X-RAY PROPERTIES IN GALAXY CLUSTERS

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ABSTRACT

Using XMM-Newton, we observed 14 distant X-ray luminous ($z \sim 0.3$) galaxy clusters selected from the REFLEX survey (REFLEX-DXL sample). We derived the X-ray properties of the REFLEX-DXL galaxy clusters using a double background subtraction method in Zhang et al. (2004). Cluster mass measurements based on the X-ray data have been used to study the X-ray galaxy cluster scaling relations and their intrinsic scatter. This is important for the use of clusters of galaxies as cosmological probes. We found that the X-ray properties of the REFLEX-DXL sample show an approximate self-similar behavior above 0.15–0.2 virial radii. This helps us to establish tight cluster mass–observables scaling relations, in particular the M–T relation with a scatter of 0.3 for M.

Key words: self-similar; cluster of galaxies; X-rays.

1. REFLEX-DXL

X-ray luminous (massive) clusters can be used in a variety of ways to perform both, cosmological and astrophysical studies. Excluding the cooling cores, a self-similar scaling of the ICM properties such as the temperature, density, and entropy of massive clusters (> 4 keV) is indicated in the ROSAT, ASCA, and Chandra observations, e.g. Arnaud et al. (2002), Reiprich & Böhringer (2002), and Vikhlinin et al. (2004), and simulations, e.g. Borgani et al. (2004). Precise ICM property measurements provide accurate cluster mass and gas mass fraction determinations. This is important for the study of the X-ray scaling relations and their intrinsic scatter for clusters of galaxies. So far, Böhringer et al. (2004) provide the largest catalog of X-ray clusters of galaxies, the ROSAT-ESO Flux-Limited X-ray (REFLEX) galaxy cluster survey. It is important to make an unbiased selection to compose a subsample of the REFLEX survey. We thus constructed an almost volume complete sample of 13 distant, X-ray luminous (DXL, $z = 0.27$ to 0.31, $L_X \geq 10^{45}$ erg s^{-1} for $0.1 - 2.4$ keV) galaxy clusters and one supplementary cluster at $z = 0.2578$ from the REFLEX survey, the REFLEX-DXL sample. The volume completeness correction can be done using the well known selection function of the REFLEX survey. This is a morphology-unbiased, flux- limited and volume-complete sample giving a representative example of morphological variations as shown in Fig. 2. We analyzed the REFLEX-DXL sample and explored ralibale ICM properties to determine an accurate cluster mass and gas mass fraction and to investigate the scaling relations and intrinsic scatter in Zhang et al. (2004), Zhang et al. (2005) and Finoguenov et al. (2005). The sample will be used to test the evolution of the temperature function in comparison to nearby cluster samples (Böhringer et al. in preparation). We adopt a flat ΛCDM cosmology with $\Omega_{\rm m} = 0.3$, $\Omega_\Lambda = 0.7$, and $H_0 = 70$ km s^{-1} Mpc^{-1}. Error bars correspond to 68% confidence levels.

2. CONCLUSION

An approximately self-similar behavior of these X-ray properties, such as metallicity, temperature, surface brightness, entropy, and gravitational mass, has been found in the $r > 0.1 r_{\rm vir}$ region for the REFLEX-DXL sample. We obtained an almost universal metallicity profile. We obtained an average temperature profile of the REFLEX-DXL clusters, which agrees with the previous studies within the observational dispersion. We performed the redshift evolution correction on the central entropies for the REFLEX-DXL clusters and obtained consistency with those for the nearby clusters in Ponman et al. (2003). The central entropies for the REFLEX-DXL sample agree with the scaling, $S \propto T^{0.65}$. The deviation around the self-similar model in the central region reveals

Table 1. Classification of the dynamical state. Col.(1): Classification. Col.(2): Cluster name.

Classification (Jones & Forman 1992)	RXCJ
Single	0307.0−2840 0532.9−3701
	2308.3−0211
Primary with small secondary	0232.2−4420 0303.7−7752
Elliptical	0043.4−2037 0437.1+0043
	0516.7−5430 1131.9−1955
Offset center	0014.3−3022 0528.9−3927
	0658.5−5556 2337.6+0016
Complex	2011.3−5725

additional physical processes and is thus correlated with the cluster morphology. The gas density and temperature profiles provide an excellent diagnostics of the cluster structure and yield precise determinations of the mass and gas mass fraction. The gas mass fractions are about 0.11 ± 0.07 and agree with previous studies by, e.g. Ettori et al. (2002), Sanderson et al. (2003) and Kotov & Vikhlinin (2005). The mass–observable relations of the REFLEX-DXL sample agree with the scaling relations of the nearby and more distant samples after the redshift evolution correction. As a morphology-unbiased sample, the cluster morphology has been taken into account to understand the systematics of the scaling relations.

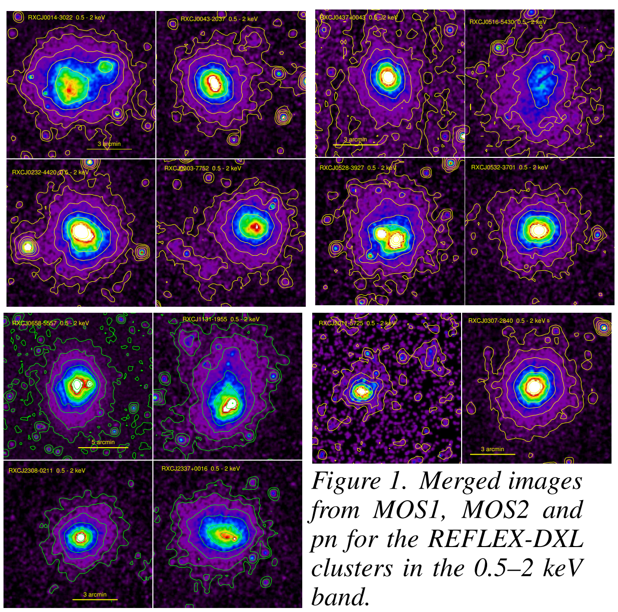

Figure 1. Merged images from MOS1, MOS2 and pn for the REFLEX-DXL clusters in the 0.5–2 keV band.

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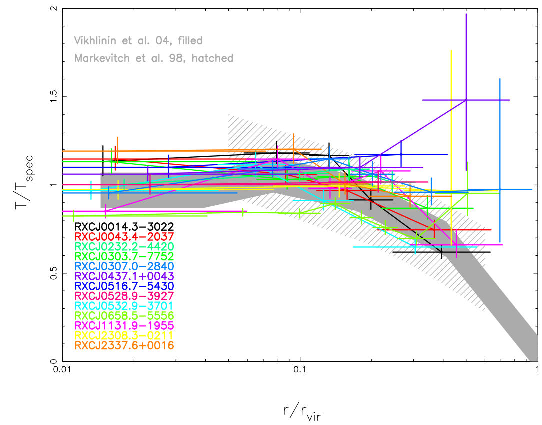

Figure 2. Temperature profiles of the REFLEX-DXL clusters. The shadows show the temperature profile ranges in Markevitch et al. (1998) and Vikhlinin et al. (2004).

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