Suzaku Observation of Large Scale Structure Filaments around ZwCl0823.2+0425 Found through the Local Cluster Substructure Survey

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Abstract

Around ZwCl0823.2+0425, several dark matter halos are found via the Local Cluster Substructure Survey (LoCuSS), which suggests that those halos constitute large-scale structure filaments. We observed a region around the cluster ZwCl0823.2+0425 (z=0.2248) with Suzaku. ZwCl0823.2+0425 itself and the halo in the north of it are clearly bright in X-ray. According to the SDSS spectroscopic data, the north and northeast halos are at the redshift of z=0.472, and the northwest one is at that of z=0.2248. Therefore, it is clear that two large-scale filaments overlap in this region. In the northeast halo area, where the lensing signal is relatively weak, very faint X-ray excess is detected. On the other hand, in the northwest and southeast small halo area, which have the stronger weak lensing signal than the northeast halo area, little X-ray excess is detected. Such a diversity of X-ray properties suggests a variety of the concentration degree of baryon and baryon fraction itself. We investigate $L_{\rm x}$-T and M-T relations for ZwCl0823.2+0425 and the other sub halos. The obtained $L_{\rm x}$-T relation does not agree with the former typical results, and the M-T relation is slightly deviated from the self-similar model (3.3σ), though any systematic errors of the background are not considered at present.

Key words: galaxies: clusters: individual (ZwCl0823.2+0425) — X-rays: galaxies: clusters — gravitational lensing

1. Introduction

Sub-cluster scale dark matter halos occupy a very large volume in the universe. Thus, they have important information of cluster of galaxies. If we obtain various physical parameters such as mass, baryon fraction, metal abundance, and their correlations, it enables us to understand how clusters evolve in the structure formation in the universe. With the joint analysis of the data of Suzaku and Subaru, we can determine the various physical parameters for sub halos. Around ZwCl0823.2+0425, several dark matter halos are found via LoCuSS (Okabe et al. 2009). Figure 1 shows projected mass distribution derived from the weak lensing analysis for this region.

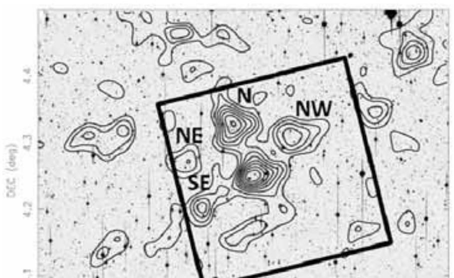

Fig. 1. Optical image of the region around ZwCl0823.2+0425 overlaid with the mass contour derived from the weak lensing analysis. The field of view of Suzaku XIS is also shown in a black square.

2. Observation

Observation of the region around ZwCl0823.2+0425 was carried out with Suzaku on 17-18, May, 2009. The XIS was operated in the normal full-frame clocking mode. The effective exposure time of XIS is 41.3 ksec. The spaced-row charge injection was adopted. Figure 2 represents the 0.5-10.0 keV XIS0 image, which is corrected for exposure and vignetting effect after subtracting non X-ray background.

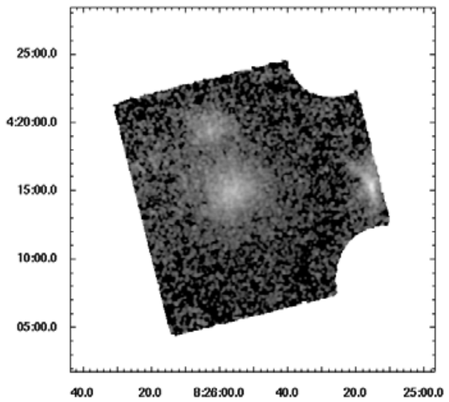

Fig. 2. XIS0 image of the region around ZwCl0823.2+0425 in the 0.5-10.0keV band. The image is corrected for exposure and vignetting effect after subtracting non X-ray background.

3. The Results

Before spectral analysis of the cluster and sub halos, we have to determine the background model. The background model are composed of cosmic X-ray background (CXB), the hot gas around the Solar system, hot gas in the Galactic halo, and Galactic absorption. We fit the data outside the cluster and sub halos by a model of APEC+WABS×(APEC+APEC+POWERLAW). With this background model, we perform spectral analysis of the cluster and sub halos. We make spectra for circular regions whose radii are 2.5', 2', and 1.8' for the cluster, N and SE, and NE and NW, respectively. We fit the observed XIS spectra by a model of WABS×APEC. The fitting results are summarized in table 1. In NW sub halo region, a little X-ray excess is detected. In SE region, the number of detected photons is so small that we cannot determine the temperature and luminosity.

Table 1. The spectral fit results for each halo

Region	kT (keV)	Abundance
ZwCl0823.2+0425	$4.72^{+0.28}_{-0.22}$	$0.32^{+0.08}_{-0.07}$
N	$5.84^{+0.74}_{-0.72}$	$0.30^{+0.15}_{-0.15}$
NE	$3.74^{+1.51}_{-0.97}$	0.30 (fixed)
NW	$1.72^{+0.60}_{-0.33}$	0.30 (fixed)

Next, we investigate $L_{\rm x}$-T and M-T relations for ZwCl0823.2+0425 and sub halos. Previous typical observations show $L_{\rm x}E(z)^{-1} \propto T^{2.5-3.0}$ (e.g. Ikebe et al. 2002), where $E(z) = \sqrt{\Omega_m(z+1)^3 + \Omega_\Lambda}$. Figure 3 shows the $L_{\rm x}$-T relation obtained from our results. This indicates $L_{\rm x}E(z)^{-1} \propto T^{3.8(\pm 0.11)}$, which does not agree with the former typical results. A self-similar model pre-

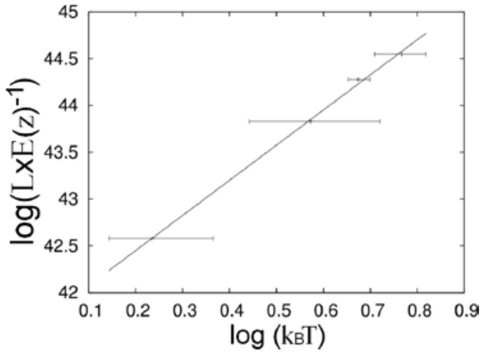

Fig. 3. $L_{\rm X}$-T relation obtained from the observed halos. Error bars stand for the 90% statistical errors. Solid lines represent the best fit power-law model ($L_{\rm x}E(z)^{-1} \propto T^{3.8}$).

dicts $ME(z) \propto T^{1.5}$ (Kaiser 1986). Figure 4 shows the M-T relation derived from our data, which indicates $ME(z) \propto T^{1.3(\pm 0.06)}$. This is slightly deviated from the self-similar model (3.3σ). However, it should be noted that any systematic errors of the background are not considered at present, which could affect the above-mentioned results.

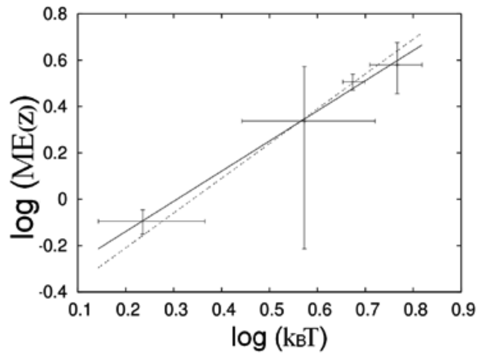

Fig. 4. M-T relation obtained from the observed halos. Error bars stand for the 90% statistical errors. Solid and dashed lines represent the best fit power-law model ($ME(z) \propto T^{1.3}$) and that predicted by the self-similar model, respectively.

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