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X-RAY OBSERVATION OF GALAXY CLUSTER ABELL 548B, POSSIBILITY OF MERGER.

L.Solovyeva[1], S.Anokhin[1], J.-L. Sauvageot[1], R.Teyssier[1] and L.Feretti[2]

Abstract.
We present a detailed X-ray analysis of the galaxy cluster Abell548b (z=0.04) from new XMM-Newton data. We analyse X-ray data to understand better the merger dynamics of Abell548b and its connection with radio relics.

1 Introduction

In hierarchical formation models, such as the Cold Dark Matter model, cluster of galaxies are formed from mergers of smaller units that have previously collapsed. Cluster are thought to form preferentially at the crossing of filaments and to grow by anisotropic metter infall sub cluster mergers along them. Merger events are thus central to theories of cluster formation. The study of cluster in non-relaxed states, and of potential merger events, has been one of the major research fields in recents years. We present the X-ray study of the one galaxy cluster to investigate in a deeper detail the observable characteristics of the merger event. X-ray observations of galaxy clusters allow us to study the hot intra cluster medium (ICM), which is the main baryon source in cluster of galaxies. Now with the help of XMM-Newton and Chandra we can obtain the detailed temperature distribution of the ICM, which can explain the influence of the cluster formation history on the thermodynamics of the gas. We would like to study the dynamical state of galaxy cluster A548b by detailed X-ray anlysis from new XMM-Newton data, to understand the connection between X-ray and radio relics. Here, we present a detailed spectra-imaging study of the A548b using the new XMM-Newton data we performed the image analysis, we obtained the detailed surface brightness profiles. Secondly, we did a spectral analysis in particular we obtained the total temperature profile and temperature profiles in sectors. We compered our results with radio relics location. In our analysis we assume the concordance cosmology with $H_0 = 70 kms^{-1} Mpc^{-1}$, $\Omega_m = 0.3$, $\Omega_\Lambda = 0.7$. At the redshift of the Abell 548b cluster, z=0.04, the angular scale of 1' corresponds to a linear size of 47 kpc.

2 Observation and data reduction

Abell 548b was observed on 2006 February 17 with 70 ksec for EPIC MOS cameras and 64 ksec for pn camera (45 and 33 ksec with flare subtraction corresponding). Fig.1 a) shows the A548b observation of XMM-Newton with contours radio relics (A,B,C). The position of observation was chosen for detailed study the region between cluster and radio relics to understand the physical phenomena and the connection between the radio emission and the X-ray emission. For data analysis we used background of J. Nevalainen (Nevalainen et al., 2005). We used the method of double background substraction by Arnaud et al., 2002. Note in all analysis we used the data from three EPIC cameras, but in image analysis we used EPIC cameras MOS2 and pn, because we do not have statistics in CCD6 for camera MOS1. From count rate of observation data we detected and excluded the periods of "flare". For correction of the vignetting effect in observation and background data we used the weighted function by Majerowicz et al., 2002. The sources were detected in the 0.3-4.5 keV energy bands. We excluded all detectable point sources from the data observation in our spectral and spatial analysis, detected point sources were masked with circles.

[1] CEA/DSM/DAPNIA, Service d'Astrophysique, L'Orme des Merisiers, Bat.709, 91191 Gif-sur-Yvette, France
[2] INAF Institudo di Radioastronomia, via P.Gobetti 101, I-40129 Bologna, Italy

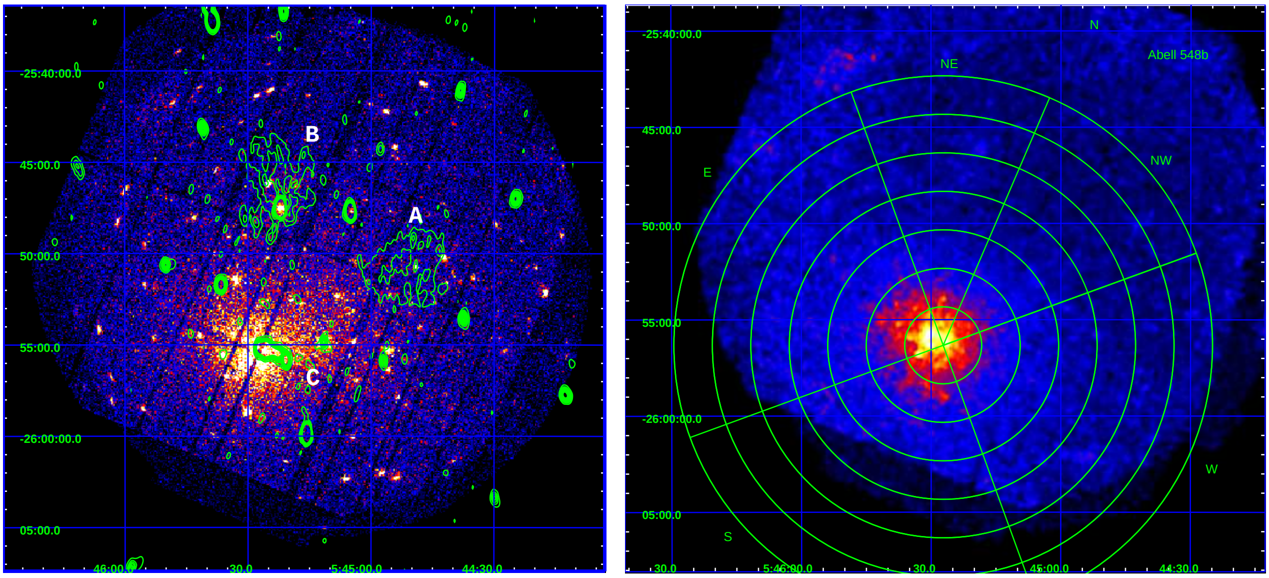

Fig. 1. a)Obtained X-ray image from XMM data, three cameras was summed.b)X-ray corrected smoothed image from XMM data with chosen sectors.

3 X-ray image

X-ray XMM image uncorrected for background or exposure is shown in Fig.1, the observation of XMM as effected by gap and also we have not statistics in the MOS1 by the absence of the CCD6. We chose the centre of X-ray emission from the ROSAT image (Bohringer et al., 2004). To show the gas perturbation and X-ray structure we need in corrected X-ray image on the vignetting effect, the background, the pointed sources and gap or we need in detailed surface brightness profiles in which we used the corrected background subtraction, the vignetting correction function and subtraction of pointed sources.

3.1 Corrected X-ray image with modelling of background from observation data

The astrophysical background plays a important role in the data analysis of galaxy clusters so we supposed that it is better to use the observation data for modeling of background. Also this observation is very sensible for vignetting effect, because A548b was observed in the south extern region of field of view so we need in vignetting correction for our image. Using observation data we modeled the Cosmic X-ray background (CXB) and non X-ray background (NXB) components of the background (Arnaud et al., 2002). The CXB component of background is vignetted by X-optics, but the NXB component is not. In this analysis we did the following: selection of the "flare" events in the observation data, creation of the surface brightness profile from observation data, using the vignetting function for searching the CXB and NXB components of the background by minimizing χ^2 in the outer regions. After we obtained image with CXB and NXB components of background with correction of vignetting effect Finally we subtracted the obtained image of background from the observation.

For our image analysis we need in correction of the gap and point sources so in the region where mask has the value equal zero we filled theirs with the chosen mean value of environment multiply by random values from Poisson distribution. We summed the obtained images for cameras MOS2 and PN, note we do not use camera MOS1 therefor the absence of important CCD6. Fig.1b shows obtained images without background, with gap and point sources correction, this image was smoothed with Gaussian filter and shows the chosen direction of sectors for study.

3.2 Surface brightness profile

Abell 548b is not relaxed cluster (Davis et al., 1995), it is interesting to study their density distribution and fit with beta model in different directions so to do the detailed analysis of surface brightness profiles.

We extracted the surface brightness profile of the cluster and background in the 0.3-4.5 keV energy band. To obtain the surface brightness profile we used the double background subtraction for each chosen sector region.

We determined the radial total surface brightness profile and surface brightness profiles in four direction: north, western, eastern and also we performed the detailed analysis in the relic directions. The chosen sectors were shown in Fig.1b. Fig.2 shows the obtained radial surface brightness profile and Fig.3 shows the surface brightness profiles in different directions.

Each surface brightness profile we fitted with the β-model (Cavaliere and Fusco-Femiano, 1976). Note we did not use the first ten points because from DSS data in the centre cluster are had the galaxy triplet VV 162. The results of beta fit was shown in the Tab.1. We obtained a beta fit for each direction with bad $\chi^2_{reduced}$, so it is consisted that it is not relaxed cluster.

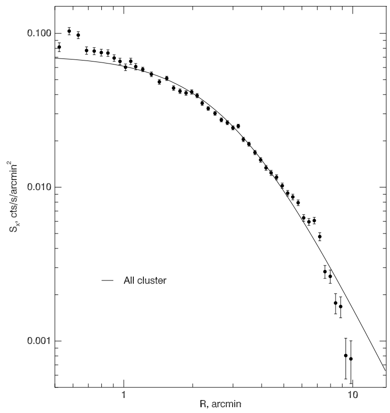

Fig. 2. Radial surface brightness profile and beta-model fit.

We observed the perturbation in each surface brightness profile. From results of radial surface brightness profile we observed the more significantly perturbation in 2' and 5'

Table 1. A548b, β-model fit in different directions

direction	β	r_c(arcmin)	$\chi^2_{reduced}$
radial	$0.67^{+0.08}_{-0.02}$	$3.01^{+0.13}_{-0.20}$	171/40
West	$0.56^{+0.03}_{-0.03}$	$2.52^{+0.44}_{-0.45}$	96/33
East	$0.80^{+0.06}_{-0.07}$	$3.91^{+0.40}_{-0.41}$	78/34
North	$0.62^{+0.03}_{-0.03}$	$2.74^{+0.20}_{-0.21}$	134/40
North-West	$0.72^{+0.06}_{-0.07}$	$3.79^{+0.42}_{-0.47}$	161/39
North-East	$0.60^{+0.03}_{-0.03}$	$2.22^{+0.22}_{-0.25}$	65/38

4 Spectral analysis

In our spectral analysis we used three cameras of XMM-Newton, the background of J. Nevalainen, the method of double background substraction by Arnaud et al., 2002 and we fitted spectrum with XSPEC using a redshifted MEKAL plasma emission model with absorbtion $N_H = 2 \cdot 10^{20} cm^{-2}$ and abundance = 0.3. We obtained a mean temperature for cluster A548b in 3' the best fit gives $kT = 3.3 \pm 0.1 keV$ and the reduced χ^2 is 1.02 Fig.3 a) shows obtained radial temperature profile for A548b up to 10', temperature was obtained for each 2'.

We extracted spectra in the sectors and fitted with MEKAL model. The reference point of sectors was chosen at centre cluster emission. We extracted spectra in each sectors up to 10' the size of sectors was chosen similar of size annuli for radial temperature profile, see Fig.1b).

We obtained temperature distribution in each directions. Fig. 3 shows the obtained temperature profiles in each direction: N, W, E and total. We observed a more significantly increasing of the temperature for north direction, in 5'-6', this is the direction on relics A and B, just before the relic location.

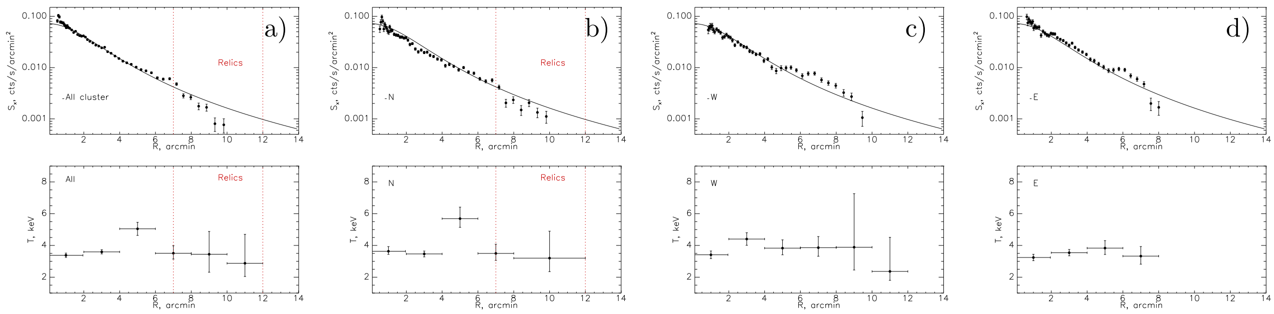

Fig. 3. a)Obtained surface brightness profiles and temperature profiles in each direction: a) total b) North c) West d) East.

5 Conclusion

From our detailed X-ray analysis we observed a more significantly perturbation, in particular the increasing of the temperature in north direction so to direction relics A and B. Is is very probably that it is the signature of the shock to relic direction. Also we observed the perturbations in each surface brightness profiles, more significantly in 2' and 6' (see Fig.3). o understand better these perturbations in emission and their signatures we need compare our results with simulation. From our analysis we detected the strong temperature and density variations, it is very typical signatures of mergers events. To determine the scenario of their formation and to analyse the complex physical processes during their evolution we need in different wavelength studies of this cluster and comparison with simulation.

References

Arnaud, M.,Majerowicz, S., Lumb D., et al 2002, A&A, 390, 27

Bohringer, H., Schuecker, P., Guzzo, L., Collins, C. A., Voges, W., Cruddace, R. G., Ortiz-Gil, A., Chincarini, G., De Grandi, S., Edge, A. C. 2004, A&A, 425, 367B

Cavaliere, A., Fusco-Femiano, R. 1976, A&A, 49, 137

Davis, D., Bird, C., Mushotzky, R., Odewahn, S., 1995, ApJ, 440, 48D

Feretti, L., Neumann, D. M., 2006, A&A, 450L, 21F

Majerowicz, S., Neumann D. & Reiprich, T. 2002, A&A, 394, 77

Nevalainen, J., Markevitch, M., Lumb, D. 2005, ApJ, 629,172