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The Spatial Correlation Properties of Dark Galaxy Halos in a CDM Universe

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We use the Hierarchical Particle Mesh (HPM) N-body code written by J. V. Villumsen (Villumsen, 1989) to investigate the two-point spatial correlation function, $\xi(r)$, of dark galaxy halos as a function of halo mass and local environment (*i.e.* high, low, or average mass density). We assume a standard cold dark matter (CDM) universe ($\Omega = 1$, $\Lambda = 0$, $H_0 = 50$, km/sec/Mpc). Because of the large dynamic ranges in mass and length that can be obtained with the HPM code, it is well-suited to an investigation of this sort.

If we define σ_8 to be the mass fluctuation in a sphere of $8h^{-1}$Mpc, then in a universe in which $1/\sigma_8 = 2.5$, high mass halos ($M_{\rm halo} \geq 9.8 \times 10^{12} M_\odot$) are more biased (relative to the mass) than low mass halos ($6.8 \times 10^{11} M_\odot \leq M_{\rm halo} \leq 3.3 \times 10^{12} M_\odot$) (Fig. 1). In a universe in which $1/\sigma_8 = 1.5$, high and low mass halos are biased to the same degree. If we define the epoch at which $1/\sigma_8 = 1.5$ to be "today", then from a redshift of ~ 0.7 to 0, $\xi(r)$ for low mass halos shows more evolution than $\xi(r)$ for high mass halos, but less than linear theory predicts (due to mergers of halos). If we assume that one luminous galaxy would reside in each of our dark matter halos and the mass to light ratio is a constant then, ignoring the possibility of luminosity evolution, we would expect $\xi(r)$ for faint galaxies to show more evolution with redshift than $\xi(r)$ for bright galaxies.

When compared to a fiducial correlation function that was computed without regard to environmental effects, $\xi(r)$ for halos in high density regions has a larger amplitude and is flatter than the fiducial correlation function, $\xi(r)$ for halos in average density regions is similar to the fiducial correlation function, and $\xi(r)$ for halos in low density regions has a smaller amplitude and steeper slope than the fiducial correlation function (Fig. 2). The fiducial correlation function of halos with overdensities ~ 2000 is completely dominated by halos in high density regions. This is not surprising because the formation of these objects is strongly biased toward high density regions (Brainerd and Villumsen, 1992). The fiducial correlation function of halos with overdensities ~ 200 and ~ 70 is dominated by halos in high density regions, but there is a contribution from halos in average density regions.

Ramella, Geller & Huchra (1992) have computed $\xi(r)$ for the galaxies in the "Great Wall" (Geller & Huchra, 1989) and find that $\xi(r)$ for the Great Wall galaxies is of the same form as that for the entire CfA survey, but has a correlation length roughly 3 times that of the entire survey ($r_{0,GW} \simeq 15h^{-1}$Mpc). We find that $\xi(r)$ for halos with overdensities ~ 200 is well-fit by a power law, $\xi(r) = (r/r_0)^{-\gamma}$, with $\gamma = 1.86$ and $r_0 = 3.5h^{-1}$Mpc, in rough agreement with the results of the CfA survey. The correlation length for the halos is short compared to the observed value for galaxies, which is likely due to an "overmerger" of halos in the simulations. Using the same normalization criteria as Ramella, Geller & Huchra, for $0.7h^{-1}\text{Mpc} \lesssim r \lesssim 3.3h^{-1}$Mpc we find $\xi(r)$ for halos with overdensities ~ 200 that reside in high density regions to be similar to $\xi(r)$ computed without regard to environmental effects and has an extrapolated correlation length roughly twice as large, in qualitative agreement with the result for the Great Wall galaxies.

References

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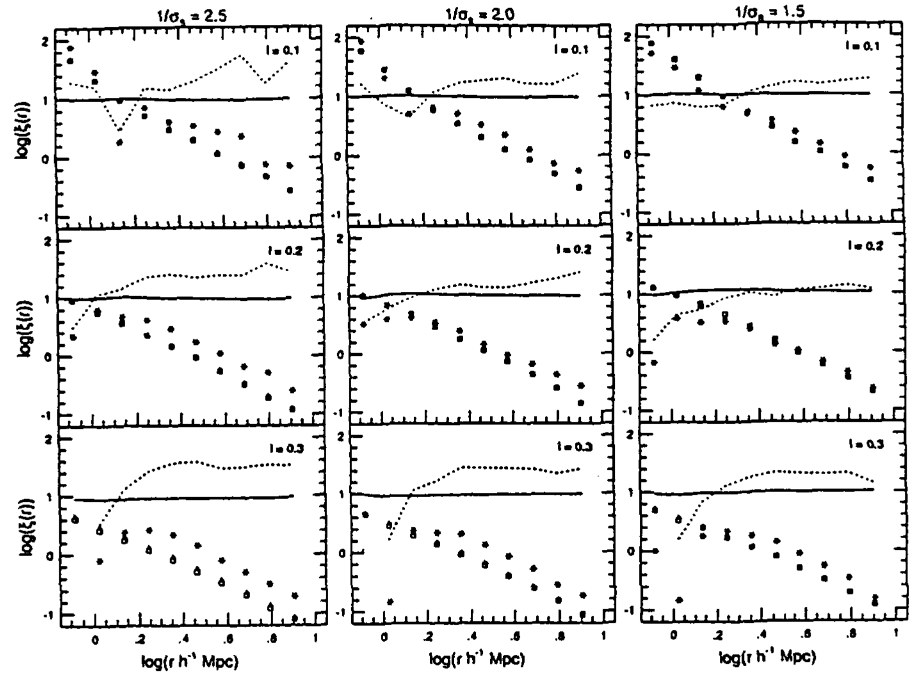

Figure 1: $\xi(r)$ for low mass halos (squares), high mass halos (asterisks), and all the halos (triangles) in the simulation at epochs corresponding to $1/\sigma_8 = 2.5, 2.0, 1.5$ for halos of overdensities ~ 2000 (l=0.1), ~ 200 (l=0.2) and ~ 70 (l=0.3). The square root of the ratio of $\xi(r)$ for the low (high) mass halos to that of $\xi(r)$ for all the halos is shown by a solid (dotted) line on a linear scale.

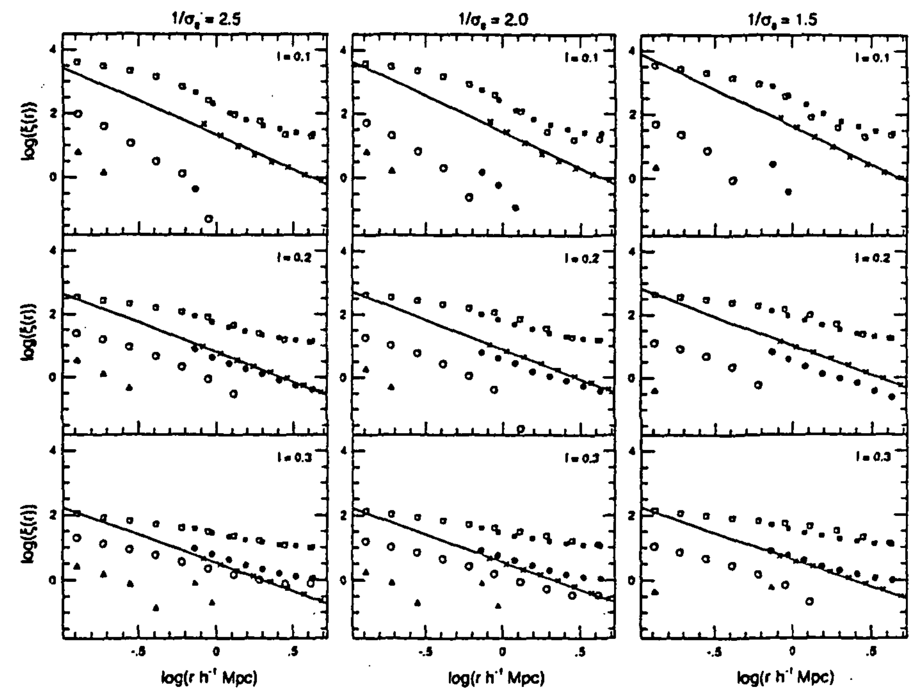

Figure 2: $\xi(r)$ for halos in high density regions (squares), average density regions (circles), and low density regions (triangles). Crosses show $\xi(r)$ for halos computed without regard to environmental effects, and the solid line is a power law fit to these "fiducial" correlation functions.