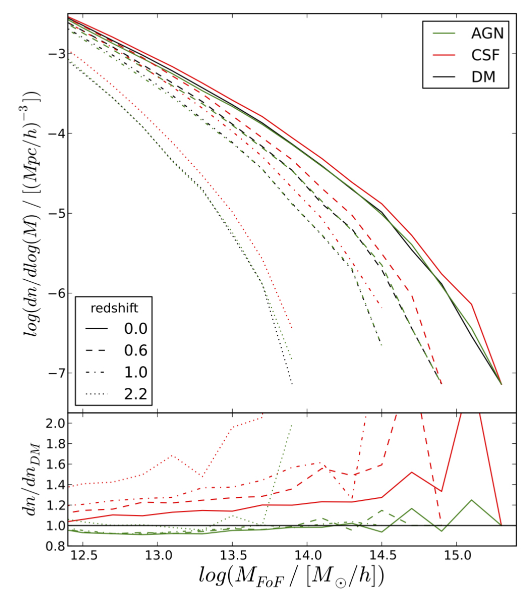
The accumulated HMF



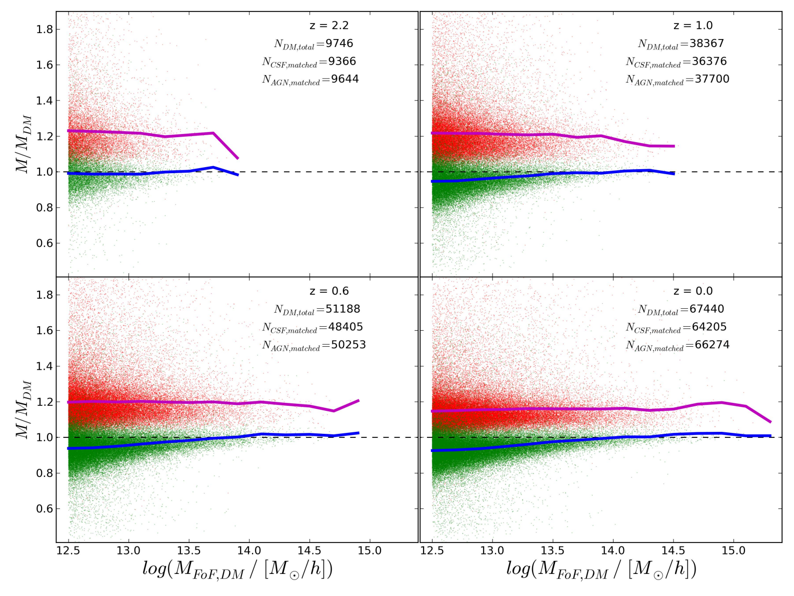
The baryon and stellar mass fraction



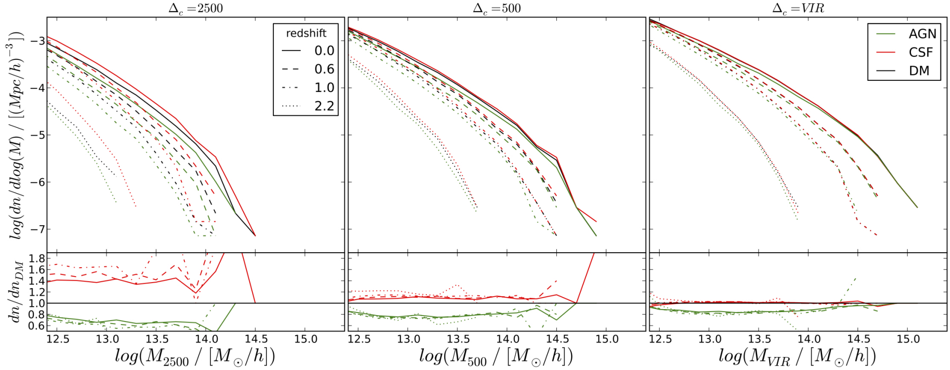
The FoF HMF


AGN
CSF
DM
redshift
0.0
0.6
1.0
2.2
$log(dn/dlog(M)\ /\ [(Mpc/h)^{-3}])$
dn/dn_{DM}
$log(M_{FoF}\ /\ [M_\odot/h])$
−3
−4
−5
−6
−7
2.0
1.8
1.6
1.4
1.2
1.0
0.8
12.5
13.0
13.5
14.0
14.5
15.0

FoF Halo Mass difference



The SO HMF



$\Delta_c = 2500$
$\Delta_c = 500$
$\Delta_c = VIR$
redshift
0.0
0.6
1.0
2.2
AGN
CSF
DM
$log(dn/dlog(M) / [(Mpc/h)^{-3}])$
dn/dn_{DM}
$log(M_{2500} / [M_\odot/h])$
$log(M_{500} / [M_\odot/h])$
$log(M_{VIR} / [M_\odot/h])$

The SO HMF

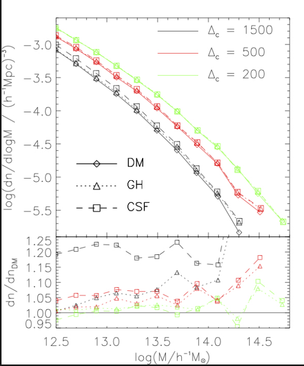


Figure : Cui, et al. 2012

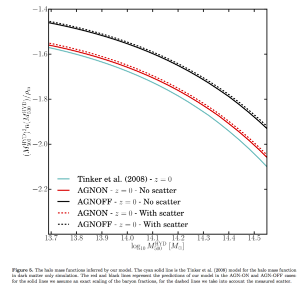


Figure : Martizzi, et al. 2013

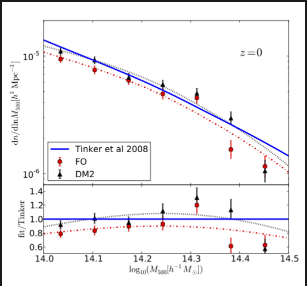
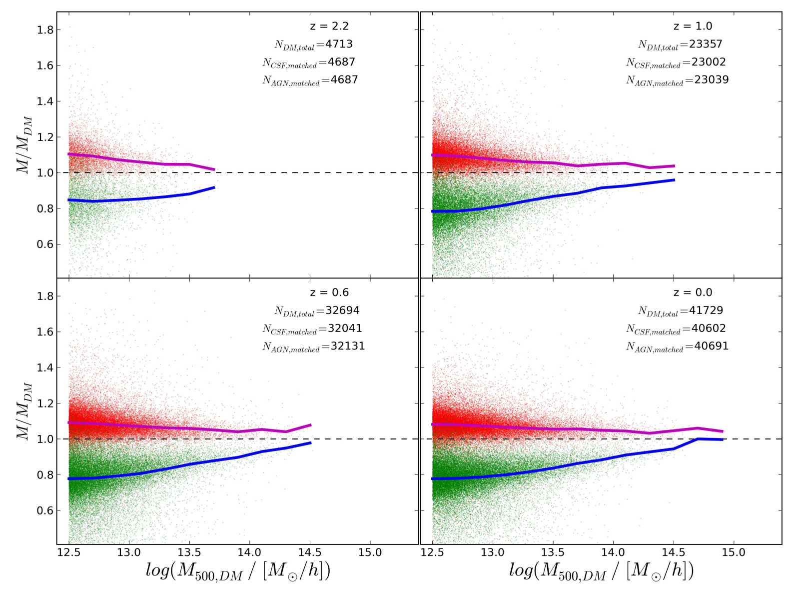
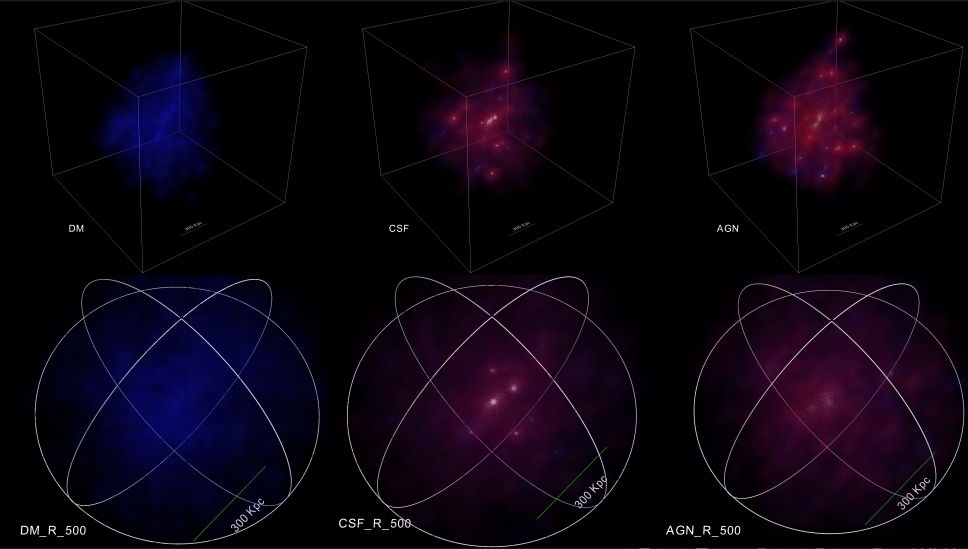


Figure : Cusworth, et al. 2013

SO Halo Mass difference

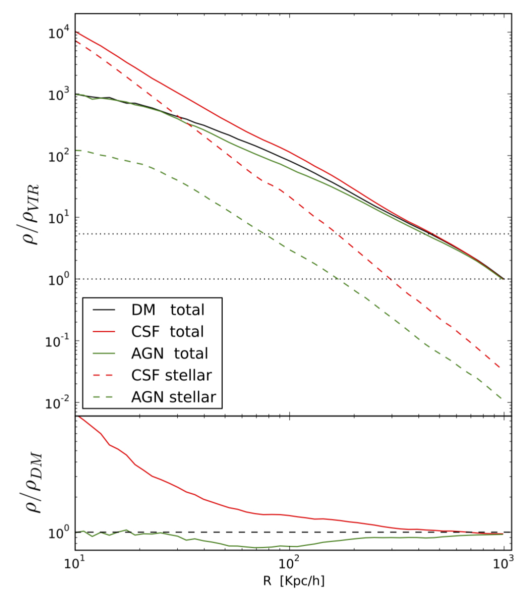


Single halo check



AGN

Density profiles



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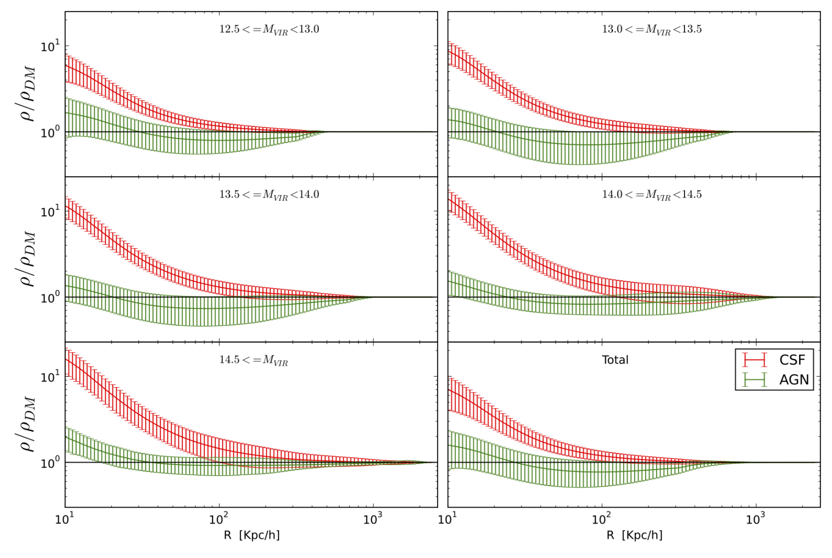
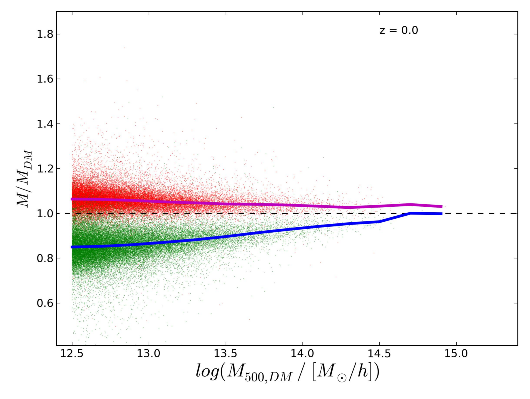


Same Radius

We apply the same radius from DM halos to the matched AGN and CSF halos.



Summary

Summary:

1. CSF set have more effects on FoF halo mass function, which shift up from $\sim 10\%$ at redshift $z = 0$ to $\sim 50\%$ at $z = 2.2$ with slightly halo mass evolution compared to DM set. While almost no redshift evolution for AGN set, and its halo mass function $\sim 10\%$ less than DM set at small halo mass, similar to DM set at larger halo mass.
2. For both CSF and AGN set, SO halo mass function have a larger difference at $\Delta_c = 2500$ ($\sim 40\%$ to $\sim 80\%$ more for CSF set, $\sim 30\%$ less for AGN set) and less difference at $\Delta_c = \mathrm{VIR}$ (almost no difference for CSF set, and $\sim 10\%$ less for AGN set) compared to DM set. The redshift evolution is also more clear with higher Δ_c.
3. It is obviously that the baryon effects have different behaviors on FoF and SO halo mass function.
4. From the density profiles difference, AGN feedback low the density profile a lot in center region, but they are still higher than DM halos', it also pushes the density down to several percent to $\sim 30\%$ lower than DM halos' at $R > 30[Kpc/h]$.