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ORIGINAL ARTICLE

The Chandra X-ray galaxy clusters at $z < 1.4$: constraints on the evolution of $L_X - T - M_g$ relations

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Abstract We analyzed the luminosity-temperature-mass of gas ($L_X - T - M_g$) relations for a sample of 21 *Chandra* galaxy clusters. We used the standard approach ($\beta-$model) to evaluate these relations for our sample that differs from other catalogues since it considers galaxy clusters at higher redshifts ($0.4 < z < 1.4$). We assumed power-law relations in the form $L_X \sim (1+z)^{A_{L_XT}} T^{\beta_{L_XT}}$, $M_g \sim (1+z)^{A_{M_gT}} T^{\beta_{M_gT}}$, and $M_g \sim (1+z)^{A_{M_gL_X}} L^{\beta_{M_gL_X}}$. We obtained the following fitting parameters with 68 % confidence level: $A_{L_XT} = 1.50 \pm 0.23$, $\beta_{L_XT} = 2.55 \pm 0.07$; $A_{M_gT} = -0.58 \pm 0.13$ and $\beta_{M_gT} = 1.77 \pm 0.16$; $A_{M_gL_X} \approx -1.86 \pm 0.34$ and $\beta_{M_gL_X} = 0.73 \pm 0.15$, respectively. We found that the evolution of the $M_g - T$ relation is small, while the $M_g - L_X$ relation is strong for the cosmological parameters $\Omega_m = 0.27$ and $\Omega_\Lambda = 0.73$. In overall, the clusters at high-z have stronger dependencies between $L_X - T - M_g$ correlations, than those for clusters at low-z. For most of galaxy clusters (first of all, from MACS and RCS surveys) these results are obtained for the first time.

Keywords Galaxy clusters: general · X-ray clusters

1 Introduction

The correlations between different physical parameters of galaxy clusters allow to get information about the global properties of clusters. The observations of the diffuse X-ray emitting medium (ICM) of galaxy clusters provide such parameters like its temperature (T), X-ray luminosity (L_X) and, after estimations, the mass (M_g). There are difficulties for theoretical predictions of these relations (e.g. Norman et al. 2010; Novosyadlyj 2007). A correlation between the mass of hot intergalactic gas, temperature and X-ray luminosity of clusters has a small scatter that indicates a similar formation history for all clusters (David et al. 1993; Markevitch 1998; Mushotzky et al. 1997). However, the detailed studies showed that the observational correlation coefficient is at odds with theoretical predictions. One of the most famous example is the slope of $L_X \sim T^{2.7}$ for hot clusters (Markevitch 1998), while the theory provides $L_X \sim T^2$ (David et al. 1993). Such differences can be explained by the fact that a heated intergalactic medium plays an important role in the non-gravitational processes as early heating of massive supernova (Cavaliere et al. 1997) or radiation cooling as well as the associated active star formation (Voit et al. 2001).

Among the works on the $L_X - T$ relation for galaxy clusters at the large redshifts we note the followings. In a series of papers, Mushotzky et al. (1997, 2000) have analyzed this ratio for a large sample of distant clusters observed by ASKA and did not find the evolution in $L_X - T$ relation. However, the later observations (Arnaud et al. 2002; Novicki et al. 2002) gave a support to an evolution parameterised in the form $L_X(z) \sim (1+z)^A$, where $A = 1.3$–1.5. A similar result for 12 distant galaxy clusters was obtained by Holden et al. (2002). Nevertheless that a value $L_X - T$ for clusters has a considerable scatter, the dispersion in $L_X - T$ for the nearer clusters can be reduced if the central region is excluded when the temperature and luminosity of clusters are evaluated (Markevitch 1998; Finoguenov et al. 2001) hereafter FRB, (Finoguenov et al. 2007; Horner et al. 1999; Apunevych et al. 2009).

A $L_X - T$ relation was derived for galaxy clusters in series of paper by Cavaliere et al. (1997, 1998, 1999) and Del

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