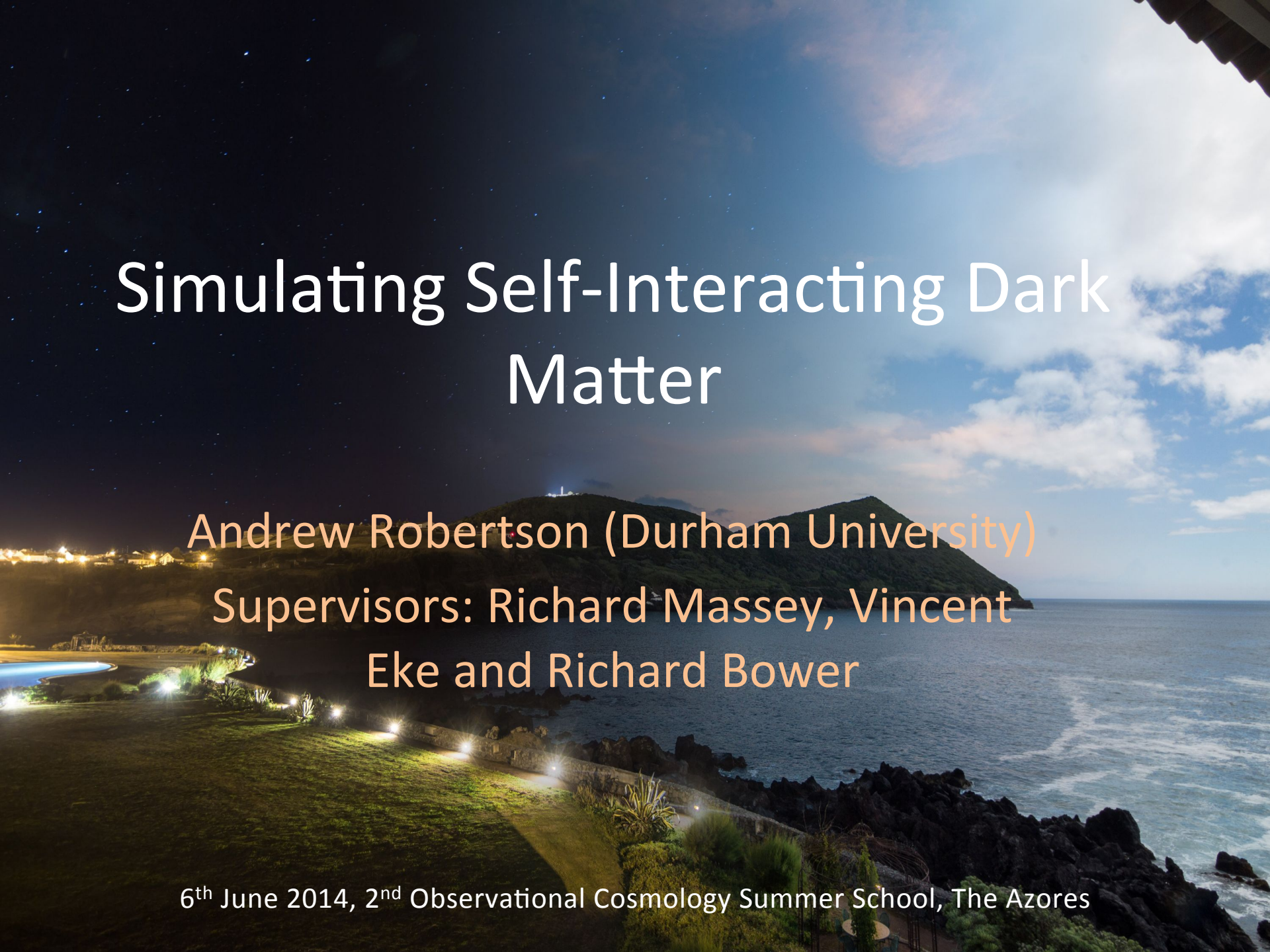

Simulating Self-Interacting Dark Matter

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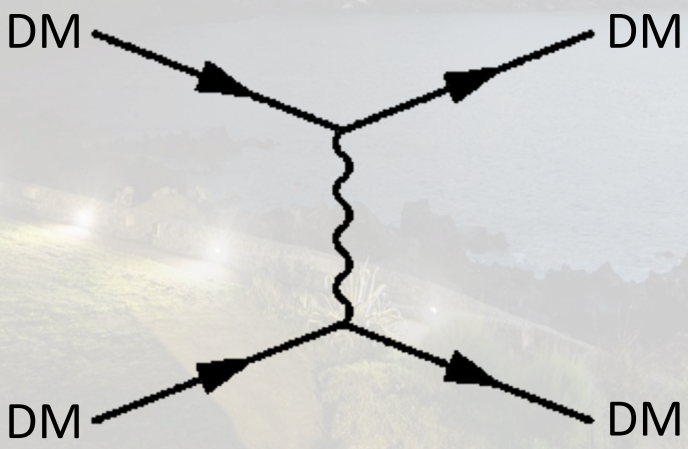
Supervisors: Richard Massey, Vincent Eke and Richard Bower

6th June 2014, 2nd Observational Cosmology Summer School, The Azores

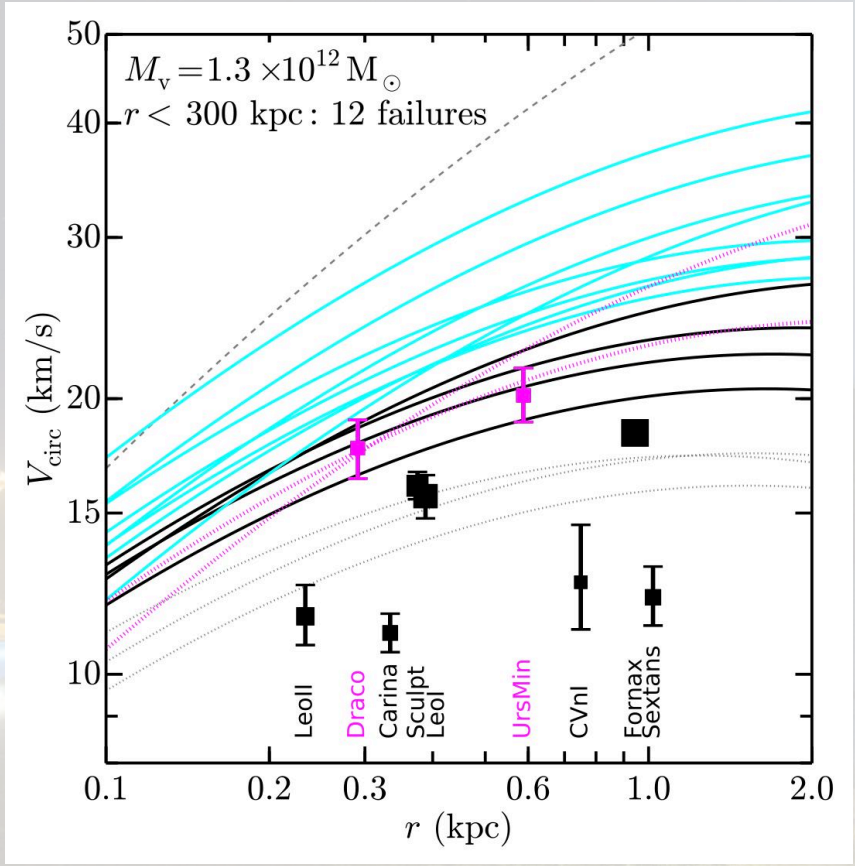
What is Self-Interacting Dark Matter?

- Dark Matter that is strongly coupled to itself.
- Natural in models with a rich dark sector which has new gauge forces.
- Examples include:
  - "Dark Electromagnetism" (Ackerman et al. 2006)
  - "Fluid Dark Matter" (Peebles, 2000)
  - "Q-balls" (Kusenko and Steinhardt, 2001)
  - "Light Asymmetric Dark Matter" (Frandsen et al. 2011)



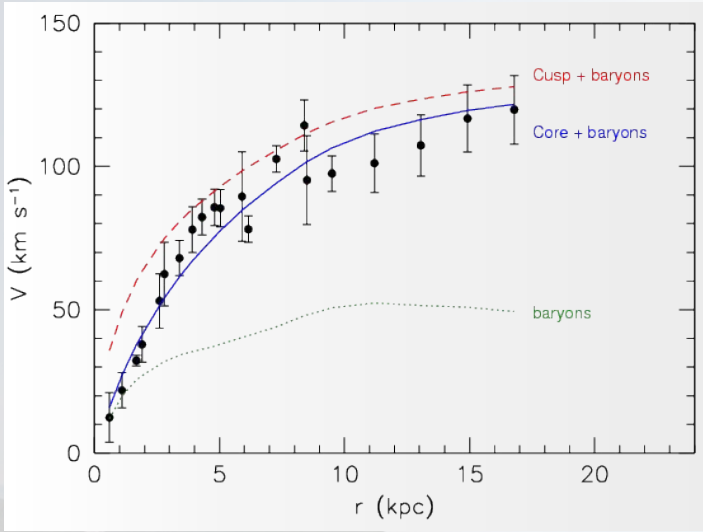
Astrophysical Consequences

Too Big to Fail

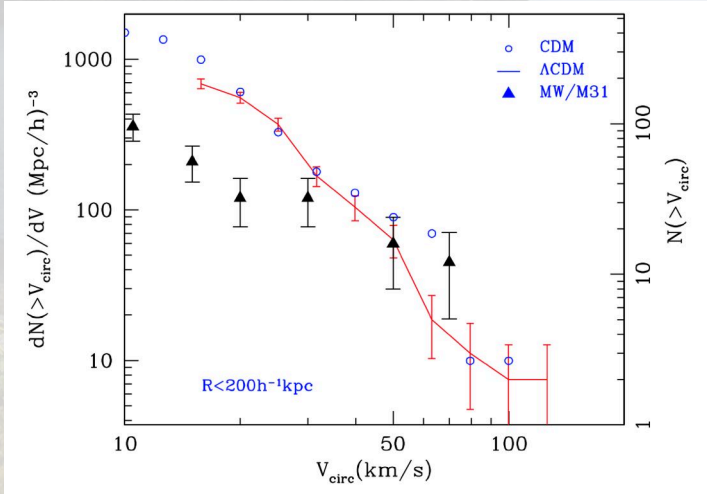


Garrison-Kimmel et al. 2014

Core-Cusp (Weinberg et al. 2013)



Missing Satellites (Klypin et al. 1999)



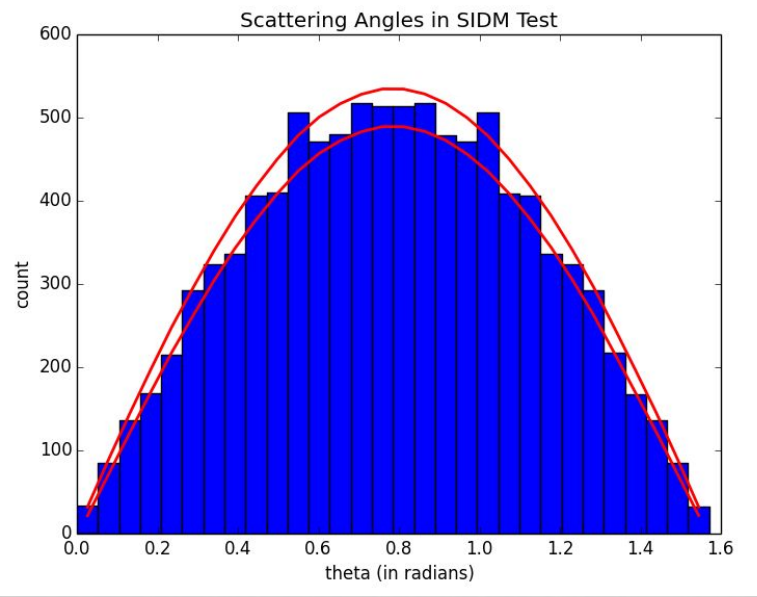
Modified GADGET-2 (Springel, 2005)

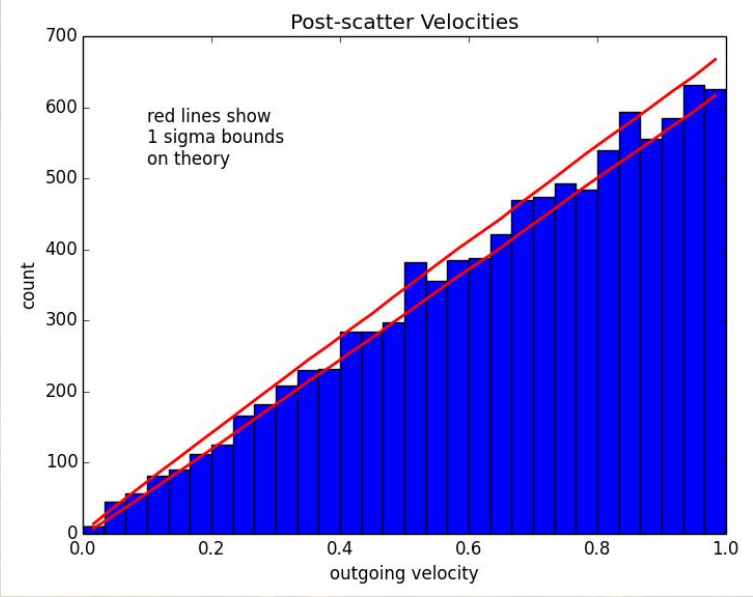
- What is GADGET-2 ?
  - "Freely available code for cosmological N-body/SPH simulations on massively parallel computers"
  - Computes gravitational forces using a hierarchical tree algorithm for short-range forces and a particle mesh on large scales.

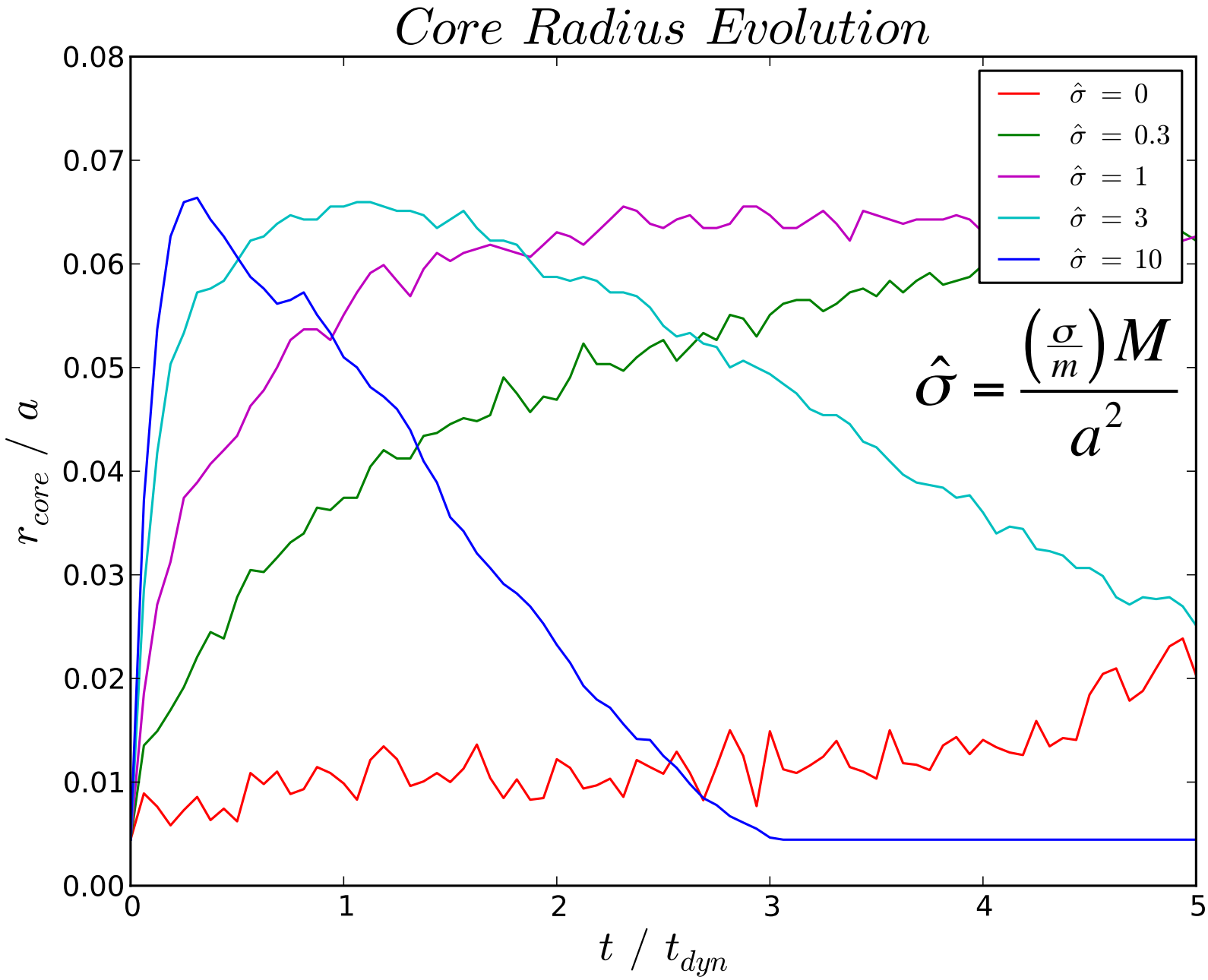
- Scattering rate given by: $\Gamma = \frac{dn}{dt} = \int f(\mathbf{v_1}) \rho \sigma_{DM} |\mathbf{v_0} - \mathbf{v_1}| d^3\mathbf{v_1}$

- Probability of particle i scattering from particle j, in time Δt is: $P_{ij} = \frac{\sigma_{DM} |\mathbf{v}_i - \mathbf{v}_j| \Delta t}{\frac{4\pi}{3} h^3}$

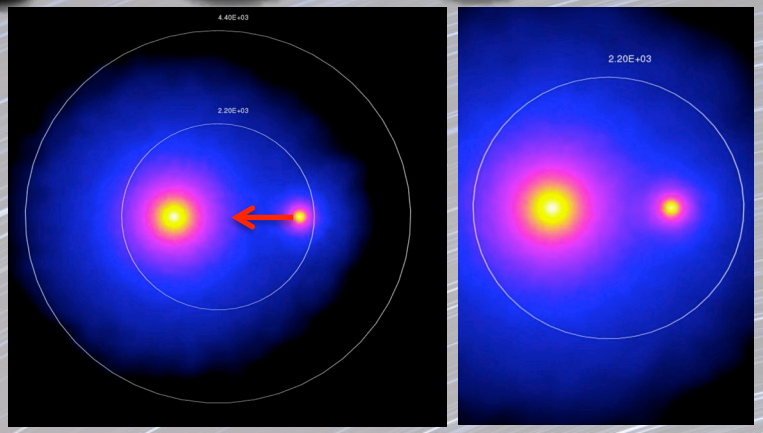
Tests of Scattering Kinematics

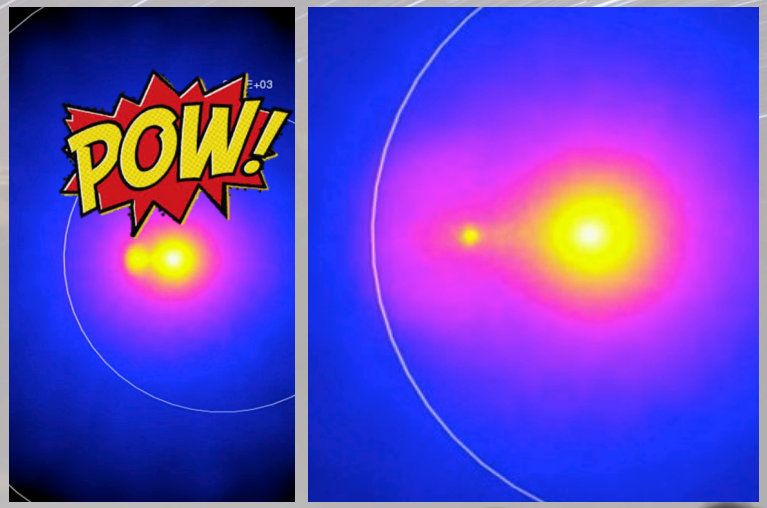


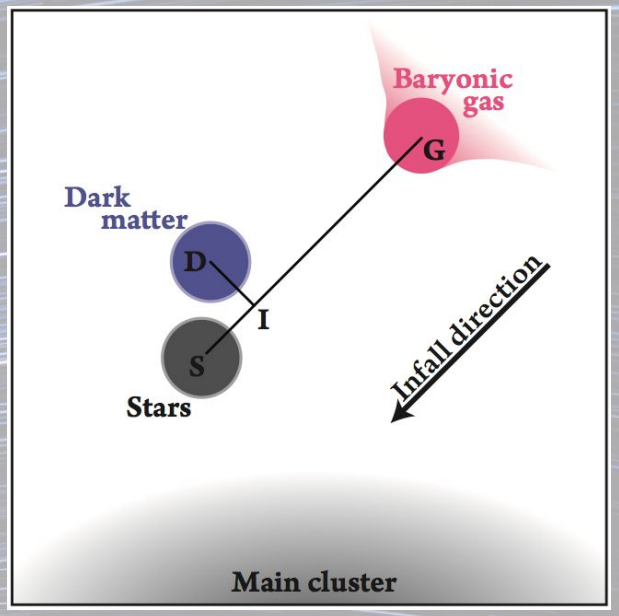



Core Radius Evolution
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
1
2
3
4
5
r_{core} / a
t / t_{dyn}
$\hat{\sigma} = 0$
$\hat{\sigma} = 0.3$
$\hat{\sigma} = 1$
$\hat{\sigma} = 3$
$\hat{\sigma} = 10$
$\hat{\sigma} = \frac{\left(\frac{\sigma}{m}\right) M}{a^2}$

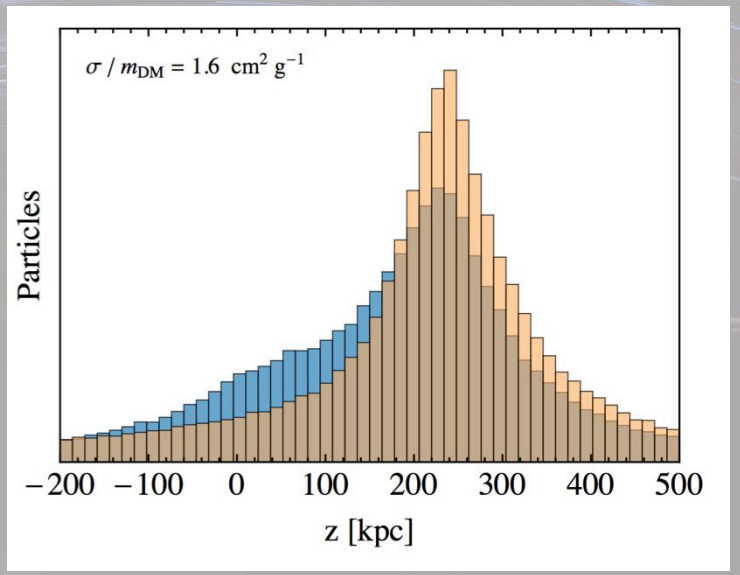
Mergers







Harvey et al. 2014



Kahlhoefer et al. 2014