



Structure in the cores of galaxy clusters

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Declaration

I hereby declare that my dissertation entitled *Structure in the cores of galaxy clusters* is not substantially the same as any that I have submitted for a degree or diploma or other qualification at any other University.

I further state that no part of my dissertation has already been or is being concurrently submitted for any such degree, diploma or other qualification.

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration, unless stated explicitly. Those parts of this dissertation which have been published, or are in press, are listed below.

1. Chapter 2 is based on the paper *X-ray colour maps of the cores of galaxy clusters*, J.S. Sanders, A.C. Fabian & S.W. Allen, 2000, *Monthly Notices of the Royal Astronomical Society*, 318, 733.
2. Chapter 3 is based on the paper *Adaptive binning of X-ray galaxy cluster images*, J.S. Sanders & A.C. Fabian, 2001, *Monthly Notices of the Royal Astronomical Society*, 325, 178.
3. Chapter 4 contains work published in *Chandra imaging of the complex X-ray core of the Perseus cluster*, A.C. Fabian, J.S. Sanders, S. Ettori, G.B. Taylor, S.W. Allen, C.S. Crawford, K. Iwasawa, R.M. Johnstone, P.M. Ogle, 2000, *Monthly Notices of the Royal Astronomical Society*, 318, L65, and *Chandra image of the X-ray core of Abell 1795*, A.C. Fabian, J.S. Sanders, S. Ettori, G.B. Taylor, S.W. Allen, C.S. Crawford, K. Iwasawa, R.M. Johnstone, 2001, *Monthly Notices of the Royal Astronomical Society*, 321, L33.
4. Chapter 5 is based on the paper *Spatially-resolved X-ray spectroscopy of the core of the Centaurus cluster*, J.S. Sanders & A.C. Fabian, 2002, in press, *Monthly Notices of the Royal Astronomical Society* (preprint astro-ph/0109336)¹.

This dissertation contains fewer than 60 000 words.

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Cambridge, UK
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¹<http://www.arxiv.org/abs/astro-ph/0109336>

Summary

This dissertation explores the structure in the cores of clusters of galaxies. Galaxy clusters are the largest gravitationally bound objects in the universe, emitting X-ray radiation from a hot ($2 - 10 \times 10^7$ K) intracluster medium (ICM). In the centres of many of these clusters the mean radiative cooling time of the ICM is short ($< 10^{7-8}$ yr), therefore gas is expected to be cooling out of the X-ray band. More gas should then flow in under pressure to replace that which is deposited. Those clusters with evidence for cooling gas (a highly peaked luminosity profile) are known as cooling flow clusters.

I start by summarising the current understanding of the subject, and the observational evidence for it. An analysis of a sample of clusters using *ROSAT* archival data is then made, to look for the spectral evidence of cool gas and absorbing material in their cores, using the method of X-ray colours. Next, I discuss an original method developed to analyse spatial and spectral data from clusters, adaptive binning, which gives similar levels of signal to noise in each spatial bin. Such an algorithm is necessary to interpret the sub-arcsec resolution images of nearby clusters taken by the *Chandra X-Ray Observatory*.

I analyse a *Chandra* observation of the Perseus cluster, making temperature and absorption maps from X-ray colours, and looking at the interaction of the cooling ICM with the central radio source. For the Abell 1795 cluster I make similar maps to examine the structure of a 40 arcsec long filament found in the cluster, and hypothesise on its nature. Finally, I examine a *Chandra* observation of the core of the Centaurus cluster. Using imaging spectroscopy I make radial plots and maps of the temperature, absorption and metallicity distributions of the gas in the cluster. I discuss an unexpected drop in metallicity in the centre of the cluster, and also a plume-like feature found there.

*"The time has come," the Walrus said,
"To talk of many things:
Of shoes—and ships—and sealing-wax—
Of cabbages—and kings—
And why the sea is boiling hot—
And whether pigs have wings."*

—Lewis Carroll, *Through the Looking Glass*

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Enjoy! :-)

