UNIVERSITY OF
CAMBRIDGE

Structure in the cores of galaxy clusters

Jeremy Stephen Sanders

Pembroke College
Institute of Astronomy

This dissertation is submitted for the degree of Doctor of Philosophy

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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.

Jeremy Sanders
Cambridge, UK
18th January, 2002.

[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

Acknowledgements

This work would never have been made possible without the help of my supervisor, Andy Fabian. I would also like to thank the members of the X-Ray Group at the Institute of Astronomy, past and present, including Steve Allen, David Ballantyne, Carolin Crawford, Stefano Ettori, Roderick Johnstone, Kazushi Iwasawa, Julia Lee, Andrea Merloni, Raquel Morales, Glenn Morris, Poshak Gandhi, Robert Schmidt, Dave White, Richard Wilman, Kelvin Wu and Andy Young. I would also like to thank Greg Taylor for discussions. I would have never been able to write this dissertation without all the hard work of the *Chandra* team, making it such a superb instrument.

I would like to thank the anonymous referee who made very helpful comments about the paper on which Chapter 2 is based. I am also grateful to the referee Silvano Molendi for his comments about the paper on which Chapter 5 is based.

I am in great debt to those in my year of PhD students at the IoA for making my time here so enjoyable, including David Bacon, Andrew Dean, Andrew Firth, Chris Jordinson, Steve Moody, Celine Peroux, Rob Sharp, Mark Sullivan and Lisa Wright. I really can't mention all those bizarre lunchtimes (but how *does* one define normality?). Thanks must also go to Phil Kendall (for geek discussion), Colin Frayne (for you-know), Fraser Clarke, Sam Rix, Richard Massey, and Lynnette Dray. I am grateful to Eileen Fenton for giving me a warm welcome when I first arrived at the department, and to Paul Aslin for being a great administrator. I've probably missed lots of important people, but the Institute of Astronomy is a wonderful place to work. I must also thank Linus Torvalds and Richard Stallman for helping me mess with computers. Douglas Adams superb writing convinced me that astronomy would be fun to work in, and Malcolm Longair's fascinating Christmas Lectures were far too interesting to ignore!

I am deeply grateful for my friends Angela Taylor, Sam Thompson and Amanda George, for putting up with me for several years. I must also mention Andrew Grantham, Becky Taylor, Joy Sarker, Mike Alexander, Emma Gibbins, David Henderson, Miriam Büttner and Daniel Coetzee at Pembroke College (unfortunately I can't name all the graduates there). Finally (and *definitely* not least), I must thank my family and Siggy for support.

Enjoy! :-)