Genetically modified halos: Towards controlled experiments in galaxy formation

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Galaxy simulations
(from a cosmologist’s POV)

Statistical samples

Specific objects

Illustris, Vogelsberger+2014

Eris, Guedes+2011
Seek answers to these questions:

What is the relation between initial conditions and observables?

Which physical processes are responsible?
Experiments?

Environment

Shape

Substructure

Mass

Other: e.g. spin
Experiments?

Ideally: in fully cosmological context

Problem: initial conditions are Gaussian random fields

Other: e.g. spin
Modify existing halo using “constrained realisations”

Draw many times

OR

Follow Hoffman & Ribak 1991: constraints on Gaussian fields

Generate subset of random fields that obey certain criteria
Particle tracking

Halo at $z=0$
(in 50 Mpc/h box)

Same particles at $z=99$
Current constraints

- Total density of halo particles
  - + density in inner region
- Halo mass
- Collapse time
- Potential derivative
- Angular momentum (in progress)
Collapse constraint

![Graph showing overdensity vs. position, with early and late regions, and early and late collapses marked.](image)
All converge to similar total mass at $z=0$

Collapse time should affect inner structure

$\rightarrow$ Density profiles
Density profiles

2.5 Mpc

Reference

Halo concentration

Early coll.

Late coll.

Early

Late
Halo concentration

Average consistent with statistical sample

Individual objects have different slopes!
Teaser: baryons

$M(z=1) \times \{0.5, 2\}$
Summary

• Constrained real. can be used to smoothly modify halos

• In addition: We have a way to measure the probability of the constrained field

• Next steps: baryons and angular momentum (suggestions?)

Roth, Pontzen & Peiris, arXiv:1504.07250
Minimal changes

Reference

Late collapse