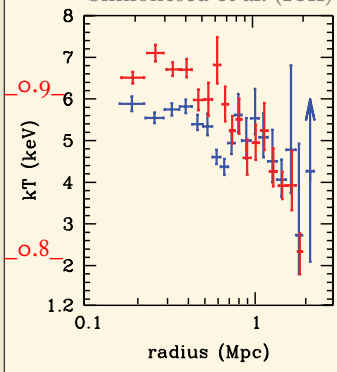
Why Aren't Clusters Isothermal?

— Sculpting Cosmic Gas into Galaxy Clusters —

Mike McCourt, Eliot Quataert, & Ian Parrish

Introduction

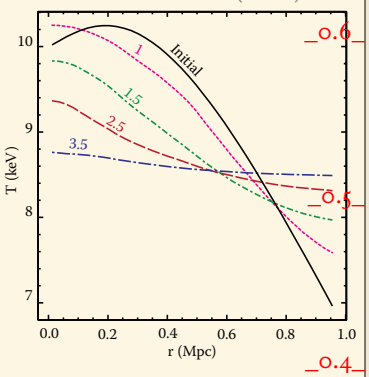
Simionescu et al. (2011)



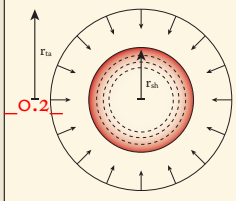
X-ray observations reveal that the hot gas in galaxy clusters steadily cools with distance from the center — this result is significant because it renders clusters unstable to a powerful convective instability known as the *magnetothermal instability*, or MTI. This result is also surprising, given that thermal conduction and convection should erase such temperature gradients, and have plenty of time to do so within the age of the universe.

Indeed, simulations of isolated clusters consistently show that the ICM becomes isothermal after a Gyr or so. Clearly, the temperature gradient is a cosmological effect, and cannot be studied in isolated simulations which neglect the cosmological context.

Parrish et al. (2008)



Entropy Generation at the Virial Shock



We use the MHD code Athena, modified to implement anisotropic thermal conduction: $Q_{\rm cond} = -\kappa \hat{b}(\hat{b}\cdot\nabla T)$.

The conductivity takes this form because the electron mean free path in the ICM is much longer than its gyroradius. The electrons (which transport most of the energy) are thus confined to move along magnetic field lines.

Results

References

McCourt et al. (2012), *Sharma et al. (2012a,b), Parrish et al. (2008)*