

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

P.J.Quinn, J.K.Salmon and W.H.Zurek
California Institute of Technology &
Los Alamos National Laboratory

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 10^3Mpc^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 :

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

where k is the wavenumber, $\alpha = 1.71 h^2 \text{Mpc}^{-1}$, $\beta = 9.0 (h^2 \text{Mpc}^{-1})^{3/2}$, $\gamma = 1.0 (h^2 \text{Mpc}^{-1})^{5/2}$ and $A = 4.63 \times 10^{-3} h^4 \text{Mpc}^4$. (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 = 5 Mpc) 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 ~ 250 kpc) to the more accurate N-body code (softening radius ~ 10 kpc, ~ 6000 bodies) takes place at $z = 5.25$. Their evolution is followed until $z = -0.2 (h=1)$.

The particle distribution at $z=0$ exhibits a number of compact clumps. Their masses ($\sim 10^{12} M_\odot$) and their density ($\sim 0.01 \text{Mpc}^{-3}$) are consistent with the inferred masses and number densities of galactic halos. When one selects only collapsed portions of these objects (relative density ~ 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 that 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.

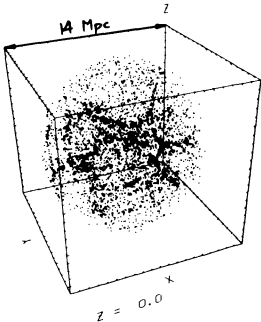


Fig: 1 The distribution of N-body particles at $z=0$.

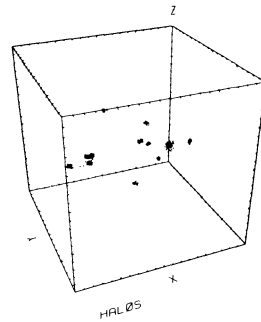


Fig: 2 The regions of figure 1 that have overdensity > 160 .

Blumenthal, G. R., Faber, S. M., Primack, J. R., Rees, M. J. 1984 *Nature* 311 517.
Davis, M., Efstathiou, G., Frenk, C. S., White, S. D. M. 1985 *Ap.J.* 292, 371.
Peebles, P. J. E. 1982 *Ap.J.* 258 415.