

Building a Computer Cluster in order to Simulate Dark Matter Interactions in Parallel

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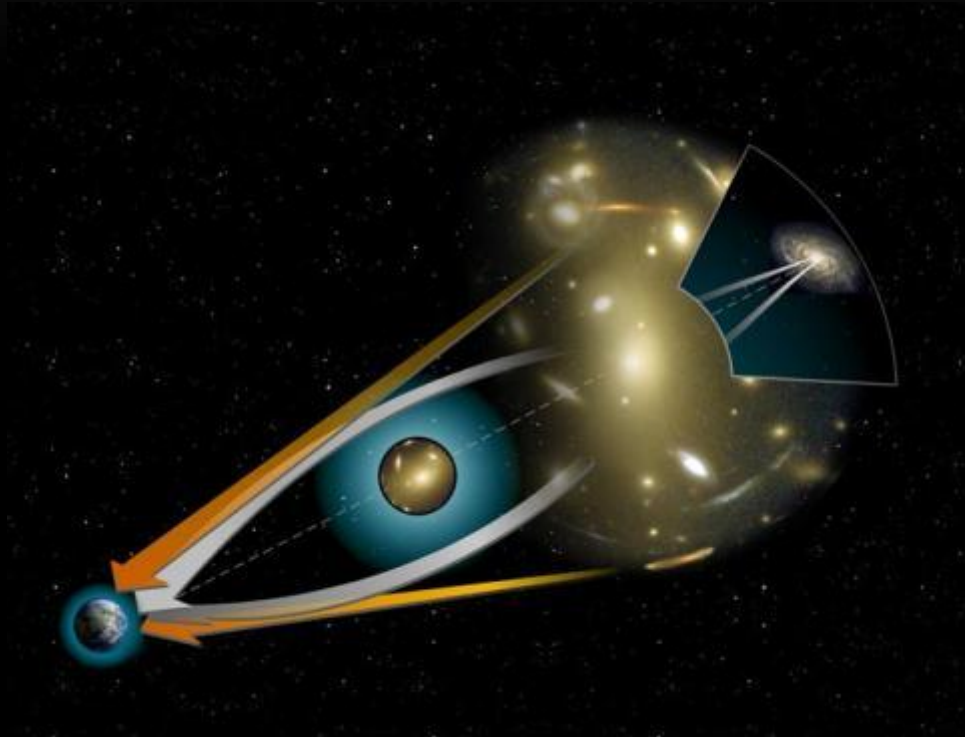
Houghton College

Houghton, NY

- Evidence of Dark Matter
- Shape of DM Halos and Direct Detection Rates
- N-body simulations
- Cluster

Evidence of Dark Matter

Gravitational Lensing



https://upload.wikimedia.org/wikipedia/commons/0/02/Gravitational_lens-full.jpg

Motivation

Changes dark matter halo morphology



Only Gravitational
interactions

http://apod.nasa.gov/apod/image/0406/m87_cfht.jpg



Full self interactions
(ordinary matter)

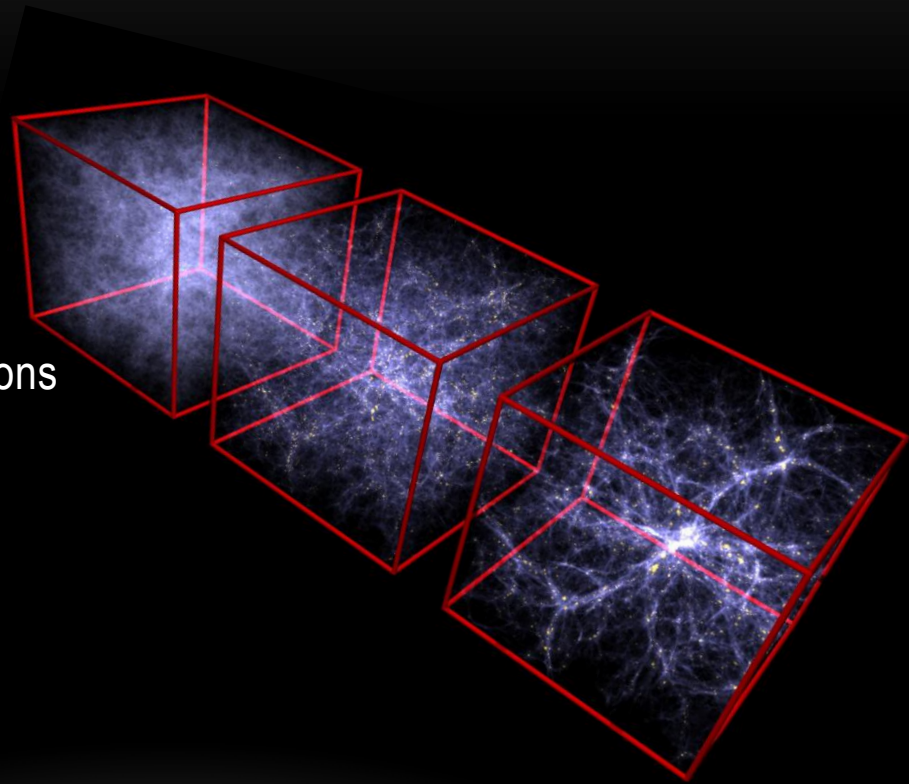
http://en.wikipedia.org/wiki/File:Ngc253_2mass_barred_spiral.jpg

Direct Detection Rate:

$$R \sim \langle n(r)v(r)\sigma \rangle$$

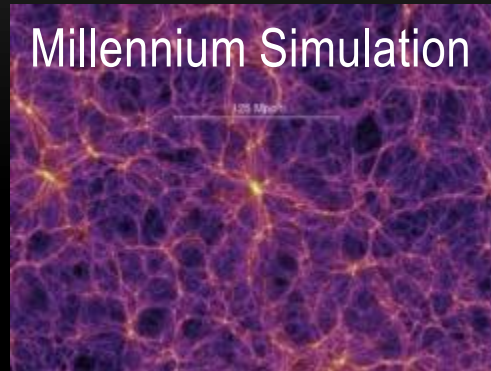
The Project

- N-body particle simulation
- Cluster and parallel computations



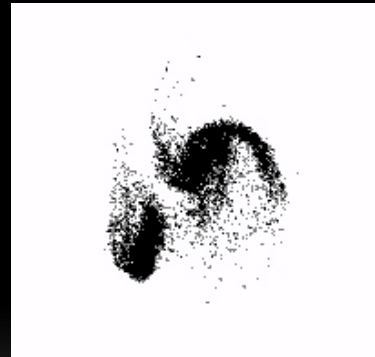
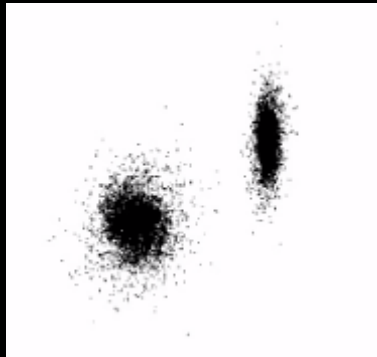
Springel, Volker

GADGET2



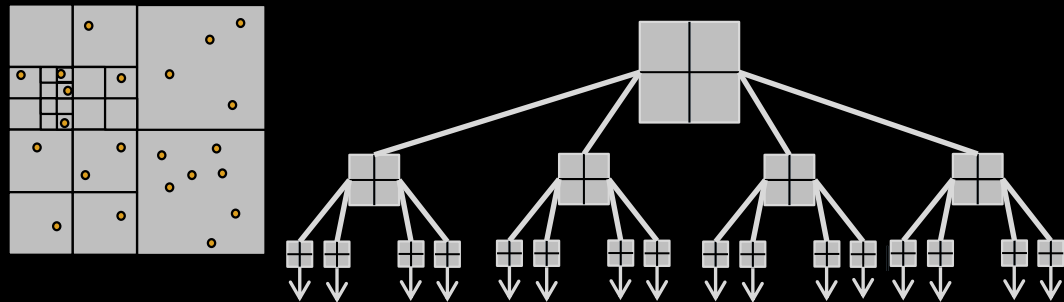
http://www.mpa-garching.mpg.de/galform/virgo/millennium/seqD_063a_half.jpg

Galaxy Collision

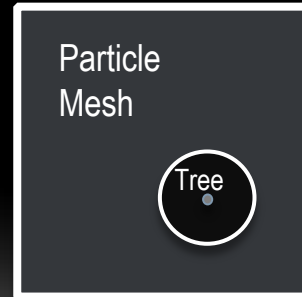


GADGET2 – Force Computation

- Particle Mesh
- Tree algorithm

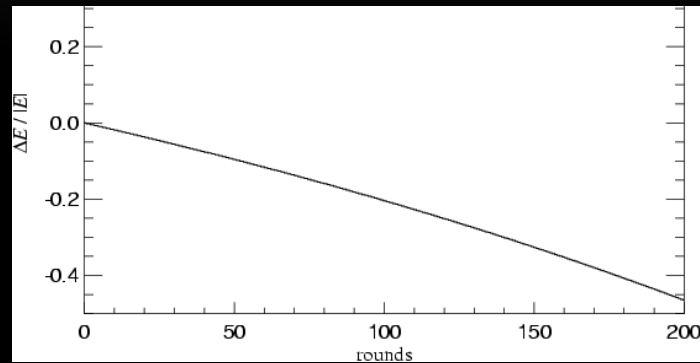


- Hybrid: TreePM



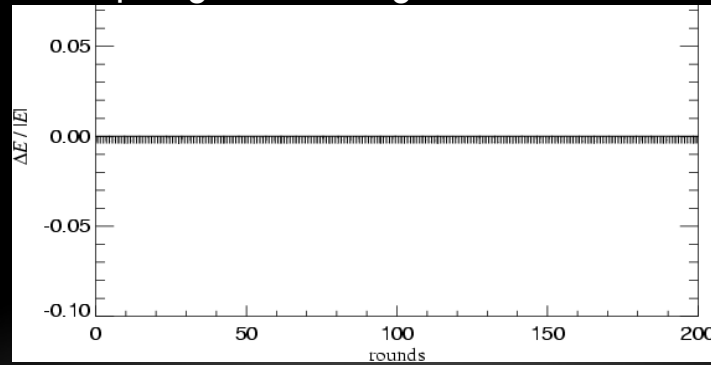
GADGET 2 – Time Step Integration

Naïve Time Integration – Euler



Springel, Volker

Leapfrog Time Integration – KDK



Springel, Volker

Possibilities for the Future:

- Expand cluster
 - Add self-interactions to force calculation
 - Run:
 - CDM
 - Self-interacting DM
 - Mixture: CDM and self-interacting DM
-

References

Parker, Barry. *Invisible Matter and the Fate of the Universe*. New York and London: Plenum Press, 1989

Olive, Keith. “Tasi Lectures on Dark Matter” (Summary of lectures given at the Theoretical Advanced Study Institute in Elementary Particle Physics at the University of Colorado at Boulder, Boulder, CO, June 2-28, 2002).

Springel, Volker. “The cosmological simulation code GADGET-2” *Monthly Notices of the Royal Astronomical Society*, **364** (2005): 1105-1134

Springel, Volker. “The GADGET code: Usage, capabilities & limitations, algorithmic aspects” (presentation, Summer school on cosmological numerical simulations, Potsdam, Germany, July/August, 2006).