Formation of Galactic Halos in the Cold Dark Matter Universe : Computer Simulations

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We simulate the formation of structure on the galactic scale in the cold dark matter, $\Omega=1$ universe.

Numerical calculations are initiated at z=24 in a cube with a volume of 10^3 Mpc^3. Such large redshifts are necessary to capture galactic scale perturbations in the linear regime. Initial conditions are imprinted by deforming a 64^3 cubic lattice of particles so that the Fourier transform of its density has the power spectrum :

$$P(k)=Ak(1+\alpha k+\beta k^{3/2}+\gamma k^{2})^{-2}$$

where k is the wavenumber, $\alpha=1.71h^{-2}$Mpc., $\beta=9.0(h^{-2}Mpc.)^{3/2}$, $\gamma=1.0(h^{-1}Mpc.)^{1/2}$ and $A=4.63x10^{3}h^{-5}Mpc^{4}$. (Peebles 1982, Blumenthal et al 1984, Davis et al 1985). Dynamical evolution is then followed with an FFT cloud-in-cell code on a 64^3 mesh.

N-body simulations of spheres(radius=5Mpc.)cut out from the FFT cube are used to follow the nonlinear development of structure on galactic scales. The change over from the FFT code(resolution$\sim$250 kpc.)to the more accurate N-body code(softening radius$\sim$10 kpc,$\sim$6000 bodies)takes place at z=5.25. Their evolution is followed untill z=-0.2(h=1).

The particle distribution at z=0 exhibits a number of compact clumps. Their masses($\sim10^{12}M_{\odot}$)and their density($\sim$0.01 Mpc^{-3})are consistent with the inferred masses and number densities of galactic halos. When one selects only collapsed portions of these objects(relative density$\sim$160),they appear to be relatively compact(sizes$\sim$100-200 kpc.)and have rotation parameters (λ)in the range 0.01-0.15. When these clumps are identified with galactic halos, one concludes the about 80% of the matter remains outside. This result -- if confirmed by further simulations -- would be of importance for biased galaxy formation but it should be treated with caution at this stage.

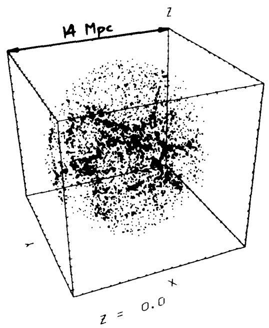

Fig: 1 The distribution of N-body particles at z=0.

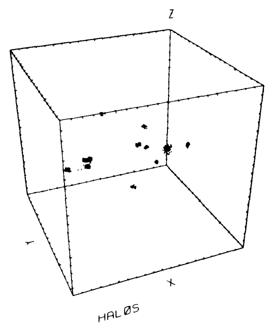

Fig: 2 The regions of figure 1 that have overdensity >160.

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