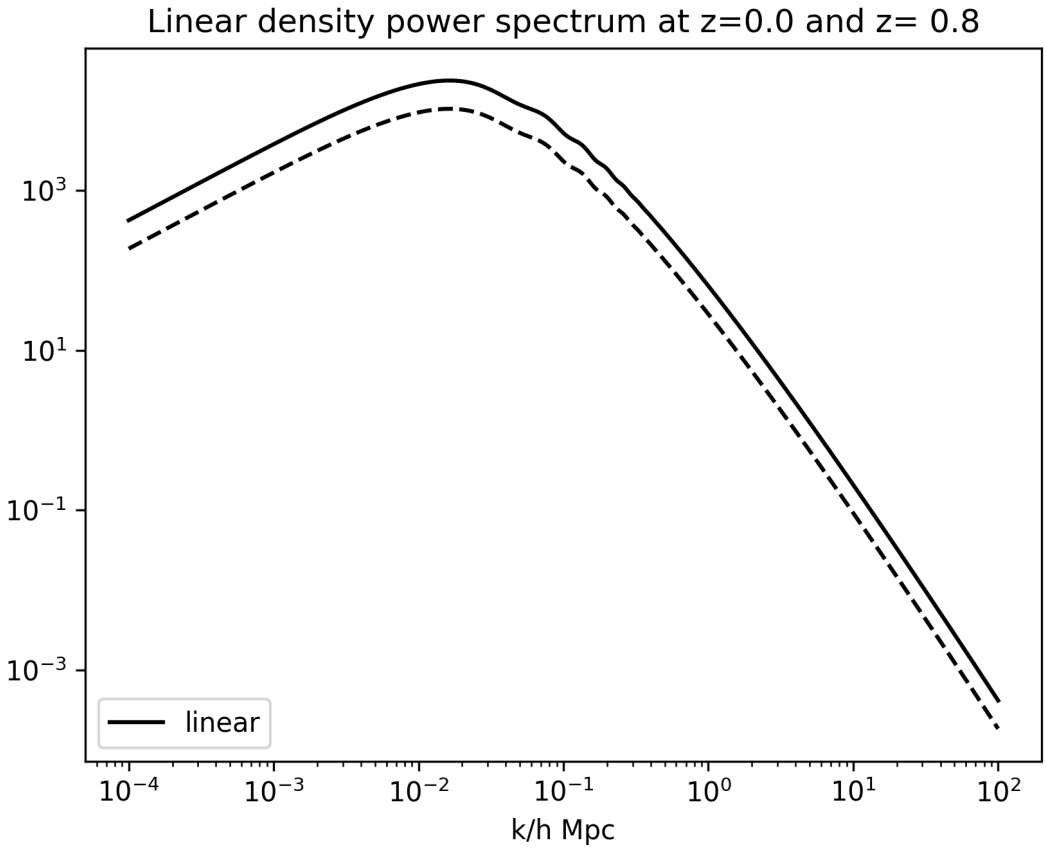
Mid Exam: Topics in Cosmology

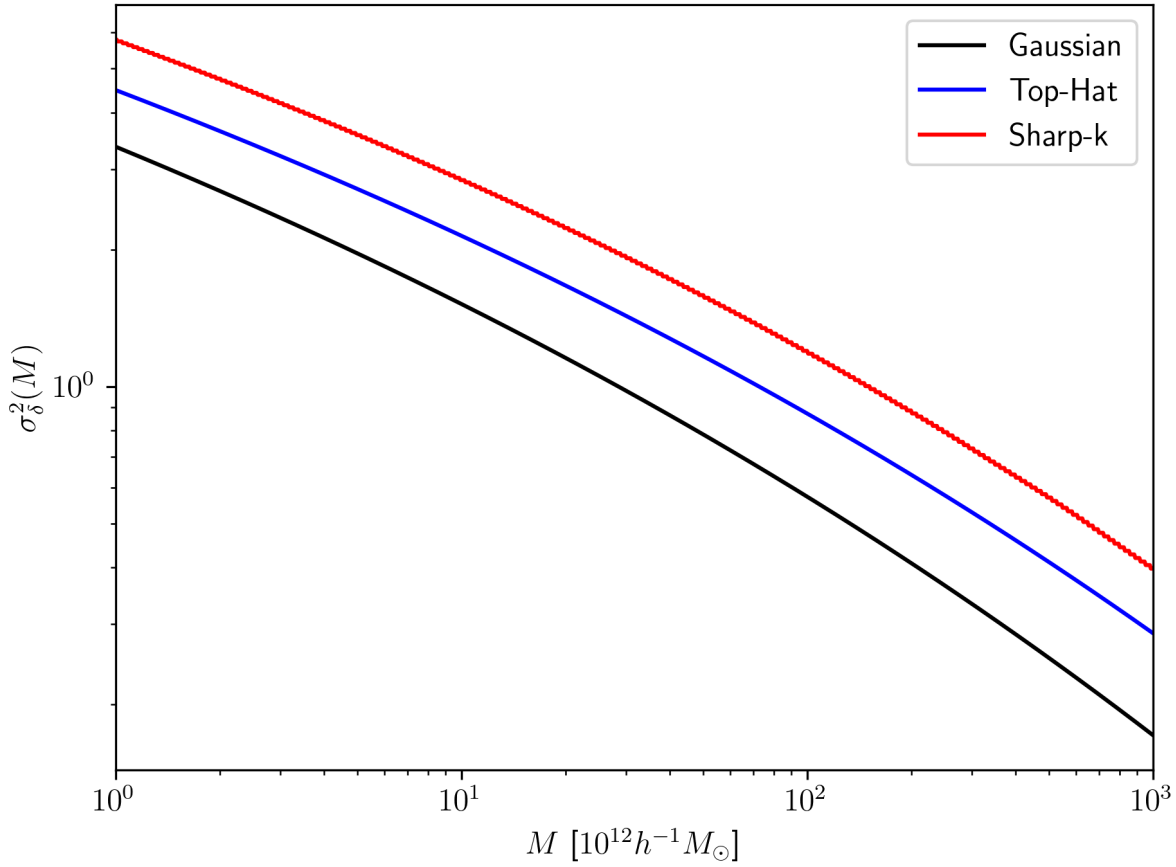
Made by Lenskiy Vladislav. 26/05/2022

Problem 1

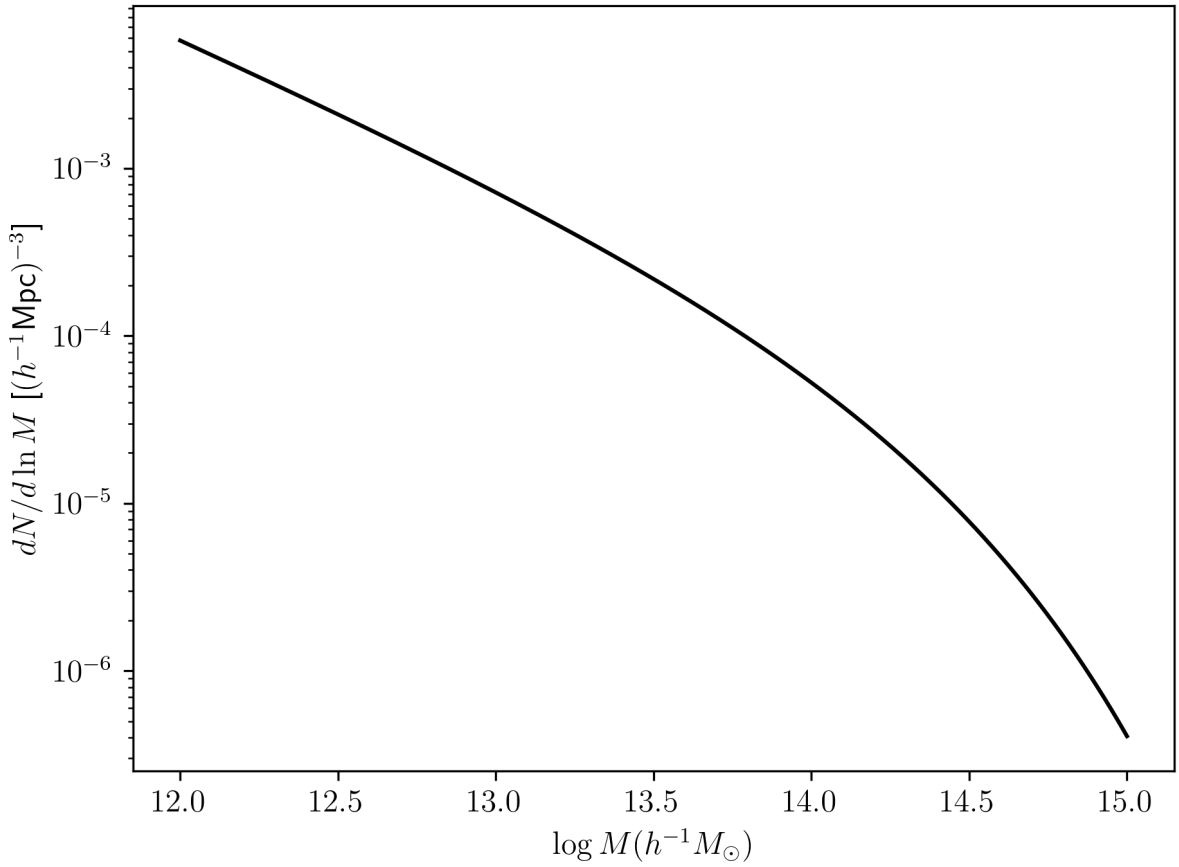
(a) Using the Python Libraries: CAMB, NumPy, MatplotLib and AstroPy I've plotted the linear density power for redshifts = 0 (solid line) and 0,8 (dotted line). The amplitude was changed to be normalized by σ_8



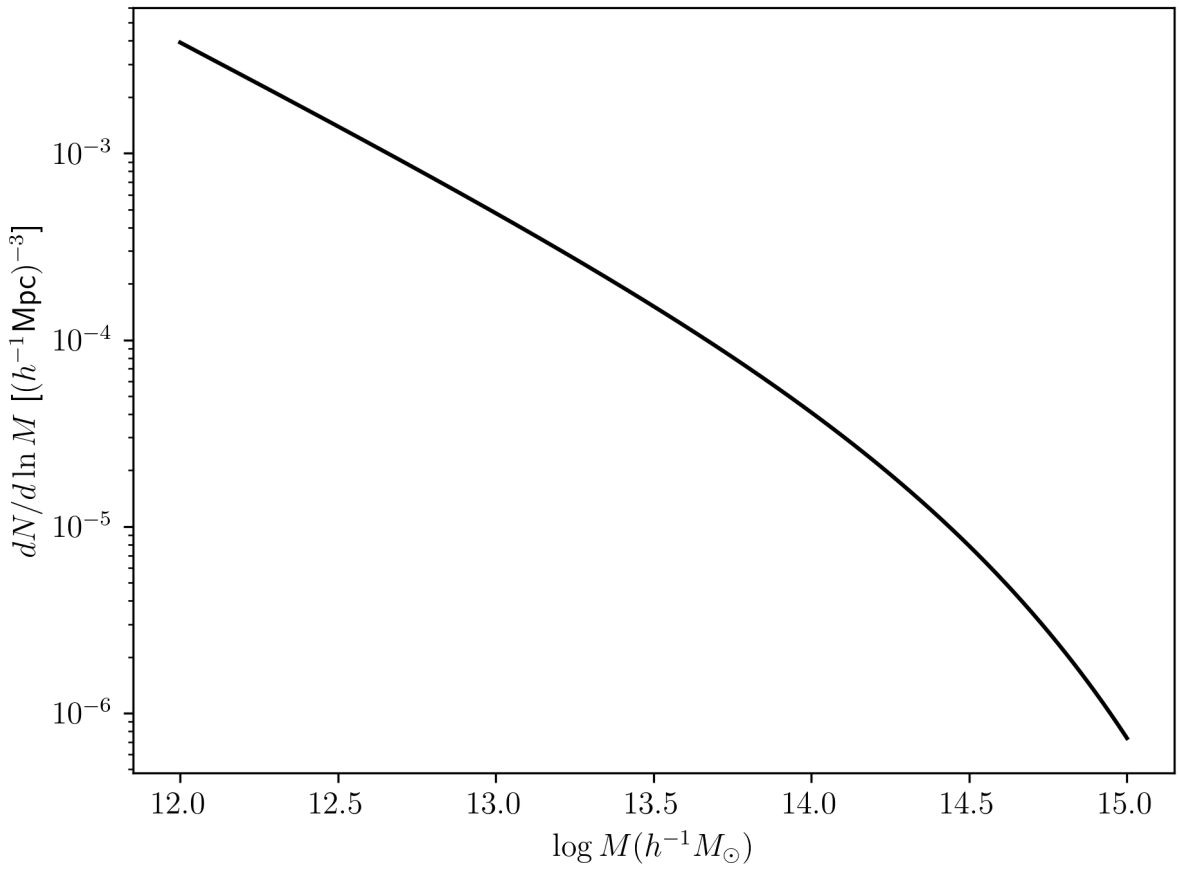
(b) Applying three handmade filters: Top-Hat,Gaussian and Sharp-k, to the linear density power spectrum and integrating, I've plotted the linear density variance as a function of M at $z=0$.



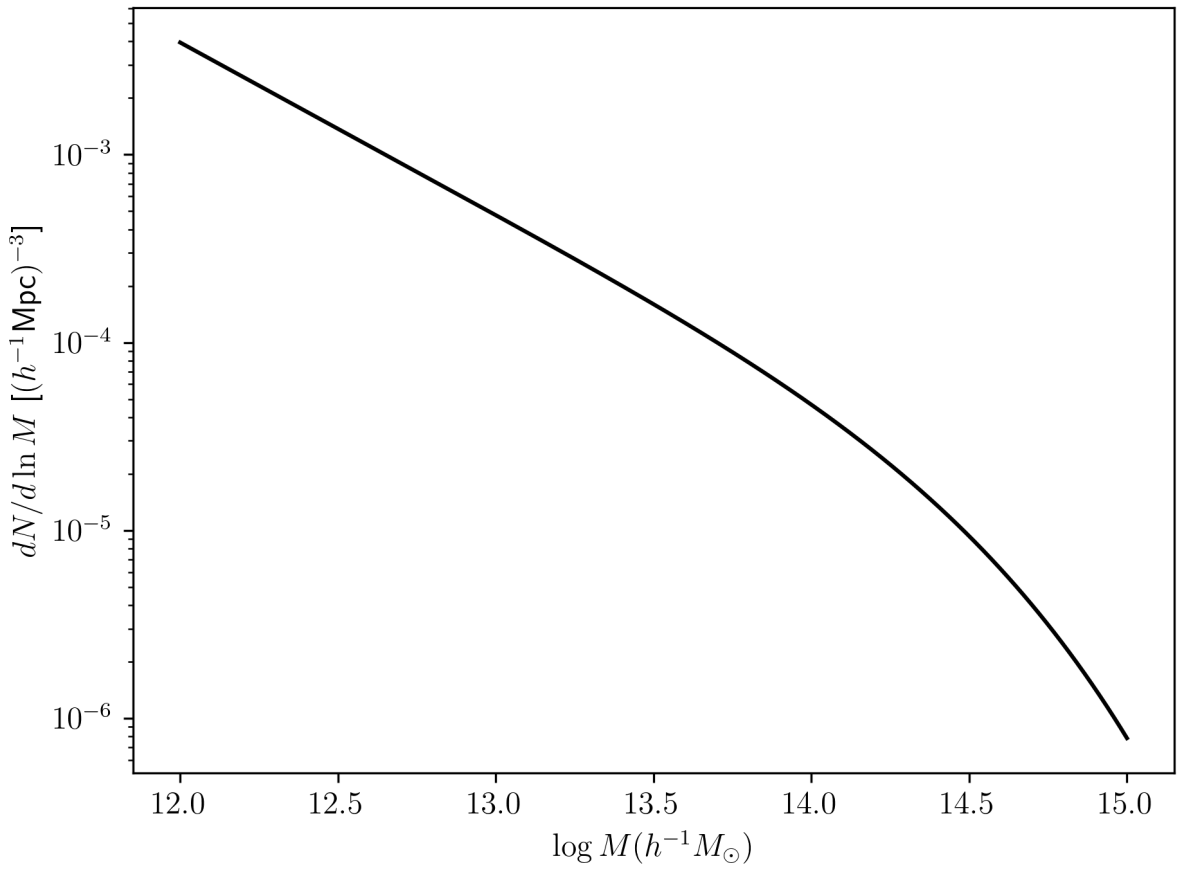
(c) Using obtained density variance I have computed the Press-Schechter mass function with normalization factor = 2, at z=0



(d) same for the Sheth-Tormen mass function

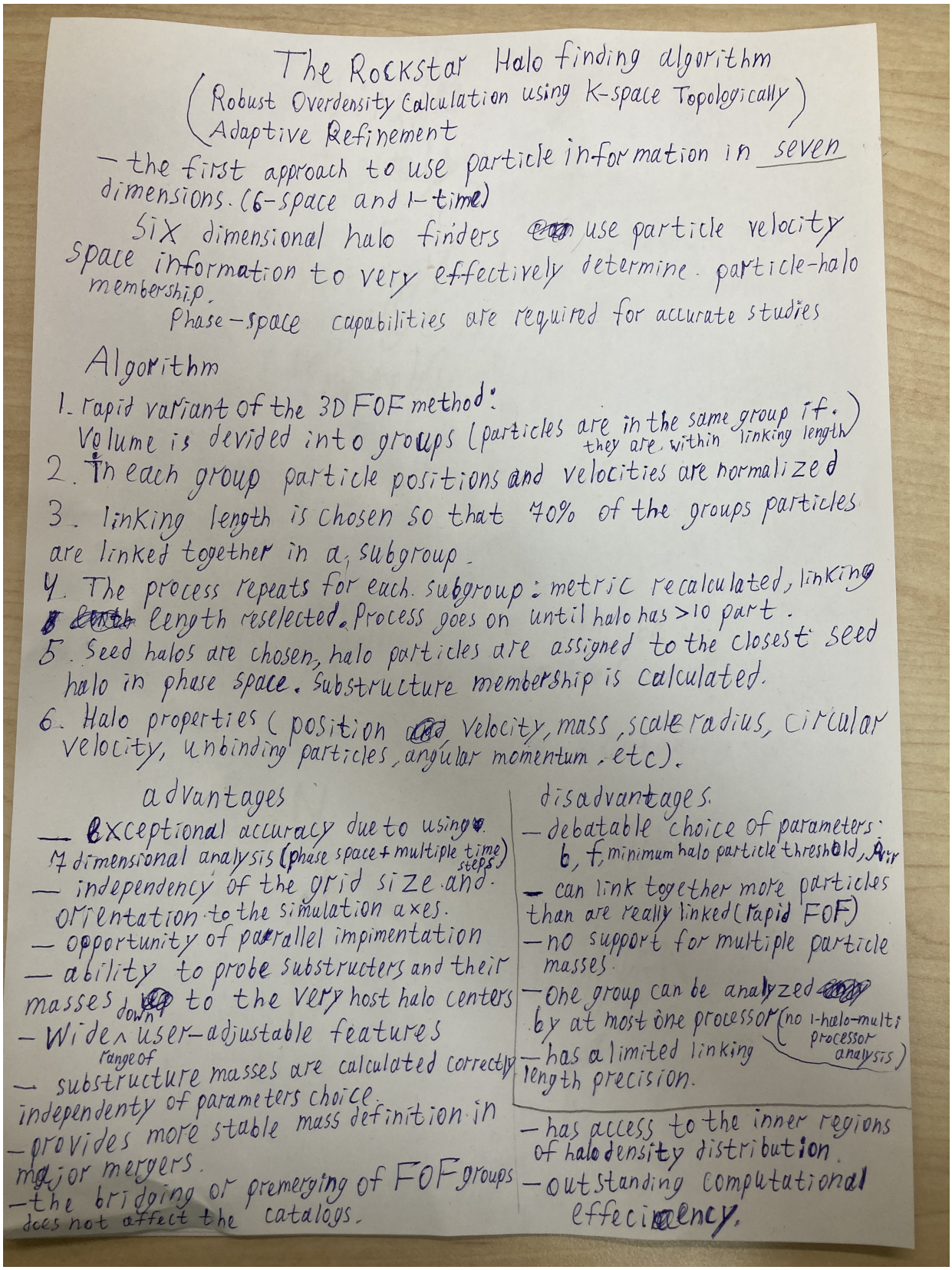


(e) and the Jenkins mass function



Problem 2

Studying the paper "THE ROCKSTAR PHASE-SPACE TEMPORAL HALO FINDER AND THE VELOCITY OFFSETS OF CLUSTER CORES" (Behroozi, P. S., et.al. 2013) I have composed a summary of the "Rockstar" algorithm, highlighting its pros, cons and differences from the FOF and SO halo finders.



The Rockstar Halo finding algorithm
(Robust Overdensity Calculation using K-space Topologically Adaptive Refinement)

– the first approach to use particle information in seven dimensions. (6-space and 1-time)

Six dimensional halo finders use particle velocity space information to very effectively determine particle-halo membership.

Phase-space capabilities are required for accurate studies

Algorithm

1. rapid variant of the 3D FOF method: Volume is devided into groups (particles are in the same group if they are within linking length)
2. In each group particle positions and velocities are normalized
3. linking length is chosen so that 70% of the groups particles are linked together in a subgroup.
4. The process repeats for each subgroup: metric recalculated, linking length reselected. Process goes on until halo has >10 part.
5. Seed halos are chosen, halo particles are assigned to the closest seed halo in phase space. Substructure membership is calculated.
6. Halo properties (position, velocity, mass, scale radius, circular velocity, unbinding particles, angular momentum, etc).

advantages

– Exceptional accuracy due to using 7 dimensional analysis (phase space + multiple time steps)
– independency of the grid size and orientation to the simulation axes.
– opportunity of parallel impimentation
– ability to probe substructers and their masses down to the very host halo centers
– Wide range of user-adjustable features
– substructure masses are calculated correctly independenty of parameters choice.
– provides more stable mass definition in major mergers.
– the bridging or premerging of FOF groups does not affect the catalogs.

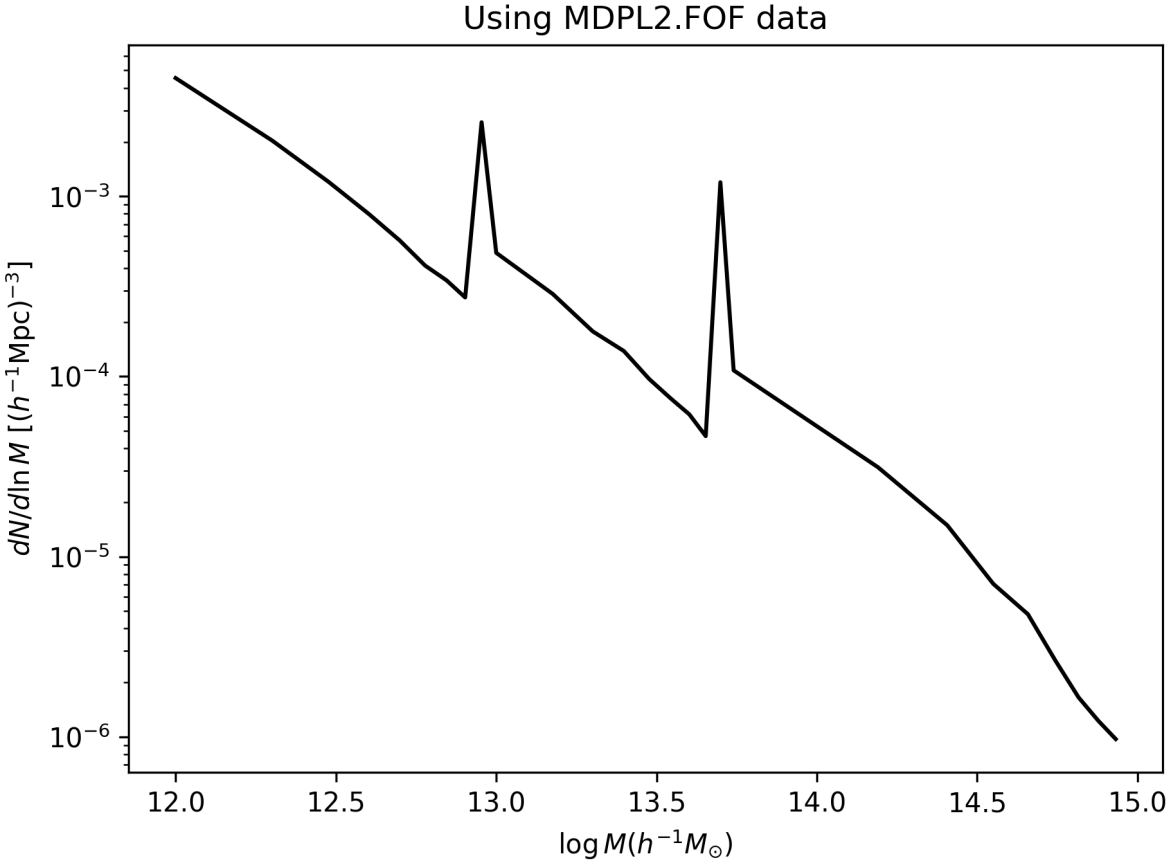
disadvantages.

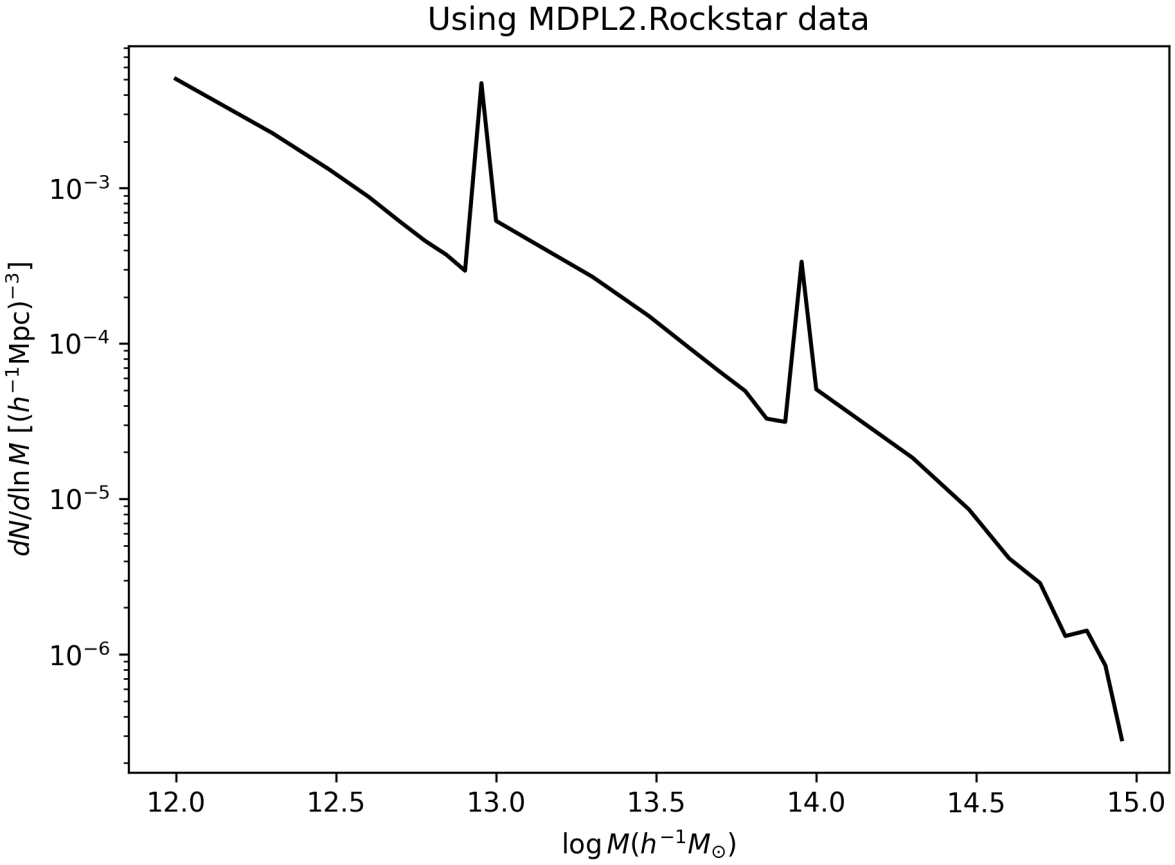
– debatable choice of parameters: b, f, minimum halo particle threshold, A_{vir}
– can link together more particles than are really linked (rapid FOF)
– no support for multiple particle masses.
– One group can be analyzed by at most one processor (no 1-halo-multi processor analysis)
– has a limited linking length precision.
– has access to the inner regions of halo density distribution.
– outstanding computational effeciency.

Problem 3

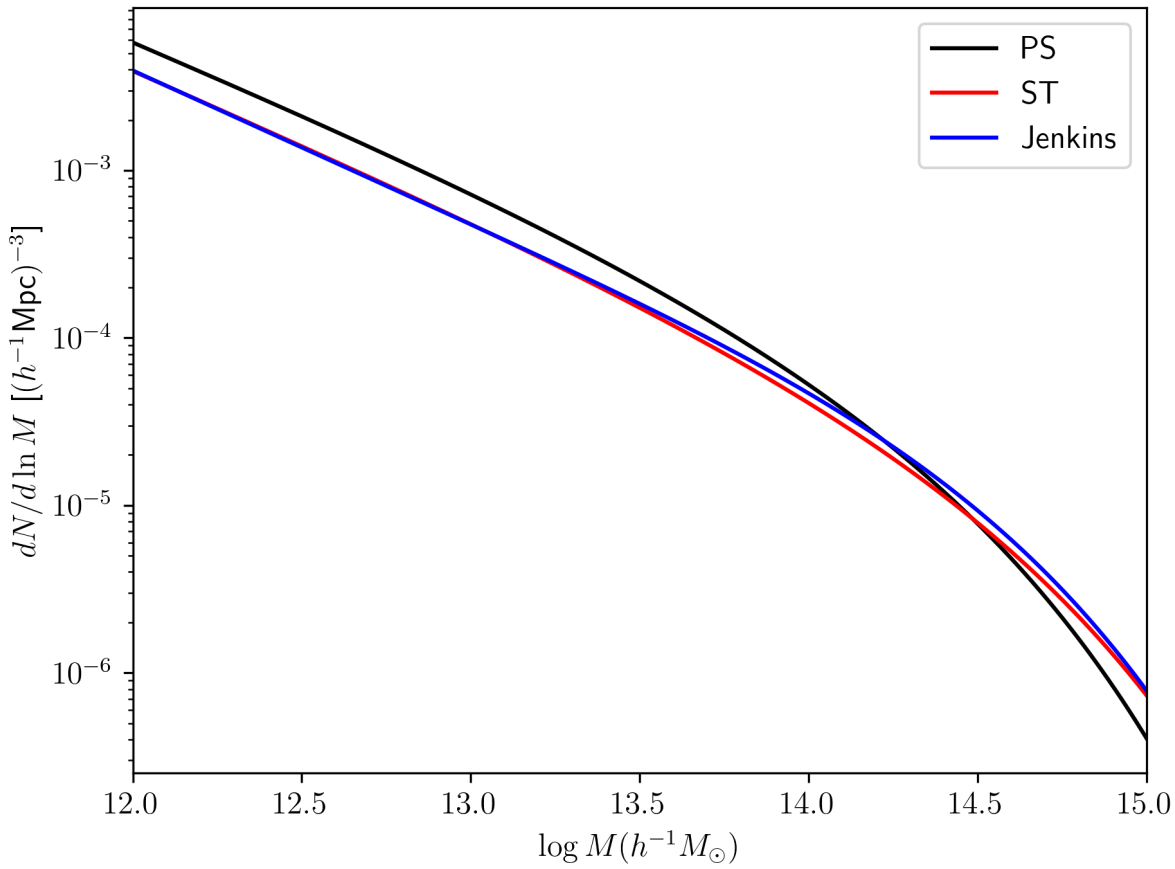
Inspecting the FOF and Rockstar halo catalogs from MDLP2 simulation, I have created graphs for the mass function.

Spikes on the pictures occurred due to the attempt to reduce computational costs(since my computer is not very powerful) and imperfection of programming skills. Actually they represent the change of mass step scale.





Below, for the purpose of comparison, is the combined graph of functions from exercise 1(c,d,e).



The graphs show general similarity. Nevertheless on the large mass scale FOF graph looks smoother.

I believe that it is caused by the better accuracy of Rockstar procedure, that gives more precise and therefore steep results.(FOF includes only not intersecting halos)