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ANALYTICAL EXPRESSION FOR THE PRESS-SCHECHTER HALO DENSITY PROFILE

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We present the density profile of dark matter halos derived from the Modified Press-Schechter (MPS) model and compare it with those drawn from N-body simulations.

Navarro, Frenk & White (1997, NFW) found that the spherically averaged density profiles of halos from N-body simulations of hierarchical cosmologies can be fitted by a simple analytical expression which depends on a single parameter: the scale radius, r_s, or, equivalently, the halo concentration, $c \equiv R/r_s$ (with R the virial radius enclosing a mean halo density equal to 200 times the cosmic critical density). c is always a decreasing function of the halo mass M, the specific form depending on cosmology. Although these results have been confirmed by other authors, the origin of the profile remains unexplained.

We use the MPS model (see Raig et al. 2001 and references therein) to derive the structure of halos in any hierarchical cosmology. The advantage of this model is that it allows the discrimination between minor and major mergers through a fractional mass increase threshold. We consider that halos grow through an alternate sequence of major mergers and long periods of accretion. During accretion density profiles develop inside-out as in spherical secondary infall, while in major mergers the structure accommodates (through violent relaxation) to the boundary conditions imposed by accretion starting at that moment. The density profiles inferred in this framework are compared in Fig. 1 with those suggested by NFW. Three cosmologies are displayed: SCDM with (Ω_m, Ω_Λ, h, σ_8) = (1.0,0.0,0.5,0.63), ΛCDM with (0.25,0.75,0.75,1.3), and FPL, a $n = -1$ power-law power spectrum, with (1.0,0.0,0.5,1.0). As can be seen, the agreement between both profiles is good. In Fig. 2 we show that the z-dependence of the theoretical profile is also in good accordance with that drawn from the high-resolution N-body simulations of Bullock et al. (2001) in a ΛCDM cosmology with (0.3,0.7,0.7,1.0).

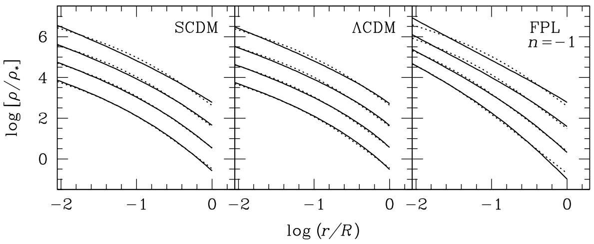

Fig. 1. Theoretical (full lines) and NFW (dotted lines) density profiles for halos at $z = 0$ with the masses $10^{-2} M_*$, $10^{-1} M_*$, M_*, and $10\ M_*$ (from bottom to top). M_* is the present collapsing mass, and ρ_* stands for $\rho_{\rm crit} M_*/M$.

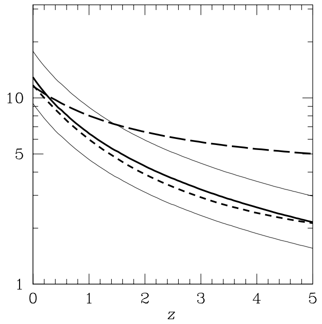

Fig. 2. Concentration vs. redshift for a fixed halo mass $M = 5.55 \times 10^{12}\ M_\odot$. Line codes are: function by Bullock et al. (2001) (solid) and its intrinsic 68 % spread (thin solid), our theoretical prediction (dashed) and the $c(z)$ dependence guessed by NFW (long-dashed)

These results give strong support to the validity of the density profile derived from the MPS model and the subsequent theoretical interpretation of the origin of the halo structure (see Manrique et al. 2002 and Salvador-Solé et al. 2002 for more details). We have also worked out an analytical expression for our theoretical profile as well as fitting formulas for its $c(M)$ relation, which are available as a FORTRAN subroutine from the authors upon request.

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