Major Halo Mergers
Investigation of Density Profiles

A cluster of galaxies Cl0024+1654 in red and associated dark matter halo in blue
Evidence for Cold Dark Matter (CDM)

- Dynamics of galaxies within clusters necessitates associating a dark matter halo with the galactic cluster.
- Rotation curves of stars orbiting about the galactic centre requires a large amount of non-visible matter to be associated with the galaxy.
- Gravitational lensing.
- Rigorous testing on large scales for example by the Wilkinson Microwave Anisotropy Probe examining expansion of universe.
Modelling CDM Halos

- 88% of galactic mass is a CDM halo
- To give the correct rotation curves the halo must have cuspy density profile
- Halo density profile should be stable
- Dark matter obeys the collisionless Boltzmann equation (Jeans equation) since particles move under the influence of the potential generated by all the other particles within the halo
Stable CDM Halos

- Analytic solutions to Jeans equation do not describe the density profile observed when modelling collapse of dark matter cloud with minor perturbations

- A suitable stable density profile takes the NFW form:

\[
\rho(r) = \rho_0 \frac{sech(r/r_t)}{(r/r_s)\gamma (1 + r/r_s)^{3-\gamma}}
\]

- Inner logarithmic slope \(1 \leq \gamma \leq 1.6\)
- Scale radius \(r_s = 1\) kpc
- Truncation radius \(r_t = 12\) kpc
In models of universe halos form hierarchically, small CDM halos merge forming larger halos.

Features of galaxies can be explained by merger halos e.g. elliptical galaxies, galaxy pairs.

Examine using N-body computer simulations what happens when two identical NFW profile halos merge.

Model head on collisions with different values for $\gamma$.

Model mergers with different impact parameters.
Results of Mergers
Density Profile

- NFW model fits density profile following merger over 3 decades of radius
- Deviation at small radii is due to two body relaxation
- Deviation at large radii is due to a outgoing wave
Results of Mergers
Varying Inner Logarithmic Slope $\gamma$

• Head on collisions
• Mergers generate halos with steeper cusps and increased scale radius
Results of Mergers
Varying Impact Parameter

- Initially halos had inner logarithmic slope $\gamma = 1.3$
- Mergers generate halos with steeper cusps and increased scale radius
Possible Further Work

- Explore relationships found in more detail, using higher resolution and examining non-linearity carefully
- Collisions between halos having different initial parameters (scale radius, truncation radius, mass and inner logarithmic slope)
- Halos having initial angular momentum
- Effects of halo inner structure e.g. bars, satellite halos and continuous accretion of diffuse material
- Alternative density profiles