HIERARCHICAL CLUSTERING: ANGULAR MOMENTUM DENSITY ANTI-CORRELATION

Yehuda Hoffman
Department of Physics, University of Pennsylvania
Philadelphia, Pennsylvania 19104

The growth of angular momentum in a general clustering scenario is analyzed and its dependence on the primordial density perturbation, δ_o, is calculated. High density peaks are found to evolve into low angular momentum and low spin parameter ($\eta = J E^{\frac{1}{2}} G^{-1} M^{-5/2}$) systems. The basic mechanism behind this anti-correlation is that anisotropic structure, which leads to the growth of angular momentum, is statistically uncorrelated with δ_o. The collapse time, on the other hand, depends on δ_o and it is this time scale which determines the angular momentum of bound objects. Three cases are studied: (i) Lagrangian sphere (quasi-linear evolution): $J(1\sigma)/J(3\sigma) = 3.3$ and $\eta(1\sigma)/\eta(3\sigma) = 1.9$ where δ_o is given in $\sigma(= \langle\delta^2\rangle^{\frac{1}{2}})$units.
(ii) Eulerian sphere (2nd order in δ): $J \propto (\delta_o/\sigma)^{-5/2}$ and $\eta \propto (\delta_o/\sigma)^{-2}$.
(iii) Arbitrary Lagrangian volume (1st order in δ):
$J \propto (\delta_o/\sigma)^{-3/2}$ and $\eta \propto (\delta_o/\sigma)^{-1}$.

If, indeed, the morphological type of galaxies depends on their angular momentum and hence on their primordial density, then the dependence of the abundance of galaxies on morphology and on local density of galaxies is readily understood. The idea is that high σ fluctuations evolve into early type galaxies and low σ's into late types. In a clustering scenario in which the power index is less than 1, the hierarchical structure of clumps within clumps is unstable against tidal interaction. As the cross section for tidal disruption scales as the surface density (hence as δ_o^{-2}), one expects disruption in late-type galaxies more than in early types. In particular, in the violent environment of rich clusters only the high σ perturbations, i.e. early type galaxies, are likely to survive tidal interactions. This explains the variation of relative abundances of galaxies of various types with the mean local density. The enhanced clustering of the high σ peaks should further enhance this variation.

J. Kormendy and G. R. Knapp (eds.), Dark Matter in the Universe, 363.