Dark Matter in Galaxies
IAU Symposium, Vol. 220, 2004
S.D. Ryder, D.J. Pisano, M.A. Walker, and K.C. Freeman, eds.

Angular Momentum in Groups from Cosmological Simulations

Jeremy Bailin

Steward Observatory, 933 N Cherry Ave, Tucson, AZ 85721, USA

Matthias Steinmetz

Astrophysikalisches Institut Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany; and Steward Observatory, 933 N Cherry Ave, Tucson, AZ 85721, USA

Abstract. We have performed high resolution cosmological N-body simulations in which halos of $10^{11}\ M_\odot$ are resolved with over 700 particles. We report on the internal structure of group-sized halos (masses between $10^{11}\ M_\odot$ and $10^{14}\ M_\odot$), particularly on how the angular momentum within the halo correlates with the shape of the halo and with the angular momentum at other radii. We find that many halos have an inner region whose angular momentum is disconnected with that of the outer halo.

1. Simulations and Shapes

To study the internal structure of groups theoretically requires simulations that contain both a large volume, in order that environmental effects are properly accounted for, and high spatial resolution, in order to resolve the internal structure. The cosmological simulation we analyze contains only collisionless N-body particles. We used the currently favoured ΛCDM cosmology, with $\Omega_{\rm m} = 0.3$, $\Omega_\Lambda = 0.7$, $\sigma_8 = 0.9$, and a Hubble constant of $h = 0.65$ where $H_0 = 100\ h$ km s^{-1} Mpc^{-1}. The simulation contained 320^3 particles in a box of side 32.5 h^{-1} Mpc comoving, allowing us to resolve halos of $10^{11}\ M_\odot$ with over 700 particles. The force was softened with a spline of width 4.232 kpc, and the simulation was evolved using the parallel version of the GADGET code (Springel, Yoshida, & White 2001).

We construct isodensity contours for our halos in the manner of Jing & Suto (2002). To improve the number statistics, we include all particles in a halo with densities greater than or equal to the density of the contour we are investigating. These contours are well fit by triaxial ellipsoids. Figure 1 shows the mean minor-to-major c/a axis ratios for our halos. Two trends stand out: inner regions are more flattened than outer regions, and lower mass halos are less flattened than higher mass halos. This continues the trends seen in cluster-size halos. As can be seen by the error bars, which give the width of the distribution, there is a lot of halo-to-halo variation. Within each halo, the axes are very well aligned.

https://doi.org/10.1017/S0074180900183858 Published online by Cambridge University Press

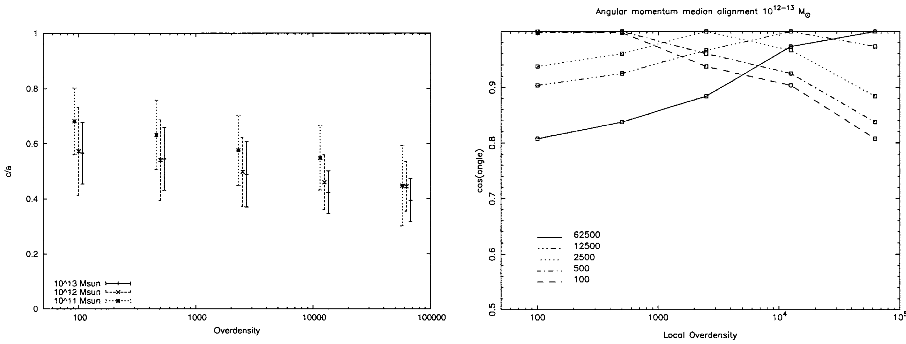

Figure 1. (*Left*) Mean minor-to-major axis ratios for all halos. Different overdensities correspond to different radii within the halos, with higher densities at smaller radii. The halos are grouped into low-mass (10^{11-12} $M_\odot$), intermediate-mass (10^{12-13} $M_\odot$), and high-mass (10^{13-14} $M_\odot$). Error bars show the 1σ width of the distribution. (*Right*) Median alignment of angular momenta within each halo at different radii, for intermediate-mass halos. Different line styles correspond to alignments relative to different fiducial radii.

2. Angular Momentum Alignments

We have calculated the angular momentum vector of each density ellipsoid defined as above. We find that in our simulation, ellipsoids with average angular momentum per particle smaller than $10^{7.6}$ $M_\odot$ kpc km s^{-1} do not have well determined angular momentum directions. For those ellipsoids with well defined angular momenta, we compare the direction of the angular momentum with the minor figure axis. We find that angular momenta are preferentially aligned within 30° of the minor axis, suggesting that rotational flattening is a factor in their shapes.

Within each halo, we compare the direction of its angular momentum at different radii. Figure 1 shows the results for the intermediate-mass halos. The angular momentum is well-aligned within the inner regions, and within the outer regions; however, a large number of halos show a break between the inner and outer regions, around a local overdensity of 2500. Comparing halos of different mass, we find that these decoupled cores are more common in the more massive systems, which are on average dynamically younger.

References

Jing, Y. P., & Suto, Y. 2002, ApJ, 574, 538

Springel, V., Yoshida, N., & White, S. D. M. 2001, New Astronomy, 6, 79