The MACSIS Project

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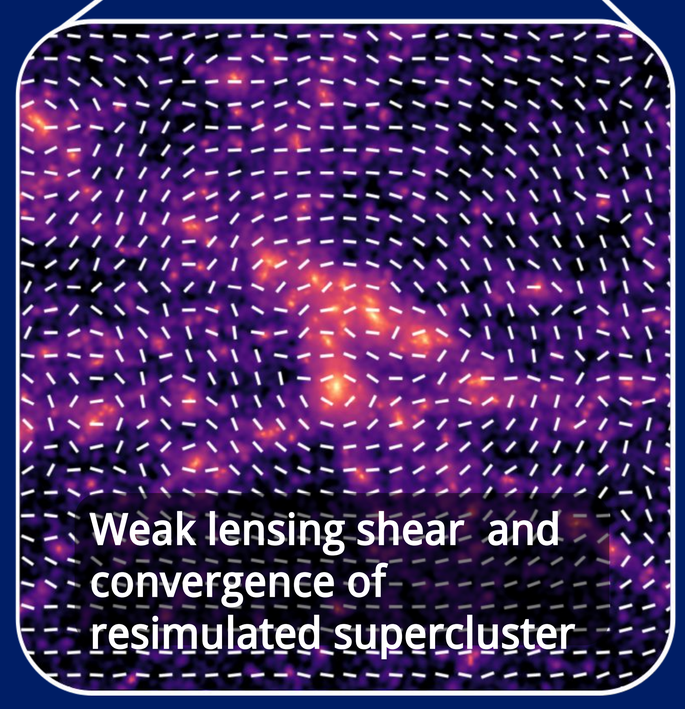
Simulating the giants of the Universe

Motivation

Why study galaxy clusters and superclusters?
- Galaxy clusters are a key cosmological probe
- They give a unique insight into the late-time behaviour of the Universe

What are existing simulations lacking?
Current simulations of galaxy clusters and superclusters:
- Lack realistic baryonic physics
  or
- Use small numbers of clusters and lack the statistics needed for cosmology

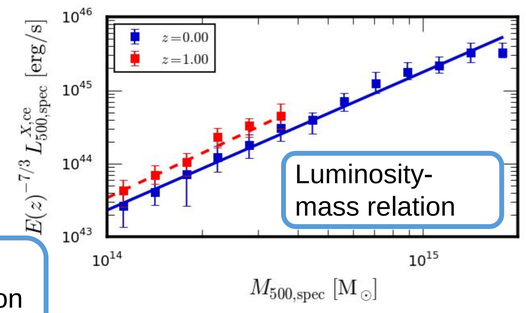


How to build the MACSIS clusters

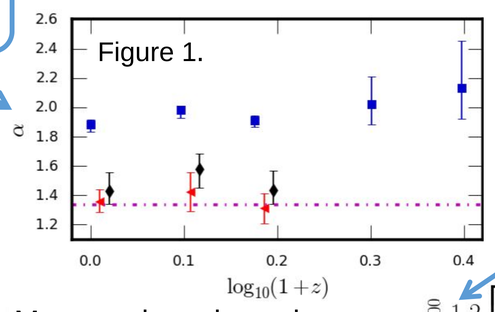
Run a 3.2 Gpc DMO simulation at low resolution using Gadget-3 (Springel 2005) → Select 390 clusters with masses $>10^{15}M_{\odot}$ → Select particles within Lagrangian region of a cluster at z=0 → Degrade resolution of initial conditions with increasing distance from cluster region → Simulate each cluster region at higher resolution using BAHAMAS code (LeBrun 2014, McCarthy 2016)

Cluster scaling relations and mass bias

Combined MACSIS with clusters from BAHAMAS simulations (McCarthy 2016)



Luminosity-mass relation slope



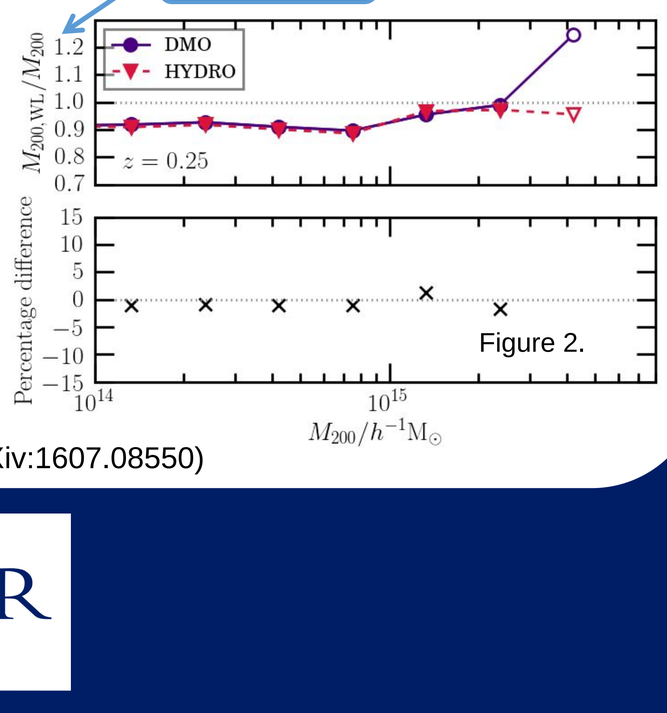
- MACSIS enables studying the evolution of observable-mass scaling relations.
- The top panel of the Fig 1. shows the luminosity-mass relation for MACSIS and BAHAMAS clusters.
- The bottom panel of Fig 1. shows selecting a sample of hot, relaxed clusters (red points) gives evolution consistent with self-similar theory predictions (dot-dashed line).

See Barnes et al. 2016 (arXiv:1607.04569)

- Measured mock weak lensing masses for MACSIS clusters
- Fig 2. shows that the weak lensing mass bias is unaffected by baryons
- Suggests DMO simulations are sufficient for studies of lensing mass bias

See Henson et al. 2016 (arXiv:1607.08550)

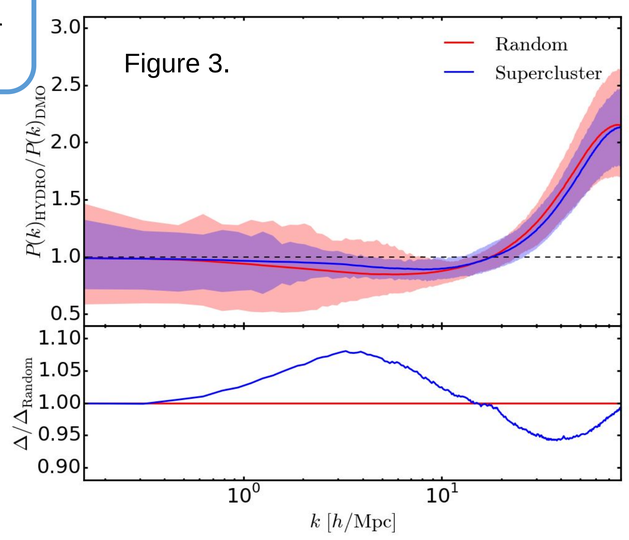
Weak lensing mass bias



Supercluster simulations

- Superclusters are large groups of smaller galaxy clusters
- Resimulated 61 supercluster regions and 60 random regions with the BAHAMAS code

Effect of baryons on matter power spectrum



- Fig 3. shows that baryons have less imact on matter power spectrum in superclusters.
- See enhancement on small scales due to cooling baryons falling into potential wells.
- See suppression on intermediate scales, as AGN feedback removes gas from clusters.

Peters et al. (in prep)

References and Credits

Barnes, D. J., Kay, S. T., Henson, M. A., McCarthy, I. G., Schaye, J., Jenkins, A. R. 2016, MNRAS, submitted
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Springel V. et al., 2005, Nature, 435, 629

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