Exploring the formation and destruction of cool-cores with IllustrisTNG

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Defining a cool-core

Select 6 criteria:

• Electron number density \([n_e]\)
• Cooling time \([t_{\text{cool}}]\)
• Entropy excess \([K_0]\)
• Physical concentration \([C_{\text{phys}}]\)
• Scaled concentration \([C_{\text{scal}}]\)
• Cuspiness parameter \([\alpha]\)
Continuous distributions

- Continuous distributions
- Cool-core fractions in general slightly lower than observed for unbiased samples
- Mass dependent scatter
Redshift evolution
Redshift evolution

Inconsistent redshift evolution
Mass dependence?

- Samples differ in mass and redshift distribution $\rightarrow$ limited simulation volume
Mass dependence?

- Create samples that have matching mass and redshift distribution
Evolution still different

- Matched sample still differ in redshift evolution
Evolution still different

- Simulated evolution noisy due to severe oversampling
- New model or missing physical process?
Modelling or missing processes?

- Current cosmological simulations still lack many physical processes

- Simulations may require:
  - Cosmic rays → an exciting area
  - Heat transport → isotropic case well studied
  - Improved AGN models → for example radiative
Modelling or missing processes?

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• 12 clusters simulated with and without anisotropic thermal conduction (Kannan+ 16)

• Use full Spitzer parallel to magnetic field to explore maximum effect (see Li+ in prep.)
More cool-cores!

Barnes+ in prep.
Flatter redshift evolution

- Increase in the number of cool cores at low redshift
- Reduction in the number of cool cores at high redshift
- Inclusion of anisotropic thermal conduction produces a flatter redshift evolution
- Eases tension with observed evolution
Less energy injected...
...but more efficiently coupled

Barnes+ in prep.
...but more efficiently coupled

Barnes+ in prep.
Radiative AGN feedback model
Conclusions

• IllustrisTNG yields a large sample of clusters whose properties are reasonably realistic

• However, the exact structure of the hot gas remains a challenge. Reproducing the observed cool-core fraction with redshift requires further work

• The inclusion of additional physical processes such as anisotropic thermal conduction helps to alleviate this problem, suggesting that theoretical models must continue to expand the inclusion of processes