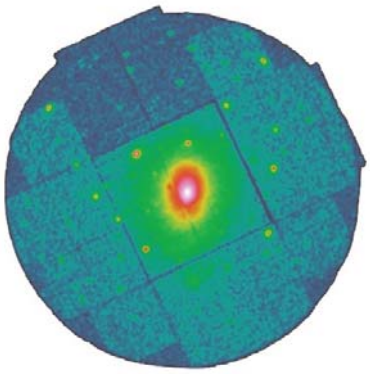

Gas Mass fractions from XMM-Newton

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1. Introduction

We present a study where the gas mass fraction of seven clusters of galaxies observed with XMM-Newton is measured. The selected clusters are fairly hot, dynamically relaxed and span the redshift range z=0.14 to 0.89. The cluster masses are derived under the assumptions of spherical symmetry and hydrostatic equilibrium, and the effects of assumptions on the spacial distributions of the gas temperature, gas density and total gravitating mass are investigated. A model independent approach is adopted to compute the final mass results from spectral fitting alone. Due to the good angular resolution of Chandra and its well-constrained background, previous studies of the gas mass fraction for constraining cosmology are largely based on Chandra observations. This work presents a complementary and independent study of galaxy clusters, where the gas mass fraction is obtained by using XMM-Newton data only. Background and PSF effects were both carefully considered. In order to check for consistency and biases, the results from this analysis are compared with previous X-rays studies from Chandra and XMM-Newton observations.

2. Data Reduction and Analysis

• Data set

Cluster	redshift	$<T_{2500}>$[keV]	G.T.I.*
A1413	0.143	7.34 ± 0.09	63 ks
A963	0.206	6.09 ± 0.15	23 ks
A2390	0.230	9.11 ± 0.45	10 ks
A1835	0.252	7.44 ± 0.08	71 ks
MS2137	0.313	4.18 ± 0.10	11 ks
RXJ0744	0.686	7.73 ± 0.42	63 ks
CL1226	0.892	12.36 ± 0.94	65 ks

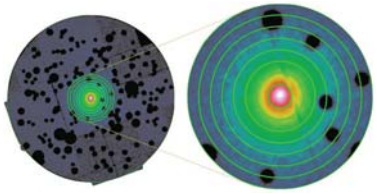
*exposure time after filtering the data – MOS only

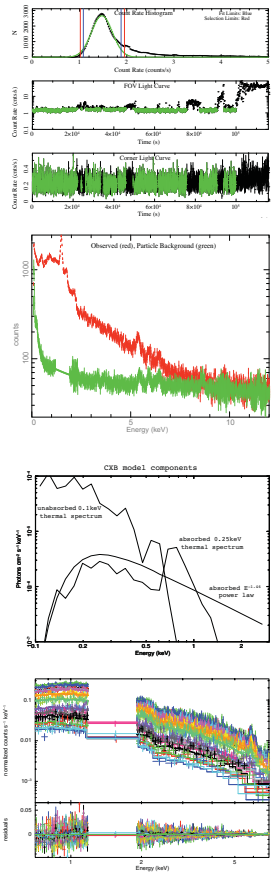
• Filtering
- Soft protons contamination.
- CCDs in anomalous states.
- Point sources.

• Spectra
- Concentric annuli centered at the peak of emission.

• Background
- Quiescent particle background (QPB)
- Fluorescent X-rays (FX)
- Soft protons
- Cosmic X-ray background model (CXB)

• Analysis
- Absorbed thermal model
- CXB model , PSF correction
- Deprojection
- Model independent





3. Results

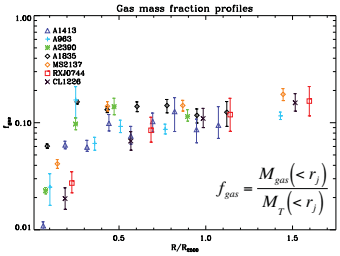
• Cluster mass (M_T)

$$M_T(<r) = \frac{kTr}{G\mu m_p}\left(\frac{d\ln\rho_{gas}}{d\ln r} + \frac{d\ln T}{d\ln r}\right)$$

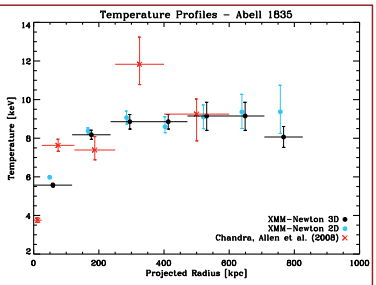
• Gas mass (ρ_{gas})

$$M_{gas}(<r_k) = \sum_{i=1}^{n} \frac{4}{3}\pi\left(r_k^3 - r_{k-1}^3\right)\rho_{gas}(r_i)$$

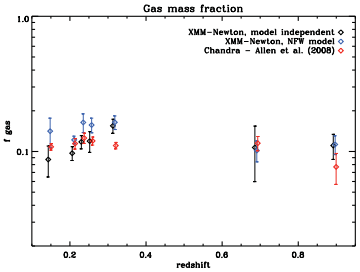
• Gas mass fraction (f_{gas})



$$f_{gas} = \frac{M_{gas}(<r_j)}{M_T(<r_j)}$$



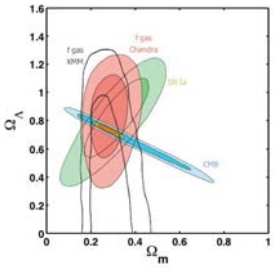
Comparison of the projected and deprojected temperature profile of A1835 from XMM-Newton and Chandra observations.



Gas mass fraction for each galaxy cluster computed at R_{2500}.

• Conclusions

The model independent measurements of the gas mass fractions from XMM-Newton observations are in overall agreement with the results from Chandra.
The gas mass fractions from XMM-Newton, derived in this study, can be used to constrain cosmological parameters in consistence with the constraints by Allen et al. (2008) with Chandra data based on a much larger sample. The constraint on Ω_m is comparable to previous results and no significant constraint on dark energy was achieved. A larger sample of clusters from XMM-Newton would provide competitive constraints on Ω_Λ.



Cosmological constraints showing the 1 and 2σ confidence constraints in the Ω_m, Ω_Λ plane for the XMM-Newton gas mass fraction data (black, no filling) over plotted on the results reported by Allen et al. (2008) for the Chandra gas mass fraction data (red contours). [Original figure from Allen et al. (2008)]

Main references:
Ferreira 2011, PhD thesis, Gas mass fractions from XMM-Newton, Dark Cosmology Centre, Niels Bohr Institute, University of Copenhagen.
Snowden et al. 2008, A catalog of galaxy clusters observed by XMM-Newton, A&A, 478, 615-658.
Snowden and Kuntz, Cookbook for analysis procedures for XMM-Newton EPIC MOS observations of extended objects and the diffuse background, Version 4.0, 2009.
Allen et al. 2008, Improved constraints on dark energy from Chandra X-ray observations of the largest relaxed galaxy clusters, MNRAS, 383, 879-896.
Allen et al. 2004, Constraints on dark energy from Chandra observations of the largest relaxed galaxy clusters, MNRAS, 353, 457-467.
Voigt L. M. and Fabian A. C. 2006, Galaxy clusters mass profiles, MNRAS, 368, 518-533.

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