Radial Profiles of PKS 0745-191 Galaxy Cluster With XMM-Newton X-Ray Observations

Aysegul Tumer[1], Cemile Ezer[1], E. Nihal Ercan[1]

[1]Department of Physics, Bogazici University, Istanbul, Turkey

Abstract

In this work, brightest distant galaxy cluster PKS0745-191 (z~0.1028) is studied. 2014 XMM-Newton observations of this cooling flow cluster PKS0745-191 are analyzed and radial temperature, abundance, pressure and entropy profiles are presented.

Introduction

Clusters of galaxies are the largest comprehensive samples of the universe. The X-ray emission from intra-cluster medium (ICM) which contains hot dilute gas provide information on the temperature, pressure, entropy of a cluster.

PKS0745-191 is a well studied cluster at the virial radius with Suzaku[1][2]. Chen et al.(2003) has studied the temperature and abundance profiles by using the XMM-Newton 2000 data (one center and one off center observation) with total uncleaned exposure time about 75ks[3].

In this work we focus on the central region of the cluster with much smaller annuli in order to better understand the effect of substructures.

Observations

Table 1: XMM-Newton Observations of PKS 0745-191

Observations (Center)	ID	Start Date yyyy-mm-dd	End Date yyyy-mm-dd	Pointing RA (J2000)	Pointing Dec (J2000)	PI
Scheduled	0744340101	2014-10-07	2014-10-07	07h 47m 31.25s	-19d 17′ 40.3"	Sanders, Jeremy
Unscheduled	0744340101	2014-10-09	2014-10-09	07h 47m 31.25s	-19d 17′ 40.3"	Sanders, Jeremy

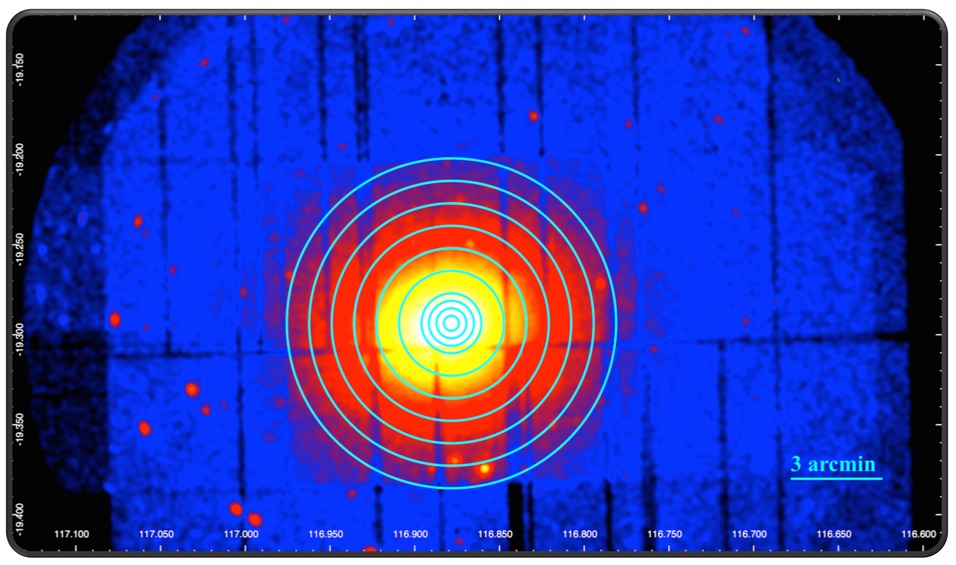

Figure 1 Background subtracted, exposure corrected combined EPIC image of PKS0745-191. Circles indicate the annular regions used for the spectral fitting.

Data Preparation

For cleaning of the raw data, image production, and annuli spectra production ESAS package of SAS software, v16.0. with the latest calibration files and additional CalDB files were used. Due to ground problems during the observation,unscheduled observations of EPIC cameras (ID: U002) with exposure times longer than 100ks were used (Table2).

Ten annular regions from the center of the cluster to 5'.5 are used for spectral fitting. CCD6 of MOS1 has been struck by a meteorite and CCD4 of both EMOS1 and EMOS2 were in anomolous state, and were further excluded from the analysis.

Table 2: Scheduled and Unscheduled Exposures

Exposure ID	Instrument	Duration (sec)	Clean Exposure (sec)
S001	EMOS1	9039	Unprocessed
S002	EMOS2	9027	Unprocessed
S003	EPN	5334	Unprocessed
U002	EMOS1	106160	95670
U002	EMOS2	106157	97100
U002	EPN	107313	75930

Spectral Fitting

- Ten annular regions from the center of the cluster to ~ $0.5R_{500}$ are used for spectral analysis.
- For the background estimation, RASS data for the cluster PKS0745-191 with specified regions covering 1° and 2° annulus were used.
- The galactic absorption column density was fixed at value 4.2E21 cm^{-2}.
- Spectral fits were performed with Xspec v12.9.1.using chi-square statistics.
- The spectra were modeled by a single temperature APEC model.However, it is found that the outermost annulus has been subjected to another cool temperature component model and required double temperature APEC model.
- DsDeproj code was used to obtain the deprojected spectra, and the best fit parameters of deprojected spectra were used to calculate the cluster's pressure and entropy profiles.[4]

Results And Discussion

Table 3: Simultaneous projected spectra fit of EPN and EMOS with a single temperature model. Errors represent 90 per cent ($\Delta\chi^2 = 2.71$) confidence limits.

Regions (arcmin)	Temperature (keV)	Abundance ($Z_\odot$)	χ^2	d.o.f.
0-0.25	$4.01^{+0.04}_{-0.04}$	$0.42^{+0.01}_{-0.01}$	1.54	1380
0.25-0.50	$5.05^{+0.05}_{-0.04}$	$0.37^{+0.01}_{-0.01}$	1.43	1830
0.50-0.75	$5.54^{+0.08}_{-0.04}$	$0.36^{+0.01}_{-0.01}$	1.66	1655
0.75-1.00	$6.17^{+0.09}_{-0.08}$	$0.35^{+0.02}_{-0.02}$	1.40	1477
1.00-1.50	$6.52^{+0.08}_{-0.07}$	$0.34^{+0.02}_{-0.02}$	1.39	1893
1.50-2.00	$6.62^{+0.08}_{-0.08}$	$0.34^{+0.02}_{-0.02}$	1.48	1660
2.00-2.50	$6.97^{+0.15}_{-0.15}$	$0.29^{+0.02}_{-0.02}$	1.43	1290
2.50-3.50	$7.36^{+0.16}_{-0.14}$	$0.28^{+0.02}_{-0.02}$	1.39	1356
3.50-4.50	$6.68^{+0.14}_{-0.13}$	$0.30^{+0.03}_{-0.03}$	1.72	960
4.50-5.50	$6.45^{+0.10}_{-0.10}$	0.300 (fixed)	1.73	748

Table 4: Simultaneous projected spectra fit of EPN and EMOS with a two component temperature model for region 10.

	Regions (arcmin)	Temperature (keV)	Abundance ($Z_\odot$)	χ^2	d.o.f.
T_{cool}	4.50-5.50	$2.17^{+0.59}_{-0.46}$	$0.14^{+0.09}_{-0.08}$	1.30	744
T_{hot}	4.50-5.50	$10.19^{+0.56}_{-0.68}$	$0.43^{+0.06}_{-0.07}$	1.30	744

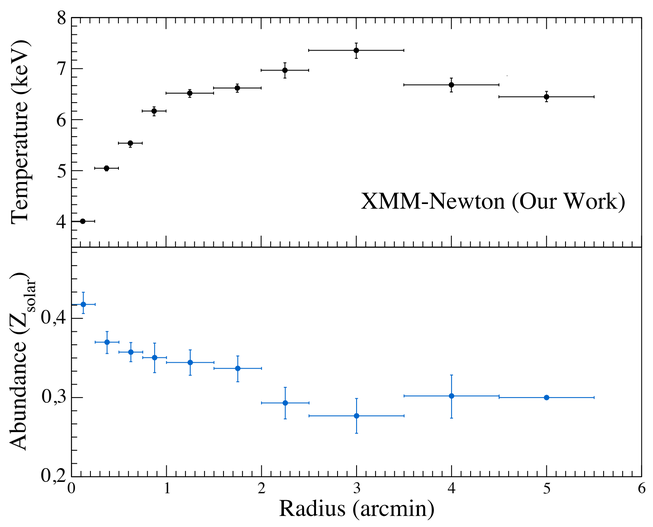

Figure 2: The temperature and abundance profiles by using 1T apec model.

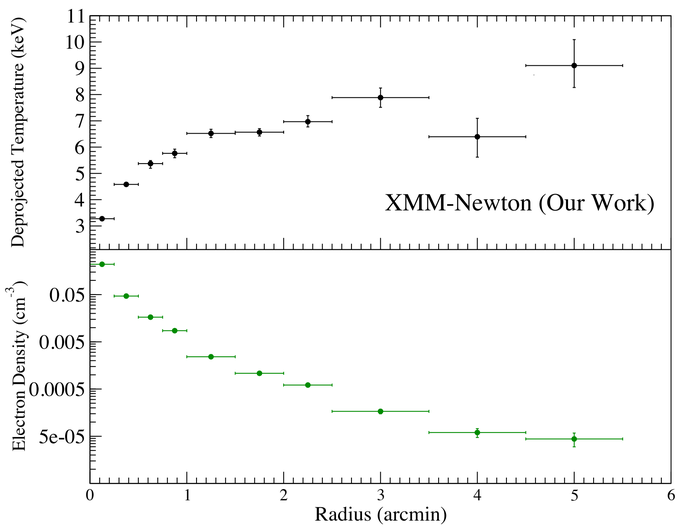

Figure 3: Deprojected radial temperature and electron density profiles are obtained from single temperature apec model in 0.7 - 9.0 keV energy range. The statistical errors at 90% confidence level.

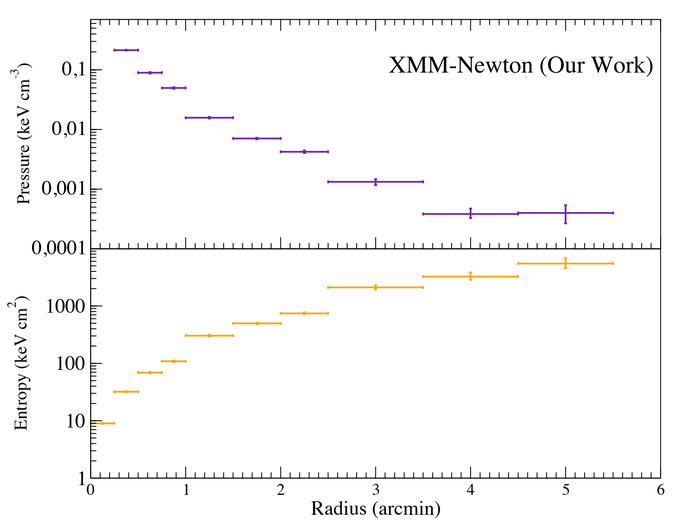

Figure 4: The pressure and entropy profiles with 90% statistical errors. The radial entropy profile increases from the center to outskirt.

The radial temperature and abundance profiles are in good agreement with the work of Chen et al. [3]. The goodness of the fits can be seen from Table 3.For the outmost annulus, we have compared the statistics of single temperature and two temperature apec model. Improvement in resulted fits (Table 4) may suggest that around 5'.5, there is multi-phase gas existing. Temperature at the core is comparably lower than the neighboring regions pointing that PKS 0745-191 is a cool core cluster. The abundance profile shows a constant trend in the outskirts.(Figure 2)

References:

[1] Walker,S.A.,*et al*, 2012,MNRAS,424.
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[3] Chen,Y.,*et al*, 2003, A&A, 407.
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