Ruling out preheating of the ICM

Baryon fractions in clusters of galaxies: evidence against a preheating model for entropy generation

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Abstract

The Millennium Gas project aims to undertake smoothed-particle hydrodynamic resimulations of the Millennium Simulation, providing many hundred massive galaxy clusters for comparison with X-ray surveys (170 clusters with $kT_{sl} > 3$ keV). This paper looks at the hot gas and stellar fractions of clusters in simulations with different physical heating mechanisms. These fail to reproduce cool-core systems but are successful in matching the hot gas profiles of non-cool-core clusters. Although there is immense scatter in the observational data, the simulated clusters broadly match the integrated gas fractions within r_{500} [no room to show in poster – see paper]. In line with previous work, however, they fare much less well when compared to the stellar fractions, having a dependence on cluster mass that is much weaker than is observed. The evolution with redshift of the hot gas fraction is much larger in the simulation with early preheating than in one with continual feedback; observations favour the latter model. The strong dependence of hot gas fraction on cluster physics limits its use as a probe of cosmological parameters.

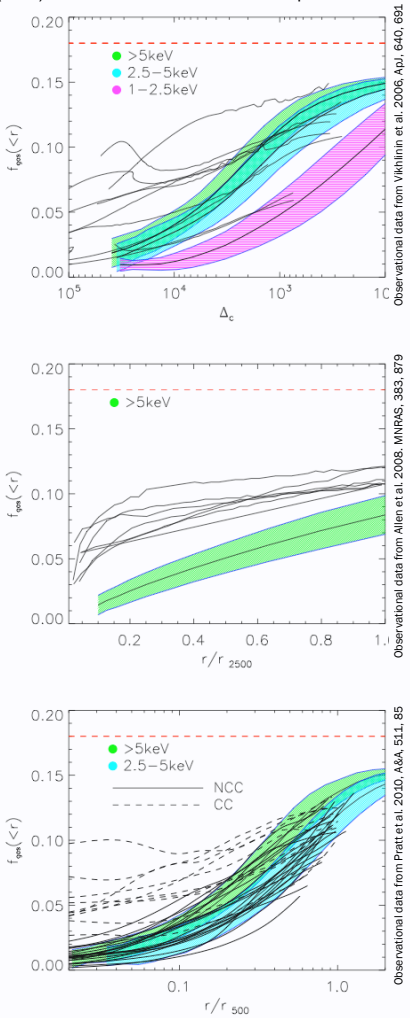
1 The simulations

The Millennium Gas Project aims to resimulate the Millennium Simulation using hydrodynamics to follow the evolution of the intracluster medium with a variety of gas physics:

GO – Gravity only: to test for self-similar scaling.
PC – Preheating plus cooling: early, distributed heating to an entropy of 200 keV cm^2 at z=4.
FO – Feedback only: continual heating from SNR and AGN is taken from a semi-analytic model as described in Short & Thomas 2009, ApJ, 704, 915.

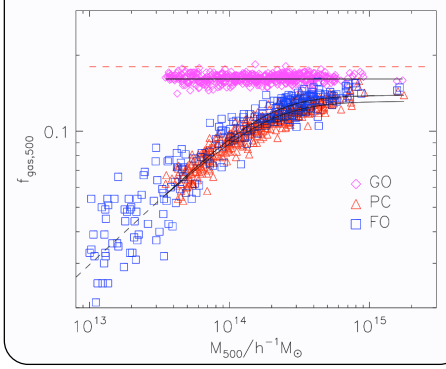
2 Gas fraction profiles at z=0

This figure shows the observed versus predicted gas fraction profiles for the FO simulation. There is poor agreement with bright, relaxed (cool-core, CC) systems but much better agreement with the non-cool-core (NCC) clusters from the REXCESS sample.



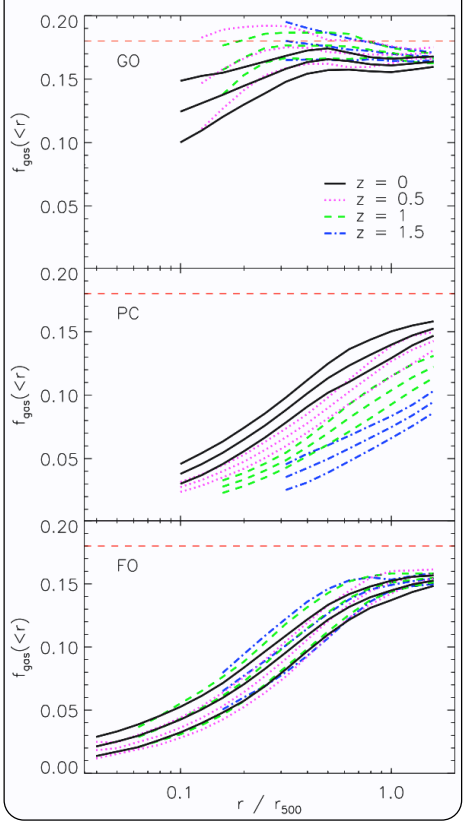
3 Gas fractions at z=0

This figure shows the simulated gas fractions within r_{500} at the current day. Both the PC and FO simulations predict similar gas fractions.



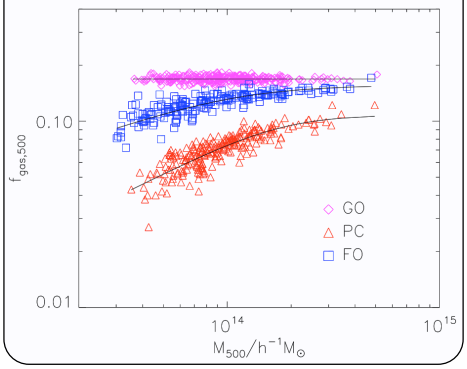
4 Predicted evolution of the gas profiles

This figure shows the evolution of the gas fraction profiles in the 10 most-massive clusters. The upper and lower lines show the 1-sigma spread. Note that the evolution of the FO run is approximately self-similar.



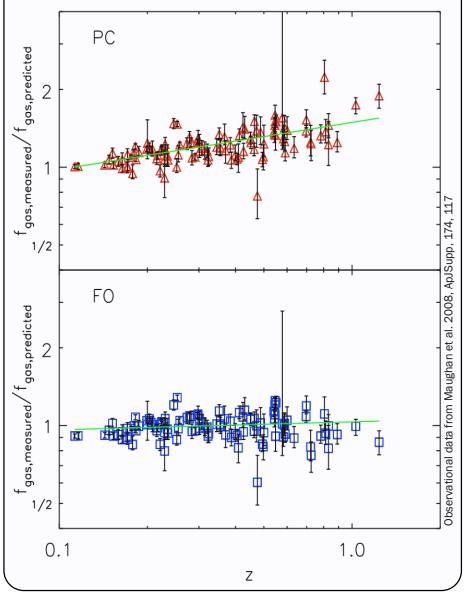
5 Predicted evolution of the gas fraction

This figure shows the simulated gas fractions within r_{500} at z=1. Note that the PC model has significantly lower gas fractions than the other two models.



6 Observed evolution of the gas fraction

This figure shows the ratio of the observed to predicted gas fractions within r_{500}. The FO model is consistent with a constant value of unity. However, this is ruled out for the PC model with high significance. This argues strongly against a preheating model for entropy generation in the intracluster medium.



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