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ASCA/ROSAT Study of Distant Clusters of Galaxies

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Abstract. Properties of distant clusters of galaxies (z=0.2-0.4) are studied with combined analysis of *ASCA* and *ROSAT* data.

1. Sample

We selected X-ray bright distant clusters detected in the *ROSAT* All Sky Survey, and observed them with *ASCA*. Adding a Zwicky cluster that happened to be observed in an *ASCA* deep survey project, we studied 8 distant clusters of galaxies, which are listed in Table 1.

2. Analysis and Results

Using the *ASCA* spectra, we measured the redshifts, temperatures and metal abundances (Table 1). X-ray brightness profiles were measured with *ROSAT* HRI data (and PSPC if available) by fitting the azimuthally averaged profile with a β-model ($\Sigma = \Sigma_0(1 + (r/r_c)^2)^{-1.5\beta+0.5}$). Assuming spherical symmetry and isothermal temperature structure, we calculated the total gravitating mass within the virial radius (Fig. 1).

3. Discussion

The self-similar scenario of cosmic structure formation (Kaiser 1986) predicts a relation between mass and temperature of clusters of the form $M_{vir} \propto T^{3/2}(1+z)^{-3/2}$ (for Ω_0 close to 1), which implies that clusters forming earlier in a denser Universe are more compact and have a smaller mass than present day clusters with the same temperature. This scenario is also supported by simulations. If we can adopt the recent-formation approximation, the evolution of the scaling law should be observed. Our results roughly follow the theoretical prediction, that is, the virial mass of distant clusters tend to be smaller than those of nearby clusters for the same temperature (Fig. 1 & 2). More detailed study of the evolution of the $M_{vir} - T$ relation with larger samples will allow us to constrain Ω_0.

References

Evrard, A., Metzler, C., and Navarro, J. 1996, ApJ, 469, 494
Fukazawa, Y. 1997, PhD thesis, University of Tokyo
Horner, D., Mushotzky, R., and Scharf, C. 1999, ApJ, 520, 78
Kaiser, N. 1986, M.N.R.A.S., 222, 323
Reiprich, T. et al. 1999, in preparation

name	z	kT (keV)	Metallicity (solar)
RXJ2129+0005	$0.232^{+0.012}_{-0.013}$	$6.3^{+0.43}_{-0.35}$	$0.40^{+0.10}_{-0.08}$
RXJ2253-3343	$0.232^{+0.015}_{-0.016}$	$5.3^{+0.51}_{-0.38}$	$0.46^{+0.16}_{-0.14}$
A2667	$0.261^{+0.013}_{-0.014}$	$6.9^{+0.30}_{-0.39}$	$0.29^{+0.06}_{-0.08}$
Zw1305.4+2941	$0.255^{+0.041}_{-0.041}$	$3.7^{+0.35}_{-0.34}$	$0.59^{+0.24}_{-0.24}$
RXJ0232.3-4420	$0.270^{+0.015}_{-0.015}$	$7.8^{+0.59}_{-0.48}$	$0.27^{+0.08}_{-0.08}$
RXJ0658-5557	$0.282^{+0.033}_{-0.016}$	$14.0^{+1.21}_{-1.21}$	$0.28^{+0.04}_{-0.02}$
A483	$0.282^{+0.076}_{-0.048}$	$5.3^{+0.60}_{-0.66}$	$0.22^{+0.20}_{-0.18}$
A1722	$0.311^{+0.020}_{-0.013}$	$5.9^{+0.73}_{-0.48}$	$0.45^{+0.17}_{-0.15}$
A851	$0.420^{+0.048}_{-0.018}$	$8.7^{+1.52}_{-1.09}$	$0.22^{+0.17}_{-0.16}$

Table 1. Our distant cluster sample. The redshift, temperature, and metallicity given here were derived from the *ASCA* spectral analysis. The errors are 90% confidence limit for one interesting parameter.

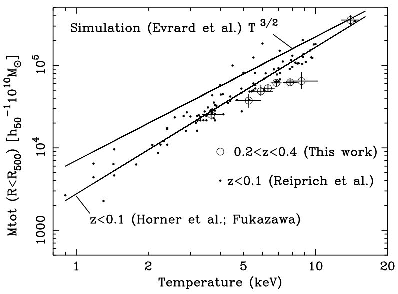

Fig. 1. The virial mass, M_{vir}, is plotted against temperatures. M_{vir} is calculated as a total gravitating mass within a virial radius, R_{500}, where the mean density within the radius is 500 times of the critical density, $\rho_c = 0.47 \times 10^{-29} h_{50}^2$ g/cm^3. For comparison, M_{vir} of nearby clusters ($z < 0.1$) by Reiprich et al. (1999) derived with *ROSAT* brightness profiles and *ASCA* temperatures are also plotted. One of the two lines illustrated in the diagram is obtained by Horner et al. (1999) based on *ASCA* results provided by Fukazawa (1997). The other line shows result of a simulation by Evrard et al. (1996).

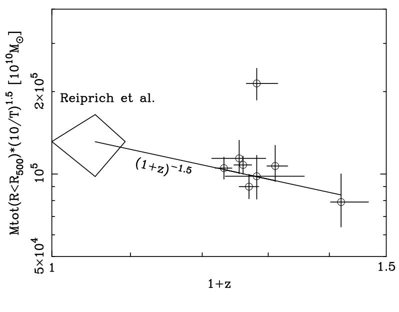

Fig. 2. Redshift dependence of the scaled virial mass given as $M_{vir} \times (10\mathrm{keV}/T)^{1.5}$. The diamond shows the mean and standard deviation of the nearby objects estimated with the $\sim$100 sample clusters of Reiprich et al.