Genetically modified halos:
Towards controlled experiments in galaxy formation

Nina Roth

Footsteps15
Soverato
09.09.2015
Galaxy simulations
(from a cosmologist’s POV)

What is the relation between initial conditions and observables?

Which physical processes are responsible?
Galaxy simulations

Statistical samples

- ellipticals
- disk galaxies
- irregular

e.g. *Illustris*, Vogelsberger+2014

g.e. *Eris*, Guedes+2011

cf S. Tonnesen’s talk

Specific objects
Genetically modified halos

**Goal:** create *controlled experiments* with cosmological simulations

**Problem:** initial conditions are random

**Solution:** constrained initial conditions
Constrained realisations

Hoffman & Ribak 1991: Generate subset of realisations that obey certain criteria
In practice

Reference simulation → Select halo → Particles in initial cond.

Constrain particles → Run second simulation → Compare with reference
Current constraints

- Total density of halo particles
  + density in inner region

- Halo mass

- Collapse time

- Potential derivative

- Angular momentum (in progress)
Collapse constraint
Collapse time

All converge to similar total mass at $z=0$

Collapse time should affect inner structure

→ Density profiles
Density profiles

Early

Late

2.5 Mpc

Halo concentration

Early coll.

Late coll.

Radius

Density
Halo concentration

Average consistent with statistical sample

Individual objects have different slopes!
Preliminary: baryons

SF history

\[ \dot{M}_*/M_\odot \, \text{yr}^{-1} \]

- a matched pair of galaxies. One quenches, one does not.

Original

z=3 Merger

GM

Pontzen, Roth, Tremmel, Governato, Peiris
2015 in prep
Summary

- Constrained real. can be used to **smoothly modify halos**
- Can be used to study **physical connections** in structure formation
- In addition: We have a way to measure the **probability** of the constrained field
- In progress: baryons and angular momentum

Roth, Pontzen & Peiris, arXiv:1504.07250