ANALYSIS OF TEMPERATURE AND ABUNDANCE DISTRIBUTION IN ABELL 3571: AN ONGOING SUBCLUSTER MERGING ?

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Abstract

We present bi-dimensional temperature and abundance analysis of the ICM by using archival data of *ASCA*. Spectrum best-fit result within a radius $12'$ is a 7.2 ± 0.2 keV temperature value. This is consistent with the previous *ASCA* analysis of Nevalainen et. al. (6.9 ± 0.2 keV). Bi-dimensional temperature map shows a region with significantly lower temperature value (6.2 ± 0.5 keV) than the ICM average and with a remarkable cool trail-like shape in the northwest of the cluster. Equivalent-Width map also displays a high abundance region on the west side, which coincides with the head of the cool trail. Quintana & Souza (1993) indicates a north-south direction alignment in the galaxy number density map. We record a disturbance of the X-ray brightness map in the same direction. In addition to above all, having an extended optical halo of its central galaxy MCG05-33-002 (Kemp & Meaburn 1991) in the same direction suggests that -if the locations of peculiar regions are not a chance projection- A3571 is experiencing an ongoing subcluster merging: A subcluster is coming from northeast of the main cluster, penetrating in the ICM and leaving a cool trail -due to destructive effects like ram pressure stripping- and a survived high abundance core for the present epoch.

1 Introduction

A3571 is a nearby (z=0.04) bright, hot (~ 7 keV) and a rich (> 100 galaxies) Bautz-Morgan type I cluster of galaxies (Abell et al. 1989). It possesses a giant galaxy MCG05-33-002 with extensive optical halo at the center (Kemp & Meaburn 1991). Quintana & de Souza (1993) suggested that the velocity distribution is asymmetric and the bi-dimensional galaxy map presents some indications of substructure. However, ASCA (Markevitch et al. 1998) and ROSAT (PSPC) (Nevalian et al. 2000) observation results of this cluster do not show significant substructure. Venturi et al. (2002) suggest that A3571 is a very advance merger, in the radio properties derived from their studies. In this study we delineate a submerging event in A3571 by reporting our analysis results of bi-dimensional temperature and metal distributions and considering the northeast galaxy density elongation to be the debris of an infalling subcluster.

2 Data Reduction and Analysis

A3571 was observed 3 times (Table 1). The former one is the only on-source observation and the others are having $\sim 14'$ offset focusing (Figure 1). For all three observations we employed standard reduction procedure.

Table 1: Log of ASCA observations

Observed Date	GIS exp.(sec)	SIS exp.(sec)	RA(J2000)	DEC(J2000)
Aug,1994	24,118	23,290	$13^h\ 47^m\ 21.4^s$	-32° 51′ 18″
Jan,1997	22,270	21,953	$13^h\ 48^m\ 32.2^s$	-32° 47′ 43″
Feb,1997	24,189		$13^h\ 47^m\ 22.3^s$	-33° 06′ 28″

To check the consistency with earlier measurements, we first analyzed the spectrum in R < 12′ that includes most of the cluster emission (Figure 2). For extracting the region we centered on the brightness peak. We use $H_0 \equiv 50\ h_{50}$km s^{-1}Mpc^{-1} and report 90 % confidence intervals throughout this paper.

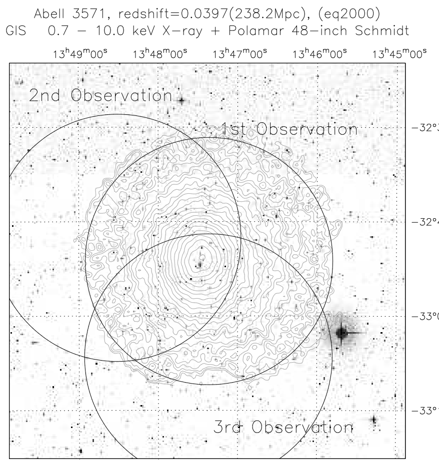

Figure 1: Three pointings of *ASCA* observations are shown with a circle of R=20′ superimposed on the contour map of the observation overlaid on the Digitized Sky Survey. 10 levels of counter lines refer to 1 order.

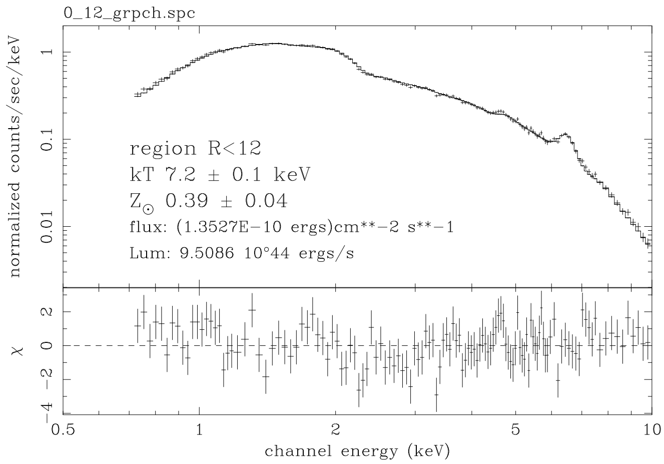

Figure 2: GIS spectrum from within a radius of 12′ fitted with the MEKAL model. Best fit parameters are scripted below the graph. ($N_{\rm H}$ is fixed at 3.69 $\times 10^{20}$cm^{-2}).

3 Temperature Map

Bi-dimensional temperature map (Figure 4) was made from the hardness ratio map, which was derived from two adjacent energy bands where the continuum component dominates and the contributions of absorption and line emissions are negligible. In this sense we used the flux ratio of 3-6 keV / 2-3 keV. We defined four peculiar regions to extract spectra.

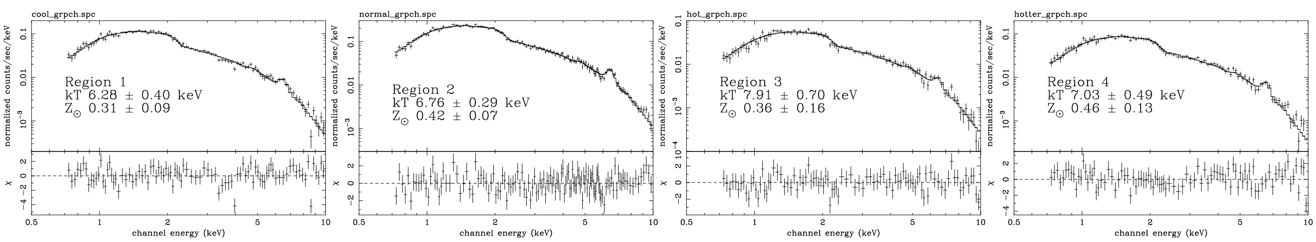

Figure 3: Spectra of the peculiar regions selected from Temperature Map (Figure 4)

The spectral result is giving us the same tendency with an exception of the region denoted 4 in

Figure 3. The most spectacular region is the region 1 which shows the lowest temperature value in a trail-like shape on the northwest side of the core. It has a significantly lower temperature value of 6.3±0.4 keV than the average cluster value.

4 *EW* Map of Fe Kα Line

As a next step, we discussed the bi-dimensional iron abundance distribution by making the equivalent width map of iron Kα line. The *EW* is defined for this cluster as it is described below;

$$EW \equiv (I_{6-7}keV - 0.1028 \times I_{3-6}keV)/(0.1028 \times I_{3-6}keV) \quad (1)$$

Where I_{3-6} keV and I_{6-7} keV are the intensities in the energy band of 3-6 keV and 6-7 keV respectively. The term 0.1028× I_{6-7} keV represents the continuum component at the 6-7 keV band when assuming that the cluster is isothermal at $kT \sim 7$ keV. The *EW* map of the Fe Kα line is shown in Figure 5. Spectral results show the same pattern as the map does. One can easily see *Region A*, has the highest abundance value 0.51±0.15 $Z_{\odot}$ (Figure 6).

5 Residual Image

In order to investigate the gas density excess we simulated a distribution of X-ray surface brightness by employing elliptical model and subtracted the simulated image from the observed $0.7'$-$10'$ data. The resultant residual image is shown in Figure 7. Here we used the core radius $r_c = 3'.85 \pm 0'.35$, $\beta = 0.68 \pm 0.03$ (Nevalainen et al. 2000) and position angle = 100°. Northern part has larger ellipticity than that of the south. To compromise both regions we set an intermediate value of axial ratio = 1.35, which is determined from azimuthal brightness structure. The peak of the cD is easily seen with its red colored excess. The white spot, which is located in the north of the center, is the contribution of an X-ray source (EXMS B1344-325). Interpretation of the west-east part of the image is supportive to our merging suggestion. The east side, where there is no peculiarity gives a negative residual. We would expect the west side to give the same result, unless there is an irregular phenomenon happening there.

6 Discussion

It is clearly seen that galaxy density map (Figure 8) shows an elongation, as the cD galaxy of A3571 does, in the NE-SW direction. Considering our analysis results and locating the cool temperature trail (blue) and a coinciding head of high abundance core (red), it seems like A3571 is experiencing a subcluster merger. We propose that a subcluster (or subgroup) is penetrating to ICM of main cluster. We see a survival high-density core and a comet like trail, which is the striped material of its surrounding halo due to ram pressure and other destructive effects.

References

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Venturi et al. 2002, A&A, 385, 39

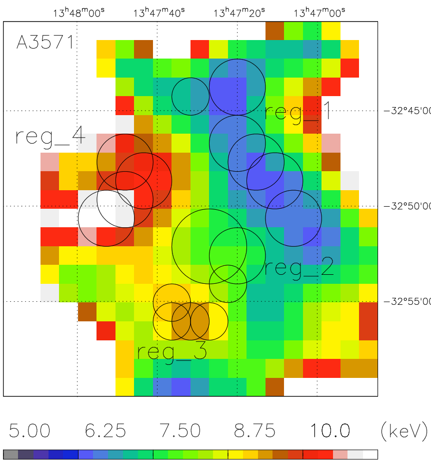

Figure 4: Color-coded temperature map with selected peculiar regions. Image size is 20′ × 20′ and centered on the brightness peak. Typical error in the studied region is less than 20%.

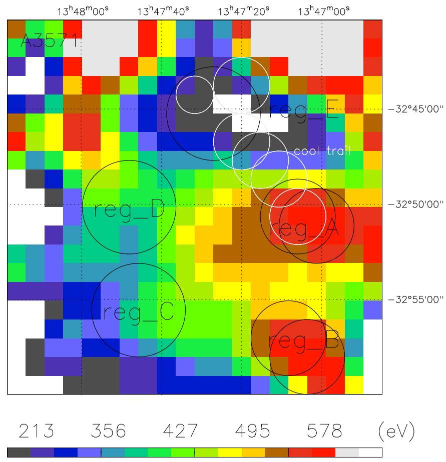

Figure 5: Color coded *EW* map of Fe Kα line with peculiar regions. White circles show the location of the cool trail determined in Figure 4. Image size is 20′ × 20′ and centered on the brightness peak.

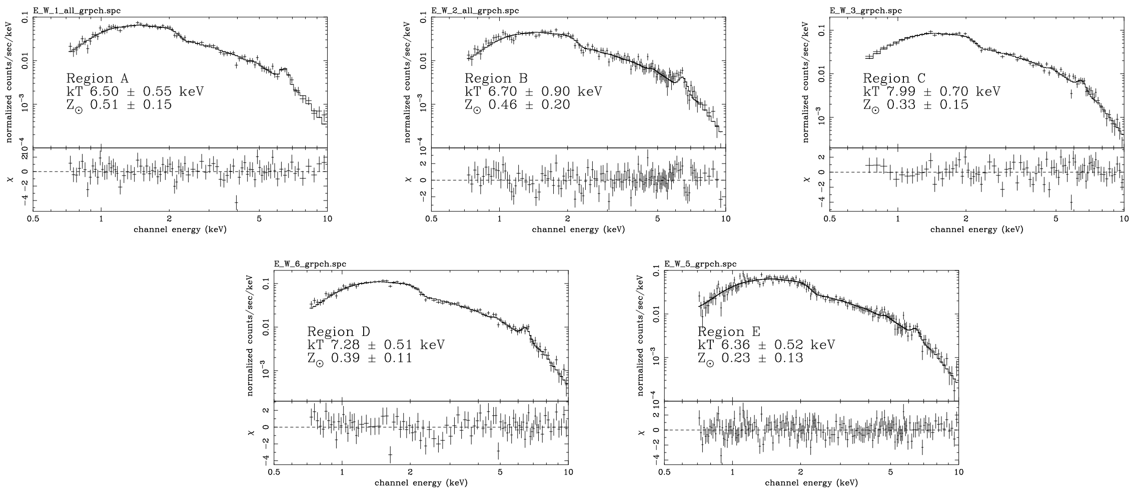

Figure 6: Spectra of peculiar 5 regions defined from *EW* map (Figure 5).

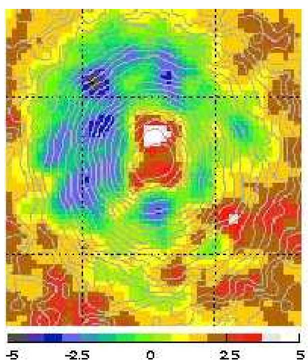

Figure 7: 2Mpc × 2Mpc residual image within ±5 σ error range. Image is centered on the brightness peak. Contours show X-ray surface brightness.

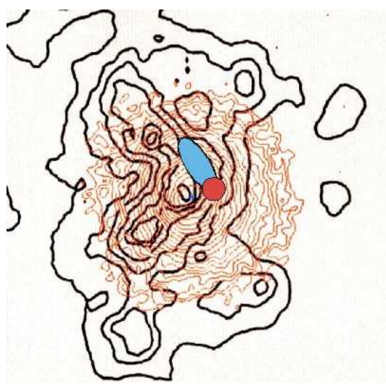

Figure 8: X-ray image contours (red) are overlaid on galaxy density map (black). 4Mpc × 4Mpc image is centered on the brightness peak.