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研究課題名

The Mass Function of Dark Halos at High Redshifts

利用者氏名 (所属機関)
Sze-Ting Chan

利用カテゴリ　XT4A 汎用 PC

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1 Introduction

We study the mass function of dark matter halos in the standard Λ Cold Dark Matter model. We perform 100 cosmological N-body simulations with 1024^3 particles for the latest fifth-year WMAP cosmology. The unprecedentedly large set of data allows us to determine accurately the mass function of dark matter halos down to the mass scale of $\sim 10^8 M_\odot$ and at high redshifts of $z = 6 - 20$. Predicted mass functions of several well-known analytical models are compared with our results, and the universality of the mass function is investigated.

2 Simulation

We adopt the latest WMAP5 cosmological parameters (Komatsu et al. 2008) : matter density $\Omega_m = 0.274$, baryon density $\Omega_b = 0.046$, dark energy density $\Omega_\Lambda = 0.726$ with equation of state parameter $w = -1$, spectral index $n_s = 0.96$, and the Hubble constant $h = 0.705$ in units of $100\mathrm{kms}^{-1}\mathrm{Mpc}^{-1}$ (Komatsu et al. 2009). We generate the initial conditions following the standard Zel'dovich approximation (Zel'dovich 1970). All the simulations are started at z=600 from "glass" initial conditions (Baugh et al.1995; White 1996), and are evolved until z=6. A high initial redshift of 600 is chosen to avoid significant suppression of halo formation due to late start of the simulations(Lukic et al. 2007). The box size is set to be $40h^{-1}$Mpc in which 1024^3 dark matter particles are sampled. In order to minimize the sample variance of the halo mass function at high-mass end, a total of 100 realizations using the same set of parameters have been performed. The dark matter simulations are carried out with the parallel Tree-Particle-Mesh code L-GADGET2 (Springel 2005) Haloes with as few as 20 particles can be robustly identified by FOF. Our particle mass is $4.5 \times 10^6 h^{-1} M_\odot$, allowing us to resolve halos down to $9.1 \times 10^7 h^{-1} M_\odot$ with 20 particles.

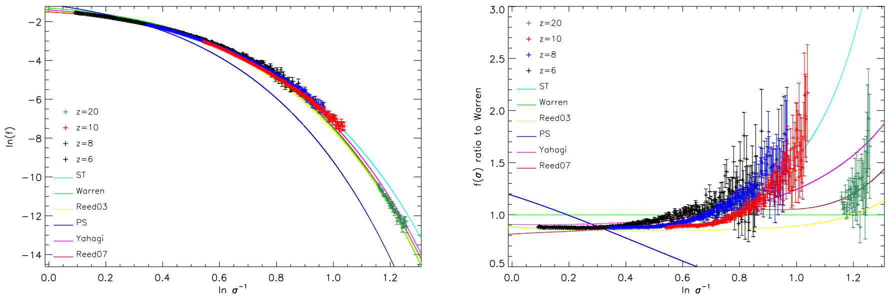

図 1: The simulated mass function and its ratio to the Warren fit, plotted in the universal form for our z=6,8,10,20 outputs.

3 Universality of the Mass Function

To investigate the universality of the mass function first found by Jenkins, we combine our results from $z = 6, 8, 10, 20$ and plot them on the $f - \ln\sigma^{-1}$ plane as shown in Fig.1. If the universality holds, the mass function is expected to lie on one single curve independent of redshifts. The left panel of Fig.1 shows that our data from various redshifts lie roughly on top of each other in a single form. On closer inspection, however, the plot of the ratio of $f(\sigma)$ to the Warren fit in the right panel of Fig.1 shows that our simulated mass function from different redshifts do not coincide on a single curve. This deviation from the universal form demonstrates that the mass function's universality is inconsistent with our simulation data. The violation of the universality is small, but could be significant if a high level of accuracy is demanded.