Simulation Description

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1 Simulation Description

We have used the data from a large N-body cosmological simulation dubbed `Multidark`. The data is available to the public through a database interface first presented by Riebe et al. [2011].

Here we summarize the main characteristics in the simulations. More details can be found in Prada et al. [2012]. The simulation was run using an Adaptive-Mesh Refinement (AMR) code called ART. Details about the technical aspects and comparisons with other N-body codes are given in Klypin et al. [2009].

The simulations follows the non-linear evolution of a dark matter density field sampled with 2048^3 particles in a volume of $1000h^{-1}$Mpc . The physical resolution of the simulation is almost constant in time $\sim 7h^{-1}$kpc between redshifts $z = 0 - 8$. The cosmological parameters in the simulation are $\Omega_m = 0.27$, $\Omega_\Lambda = 0.73$, $n_s = 0.95$, $h = 0.70$ and $\sigma_8 = 0.82$ for the matter density, dark energy density, slope of the matter fluctuations, the Hubble constant at $z = 0$ in units of 100km s^{-1} Mpc^{-1} and the normalization of the power spectrum, respectively. With these characteristics the mass per simulation particle is $m_p = 8.63\times10^9 h^{-1}\mathrm{M}_\odot$, which means that group-like halos of masses $\sim 10^{13}h^{-1}\mathrm{M}_\odot$are sampled with at least 1100 particles.

Dark matter halos are identifyed using a Bound-Density-Maxima algorithm (BDM). The code finds density maxima in spherical regions. For each maxima the code estimates the radius that encloses an specified value for the density

The halos we have used take define the spherical regions that enclose within a radius R_{200} an average density $\Delta = 200$ times larger than the critical density of the Universe, ρ_{cr}. This allows the code to relate the radius R_{200} and the enclosed mass M_{200} as follows:

$$M_{200} = \frac{4\pi}{3}\Delta\rho_{\mathrm{cr}}(z)R^3 \tag{1}$$

1.1 Concentration Estimates

The estimation for the concentration values is done using an analytical property of the NFW profile that relates the circcular velocity at the virial radius:

$$V_{200} = \left(\frac{GM_{200}}{R_{200}} \right)^{1/2}, \tag{2}$$

with the maximum circular velocity

$$V_{\max}^2 = \max \left[\frac{GM(< r)}{r} \right]. \tag{3}$$

The $V_{\max}/V_{200}$ velocity ratio is used to determine the halo concentration, c, by using the following relation [Klypin et al., 2011]:

$$\frac{V_{\max}}{V_{200}} = \left(\frac{0.216c}{c} \right)^{1/2} \tag{4}$$

where $f(c)$ is

$$f(x) = \ln(1+c) - \frac{c}{(1+c)}. \tag{5}$$

For each BDM overdensity the $V_{\max}/V_{200}$ ratio in order to find the concentration c by solving numerically the previous two equations.

This method provides a much robust estimate of the concentration compared to a radial fitting to the NFW profile which is strongly dependent on the radial range used for the fit [Klypin et al., 2011, Meneghetti and Rasia, 2013]. Comparison of these two methods to using halos where the NFW functional fit is robust yield a small systematic offset of $(5-15)\%$, with the concentration derived by the velocity ratio method being higher [Prada et al., 2012].

References

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