Exercise 7

1. DM halo mass function:

- Download the .list files containing data of a halo catalogue at z=0 (out_94), 1 (out_27), and 2 (out_44) from a DM-only simulation (size: $(72\text{Mpc/h})^3$, Planck cosmology, etc see header) in the following format:

  ID, DescID, **Mvir**, Vmax, Vrms, Rvir, Rs, Np… more columns

  Note: Mvir is in $M_\odot/h$

- Choose your preferred language (python, matlab etc) for data analysis and visualisation (of ascii files)
  1. Select halos with masses > $3*10^{10}$ $M_\odot/h$ at z=0,1,2 (why is this important?)
  2. Plot their *halo mass function*: number density, i.e. amount of halos per unit volume, Mpc^3, versus halo mass at z=0,1,2
  3. How do you think the halo mass fct would qualitatively change when adopting a warm dark matter cosmology? Explain your thought.

Exercise 7

2. The build-up of galactic dark matter halos in a CDM universe:

Using merger tress for different halo masses in Selected_trees_*.dat, examine the DM halo mass assembly and answer these questions.

1. How do the mass assembly histories differ for 3 different z=0 halo masses (1e10, 1e12, 5e13 $M_\odot$) in a CDM universe?

BONUS EXERCISE: 2. How many major (1:1-1:4) and minor mergers (1:4-1:10) do occur at what cosmic time?

BONUS EXERCISE: 3. How different are assembly and formation times (see lecture) and how do they vary with halo mass? Can you give an explanation for your results?

Coding instructions:

- For each halo tree, follow the *main branch tree* until the highest redshift (look at the progenitors of a halo one time step earlier via "desc_id=id_halo" and choose the most massive one)
- Plot halo main progenitor mass versus redshift and/or scale factor for the different halo masses, indicate as vertical lines when major merger happens
- Plot formation/assembly times versus present-day halo mass

Note: if you are wondering how such plots look like, Maulbetsch+07 may help…

Information to Exercise

Details for the dark matter-only simulation

- WMAP7 cosmology adopted
- Boxsize: ~72 Mpc/h
- DM particle mass: 3.5e8 $M_\odot$
- Merger trees constructed by post-processing the simulation with the open-source code "Rockstar"

Information to Exercise

An example output file for Rockstar trees

Each row is one halo, columns are:

Scale factor of halo(0) halo ID(1) scale factor of descendent(2) halo ID of descendent (3) number of progenitors (4) viral mass(5)

(simplified compared to original Rockstar output)

1.0000	29882328	0.0000	-1	5	
0.9900	29584929	1.0000	29882328	4	Most massive prog.
0.9900	29584930	1.0000	29882328	1	
0.9900	29584932	1.0000	29882328	1	
0.9900	29584934	1.0000	29882328	1	
0.9900	29584935	1.0000	29882328	1	
0.9800	29281236	0.9900	29584929	4	Most massive prog.
0.9800	29281238	0.9900	29584929	1	
0.9800	29281239	0.9900	29584929	1	
0.9800	29281241	0.9900	29584929	1	
0.9800	29281243	0.9900	29584930	1	