Numerical Galaxy Formation and Cosmology

Lecture/Exercise 7 - 1st Example - part 2: Analysing a cosmological simulation

---

Ewald Puchwein & Benjamin Moster

Performing a cosmological simulation with Gadget-2

- main steps for creating initial conditions (last week):
  - compile initial condition code (e.g. N-GenIC)
  - set parameters for initial condition code
  - create initial condition files
- main steps for running the simulations (last week):
  - compile simulation code (e.g. Gadget-2)
  - set parameters for the simulation code
  - run simulation
- **read simulation output and perform analysis (today)**

Analysing a cosmological simulation

- examples of post-processing / analysis tasks for DM simulations:
  - halo / sub-halo finding (e.g. with the Rockstar code)
  - halo mass functions
  - creating maps / images
  - halo profiles
  - halo shapes
  - filaments and voids
  - predictions for dark matter detection signals

Analysing a cosmological simulation

- examples of post-processing / analysis tasks for DM simulations:
  - halo / sub-halo finding (e.g. with the Rockstar code)
  - halo mass functions
  - creating maps / images
  - halo profiles
  - halo shapes
  - filaments and voids
  - predictions for dark matter detection signals

Halo / subhalo finding

- Rockstar code (by Behroozi et al.)
  - starts with FoF group finder
  - decomposes FoF groups into halos and subhalos in 6D position/ velocity phase space
  - removes unbound particles
- installing Rockstar:

```
git clone https://bitbucket.org/gfcstanford/rockstar.git

cd rockstar

make
```

Halo / subhalo finding

- the parameter file for Rockstar (change compared to quickstart.cfg)
  - specify force resolution, for our 32^3 run with 0.05 Mpc/h softening

    FORCE_RES = 0.001 -> FORCE_RES = 0.05
- run Rockstar:

```
./rockstar -c quickstart.cfg ../Gadget-2.0.7/sim/snap_005
```

- Rockstar produces halo catalog:

  -> halos_0.0.ascii

HMFcalc

- for comparison we get an approximate Tinker et al. 2008 mass function for our cosmology from

  http://hmf.icrar.org/

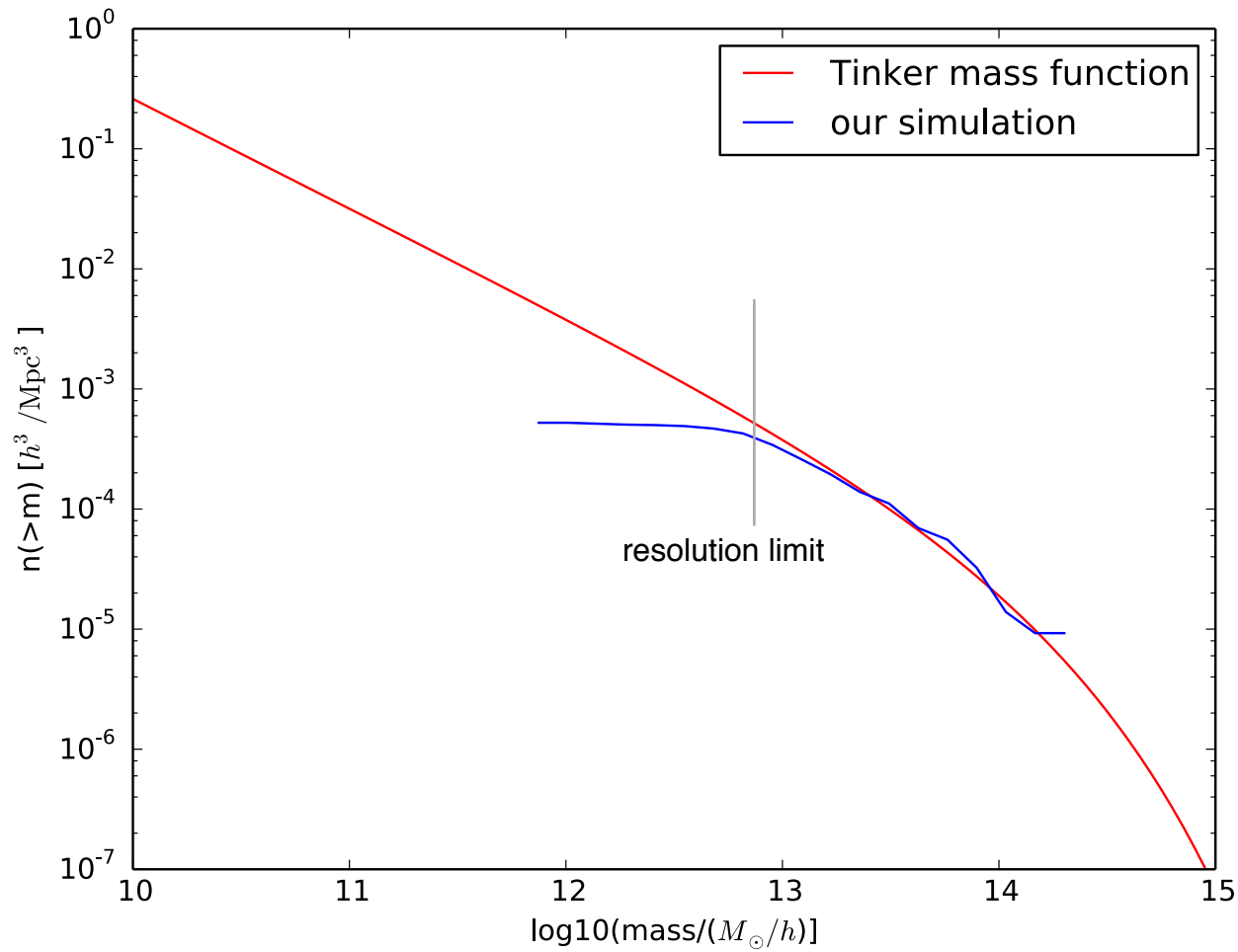
- select overdensity with respect to “Critical density” and “Tinker (2008)” mass function
- select same cosmological parameters as in N-GenIC / Gadget2 (also Eisenstein & Hu spectrum, n_s=1)
- compute the halo mass function and download the data files

Comparing our simulations to the Tinker mass function

- have a look at plot_mass_func.py

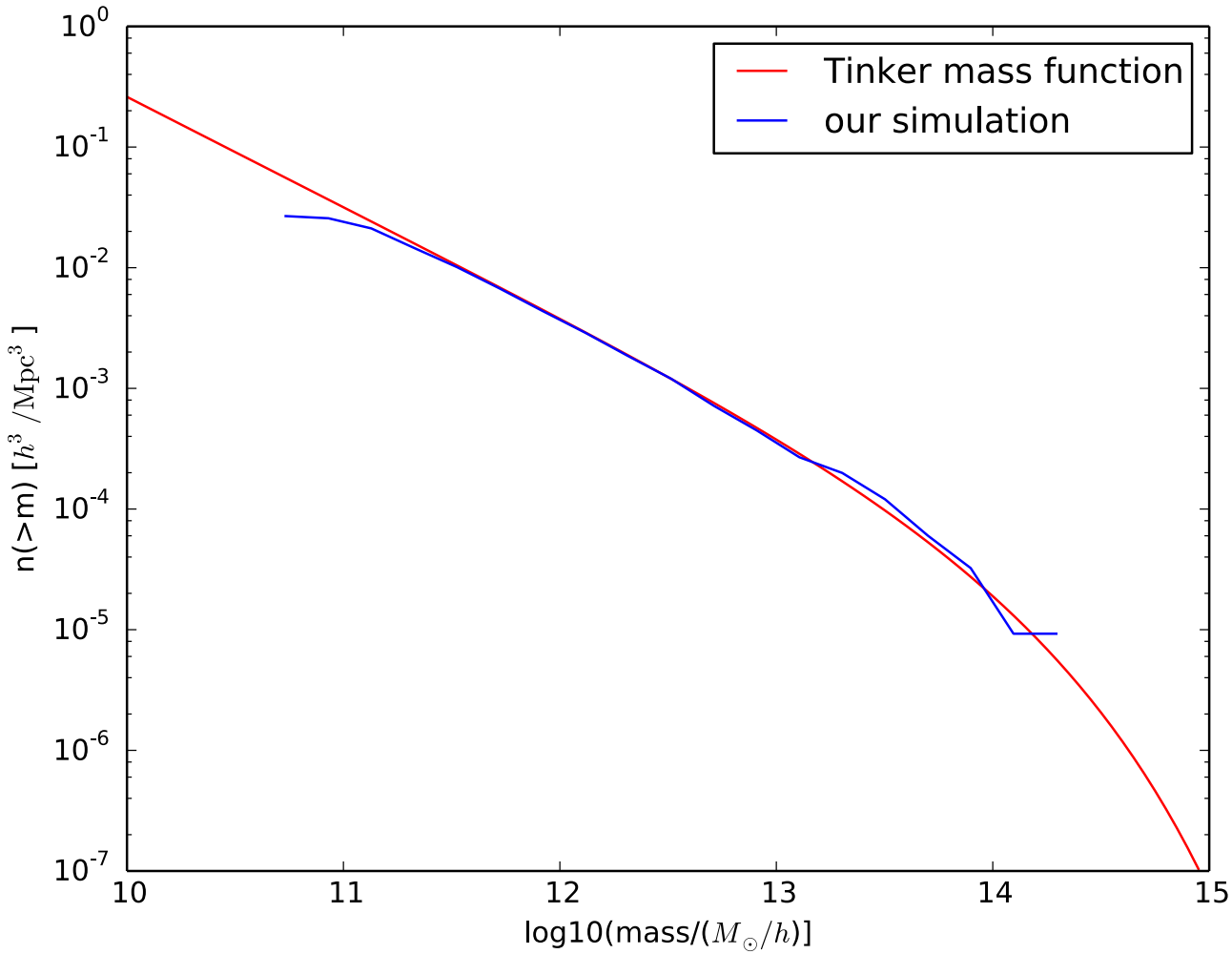
Comparing our simulations to the Tinker mass function

- have a look at plot_mass_func.py



Comparing our simulations to the Tinker mass function

- at somewhat higher resolution 128^3 particles



Plotting particle and halo positions

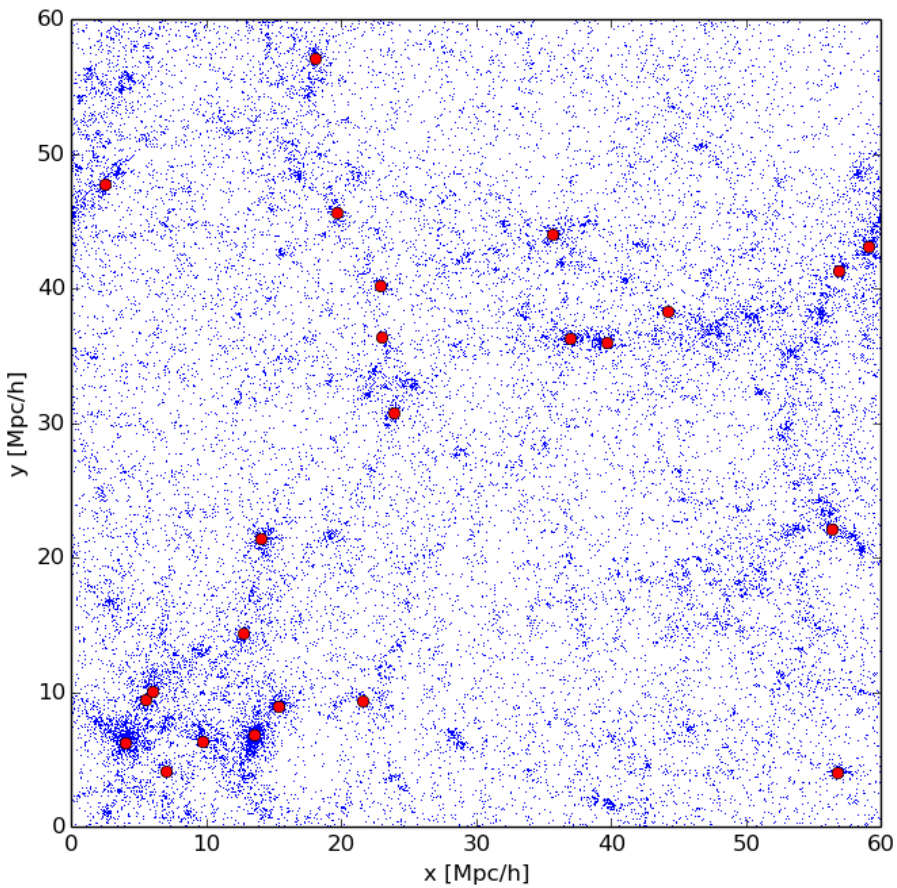
- next we plot the particle and halo positions
- you can use readsnap.py to read the Gadget snapshot files
- have a look at plot_particles.py

get Python sample files form:
http://www.ast.cam.ac.uk/~puchwein/postprocess.zip

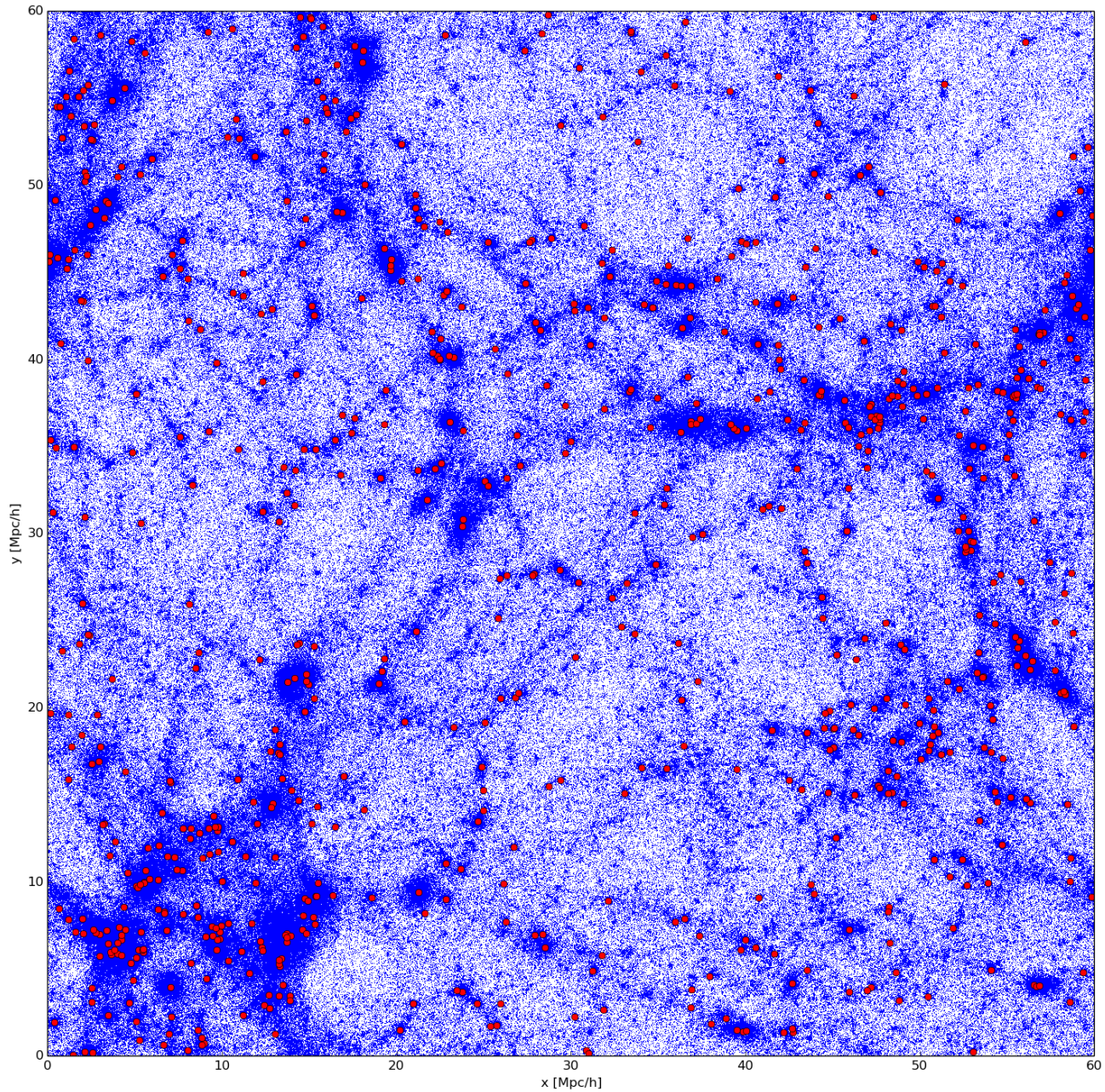
Plotting particle and halo positions

- next we plot the particle and halo positions
- you can use readsnap.py to read the Gadget snapshot files
- have a look at plot_particles.py

get Python sample files form:
http://www.ast.cam.ac.uk/~puchwein/postprocess.zip



at slightly higher resolution
128^3 particles



Literature & Outlook

- “The ROCKSTAR Phase-space Temporal Halo Finder and the Velocity Offsets of Cluster Cores”, Behroozi et al., 2013, ApJ, 762, 109, arXiv: 1110.4372

- “ HMFcalc: An Online Tool for Calculating Dark Matter Halo Mass Functions”, Murray et al. 2013, arXiv: 1306.6721