Exercise 5: Analysis of Cosmological Simulations

handed out: 18.12.2007 handing in: 15.01.2008

Problem 10: `AMIGA's-Halo-Finder` (`AHF`)

The goal is to analyse those simulations produced as part of problem #9. You should use the publicly available halo finder `AHF` to locate dark matter haloes in those runs and study their properties.

1. Use `AHF` to locate haloes in both the CDM and WDM runs. Please not the following things: a) the halo finder should only take a couple of minutes at most b) the output files may be empty in case there were no haloes found.

   For the time being we simply focus on the `[...]_halos` files. The first column in this file gives the number of particles in a halo, the third, fourth and fifth column are the position in Mpc/h.

   Overplot the simulation and the positions of the halos.

   Tip: the little shell scripts `makeinput.sh` scans a specified directory for `AMIGA` output files and generates the necessary input files for `AHF`. `runAHFstep.sh` further works its way through all input files automatically.

   (7 points)

2. How many haloes are there? Generate a plot that shows the number of haloes as a function of redshift. Are there differences between CDM and WDM?

   Tip: the UNIX command `wc -l [file]` counts the number of lines in a given file. Feel free to use the tiny shell script `halonumber.sh` for this task.

   (7 points)

3. Investigate the three most massive haloes in more detail at redshift $z = 0$. Generate plots that show the mass profile, density profile (on a logarithmic scale) as well as the rotation curve. For this task you need the information written to `[...]_profiles`.

   (6 points)

AHF primer

AHF is part of the package AMIGA but (possibly) requires some changes in the Makefile to be created successfully. In Layman's terms, AHF locates peaks in the density distribution and checks for gravitationally bound particles orbiting about those peaks. All these bound particles constitute the halo whose properties are determined by AHF, too.

- **compilation**

  - `make clean`

  - edit `Makefile` (the only `DEFINEFLAG` should be `-DSTANDARD`)

  - compile via `make AHFstep`

  - you will find the executable binary in `bin/`

- **execution**

  The code requires an input file akin to the one used for the simulation itself. As a matter of fact, simulations run with AMIGA require no change to the input file at all! However, you will always need to specify the actual name of the file to be analysed and hence need an input for for every redshift; the little script `makeinput.sh` helps you in that regards.

  You should execute the code via `bin/AHFstep < [inputfile]`

  Note that you need to execute this command for every `[inputfile]` and hence check the script `runAHFstep.sh` that automates this process for you.

- **output**

  AHF writes several output files of which only two are of concern to you:

  `[...]_halos` contains information about integral properties of the haloes, i.e. number of particles, mass, position, velocity, etc. There is one line per halo and they are ordered according to mass (highest mass first).

  `[...]_profiles` contains information about the spherically averaged radial profiles of certain properties. The relevant information for you is contained in the columns:

  1 = radius (in kpc/h!)
  2 = number of particles within that radius (= mass profile)
  5 = density
  6 = rotational velocity