THE TRUE SURFACE MASS DENSITY OF COLD DARK MATTER HALOS

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INTRODUCTION

While the cold dark matter (CDM) scenario generically predicts triaxial dark matter halos with substructure, spherical models with smooth density profiles are nonetheless routinely adopted in the modeling of light propagation effects through such objects. The most popular spherical model during the last decade has been the NFW density profile (Navarro et al. 1996).

In our current study, high-resolution, dissipationless N-body simulations are used to study the surface mass density (Σ) of dark matter along random lines of sight through CDM halos. By comparing the results to the corresponding surface mass densities obtained from smooth and spherical NFW-fits to the halos, the errors in projected mass density introduced by using such simplified models are assessed.

SIMULATIONS

We use state-of-the-art cosmological ΛCDM simulation codes to construct our N-body halos. The newest code is called Adaptive Mesh Investigations of Galaxy Assembly (AMIGA), which is a next generation version of a relatively new adaptive mesh code called MLAPM (Knebe et al. 2001).

We have run MLAPM and AMIGA to produce a total of **10 simulations** from which to extract halos. The simulations have box sizes from 10 Mpc/h to 64 Mpc/h, and typical redshift steps of $\Delta z = 0.1$ when $z < 2$ (see Figure 1).

Our halo finder, Amiga Halo Finder (AHF), is a very sophisticated algorithm which uses the adaptive mesh grids in defining halos and subhalos (Gill et al. 2004). With AHF we are able to find and isolate all subhalos which contain more than 100 particles. A typical simulation box contains almost 17 million particles and thousands of halos and subhalos. From each simulation box, we use the halos which contain more than 100 000 particles. These halos typically contain an order of 100 subhalos and have a mass range of 10^{12} - 10^{14} $M_{\odot}/h$.

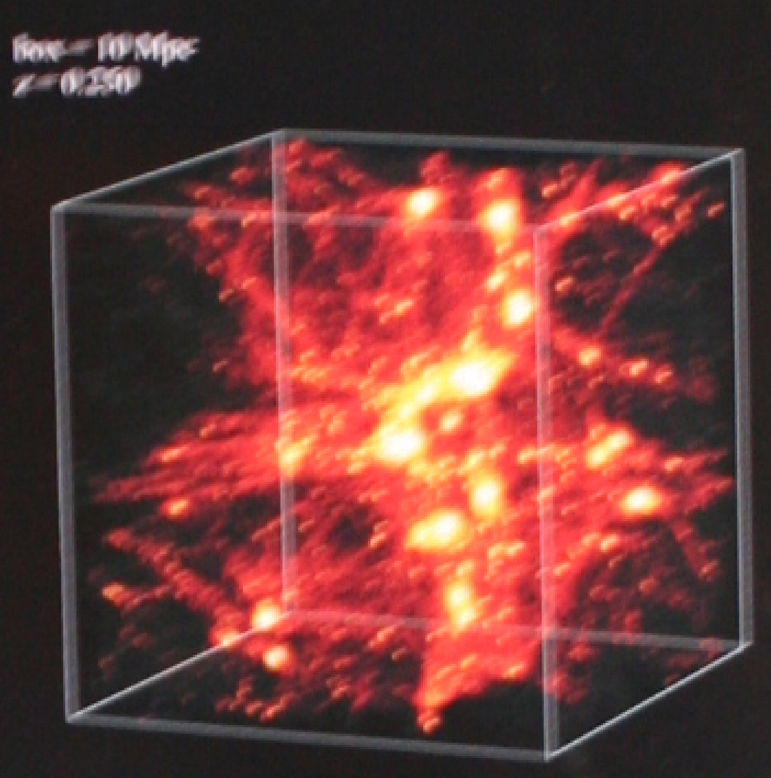


Figure 1: A snapshot from our cosmological AMIGA simulation. In the box, individual halos are clearly visible as irregular mass concentrations. The largest halos seen here have masses of ~10[illegible] $M_{\odot}/h$.

SURFACE MASS DENSITY

To measure the surface mass density in the halos, we 'shoot' one-dimensional, randomly oriented sightlines through the largest halos with impact radii of up to 2 times the virial radius. In order to measure surface densities along the sightlines, we have to treat the simulation particles as extended mass concentrations instead of point masses. To be consistent with the way the particles are treated in the cosmological simulation, we assign the particles a linear density profile with a radius of the size of their local adaptive grid box. A local adaptive grid box typically contains a maximum of eight simulation particles. The same particle extending technique is used in Holopainen et al. 2006.

PRELIMINARY RESULTS

We find that, while the errors in Σ-estimates associated with dark halo substructure are on the level of a few percent only, neglecting halo triaxiality introduces typical Σ-estimate errors of up to 100 per cent. Furthermore, The NFW density profile tends to overestimate Σ near the halo core and underestimate it with impact parameters larger than 0.5 times the virial radius of the halo. Subhalos induce large Σ-values, notably above the normal scatter, especially with large impact radius sightlines (see Figure 2, light-blue area).

At the moment, we are studying simple relations for the variations in Σ as a function of distance to the halo centre, halo redshift and halo mass. With derived analytical expressions it will be possible to investigate the reliability of results obtained with simplified halo models. Moreover, the expressions may also be used to recover the Σ-scatter lost when sightline to sightline propagation statistics are modeled using smooth and spherical halo models. As an example, we plan to apply our numerical recipe to the microlensing optical depth distribution expected for MACHOs in CDM halos located along the line of sight to high-redshift light sources.

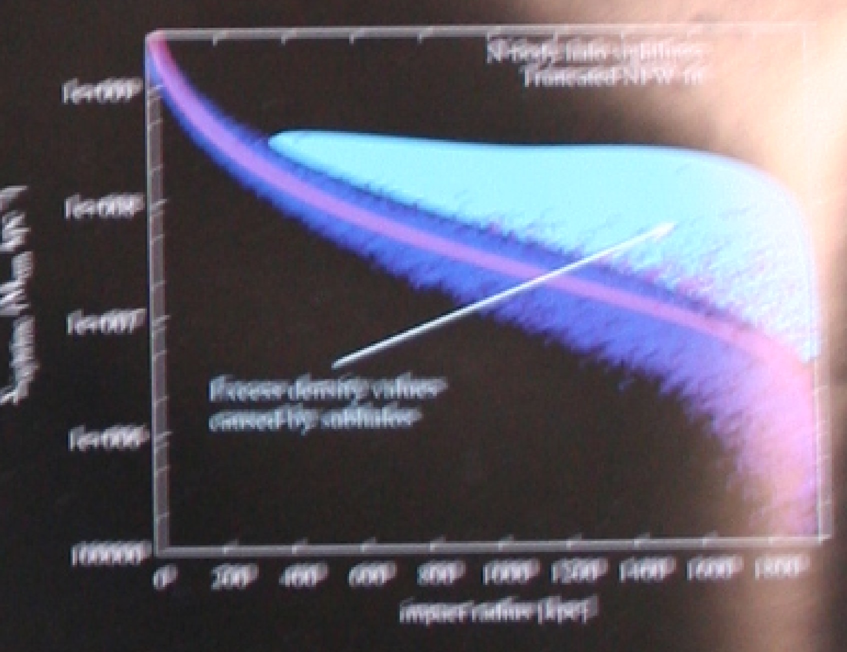
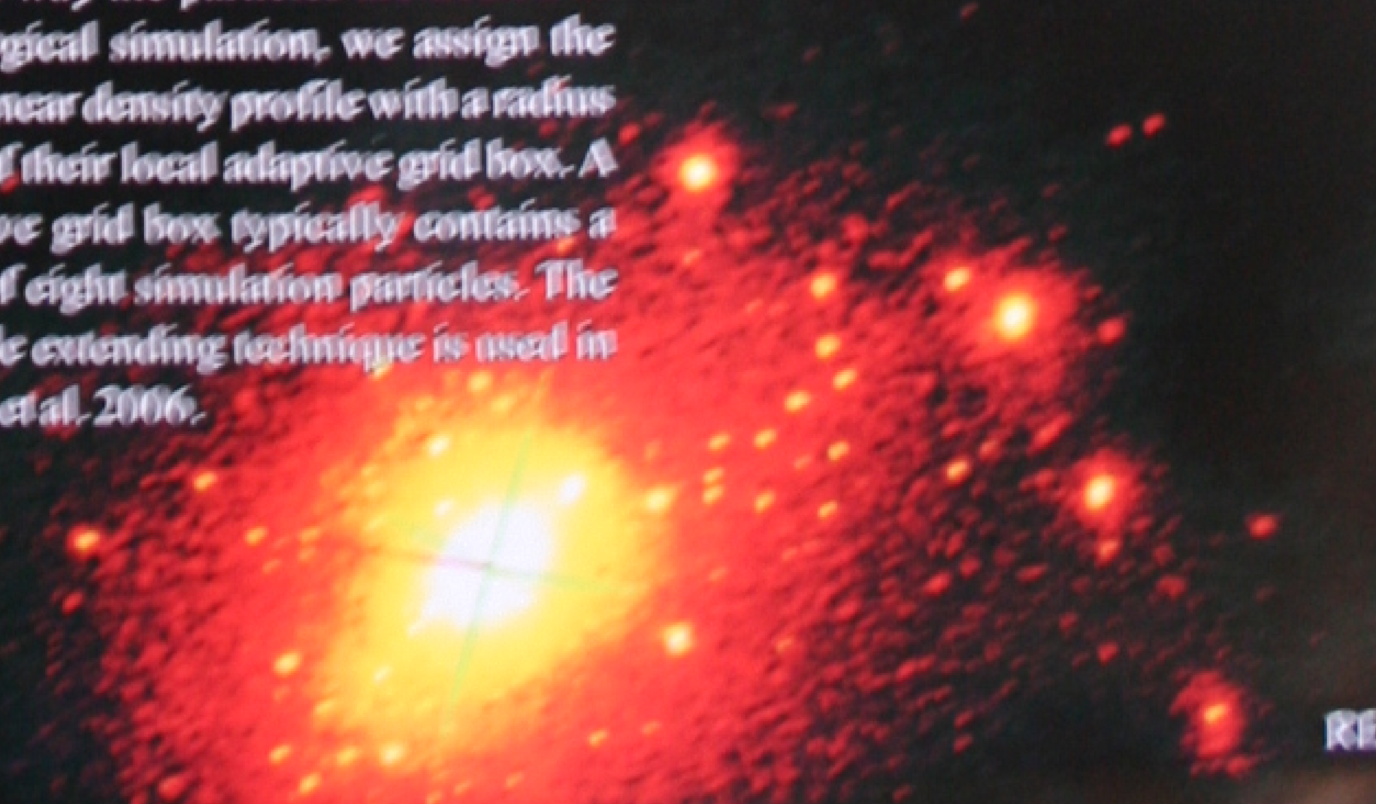


Figure 2: A typical surface mass density scatter and the NFW-fit for a cluster sized halo at $z = 0$. Our halos are sampled with 10000 randomly oriented sightlines in 3D with different impact radii. Each point in the figure represents an individual Σ-measurement for one of the sightlines for this example halo. Note the excess density values caused by subhalos, marked with the light-blue area.



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