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CHANDRA OBSERVATIONS OF $z > 1$ CLUSTERS

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ACIS on board the Chandra Observatory was used to obtain a very deep image of three high redshift galaxy clusters. The results of our preliminary analyses of these data are reported. A fit to the X-ray spectrum of one of the clusters at $z = 1.26$ yields a temperature of 6.8 ± 2.1 keV, approximately in line with the expectation based on its L_x according to the low redshift $L_x - -T_x$ relation. The very different morphologies of the X-ray emission in this and the other $z > 1$ cluster are discussed in light of their member galaxy distributions.

1 Observations

In early May 2000 we obtained a 190 ks exposure using ACIS-I in a single pointing on three RDCS clusters in the Lynx field (Stanford et al. 1997; Rosati et al. 1999). One cluster is at $z = 0.58$ and will not be discussed further here; a paper is in preparation describing these results (Holden et al. 2000). The other two clusters are at $z = 1.26$ and 1.27 and only 4.2 arcmin apart on the sky. We will describe the results obtained from the ACIS data on these two clusters more fully below.

2 Results

Both high-z clusters are detected and found to contain spatially extended X-ray emission (Figure 1). However, in both cases there are relatively strong point sources within the ROSAT detection area. Thus the fluxes of the two clusters measured from the ROSAT data were contaminated, showing the importance of obtaining high spatial resolution images. We have attempted to determine the X-ray temperature of RX0849+4452, the more luminous of the two high-z clusters, using the spectrum obtained from the ACIS-I image (left panel of Figure 2). Though hampered by the smaller than expected number of photons, a preliminary fit of a Raleigh-Smith model (with the column density fixed to the value found from the spectrum of the neaby $z = 0.58$ cluster and assuming the metallicity is 1/3 solar) to the X-ray spectrum finds 6.8 ± 2.1 keV, approximately in line with the expectation based on its L_x according to the low redshift $L_x - T_x$ relation (Figure 2). The T_x of RX0849+4452 supports the idea that the $L_x - T_x$ relation is constant with redshift.

The spatially extended X-ray emission seen in RX0849+4452 clearly shows that the hot intracluster medium exists in galaxy clusters at $z > 1$. In this cluster the ICM has a regular, centrally concentrated spatial distribution, similar to that of the relaxed appearance this cluster presents in the optical/IR. But the ICM in the other $z > 1$ cluster, RX0848+4453, is very weak and appears to be divided between the two sides of the cluster, as if there are two groups in the process of merging. This morphology is also seen in the distribution of the red galaxies as shown in the left panel in Figure 1. While the two clusters show rather different distributions both in the optical/IR and in the X-ray, they both contain galaxy populations apparently dominated by early-type galaxies which have little or no recent star formation (Stanford et al. 1997; Rosati et al. 1999; van Dokkum et al. 2000). This suggests that the early-type galaxies in clusters formed prior to cluster formation.

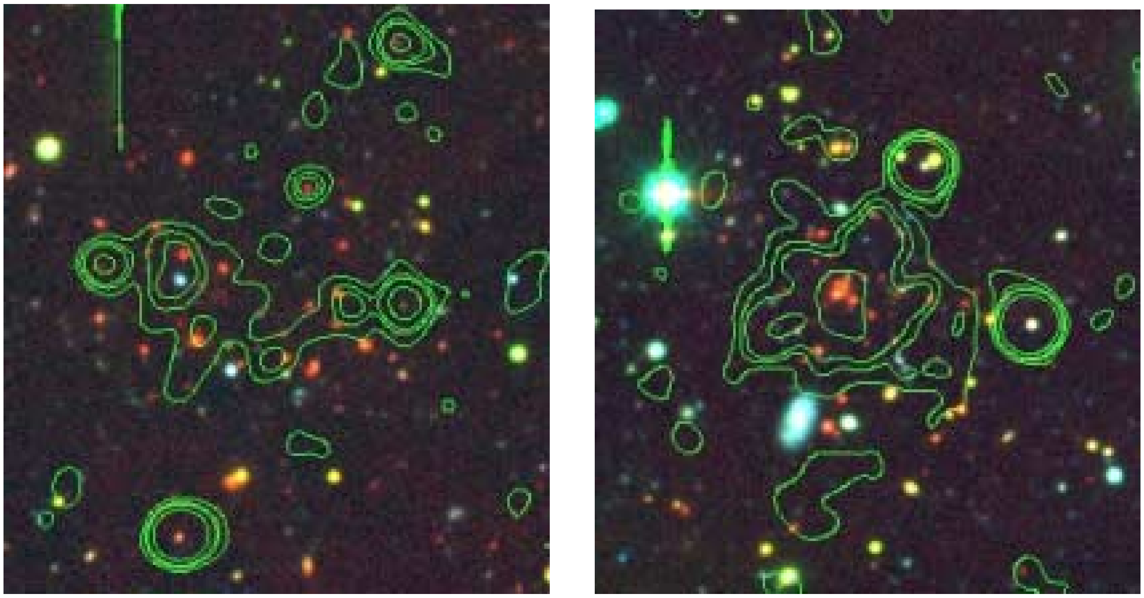

Figure 1: Two panels showing BIK images of RX0848+4453 (left; $z = 1.27$) and RX0849+4452 (right; $z = 1.26$) with contour overlays of the X-ray emission detected by Chandra/ACIS-I. Note the strong point sources centered on optical objects which are not associated with the clusters, and the very different overall X-ray morphologies.

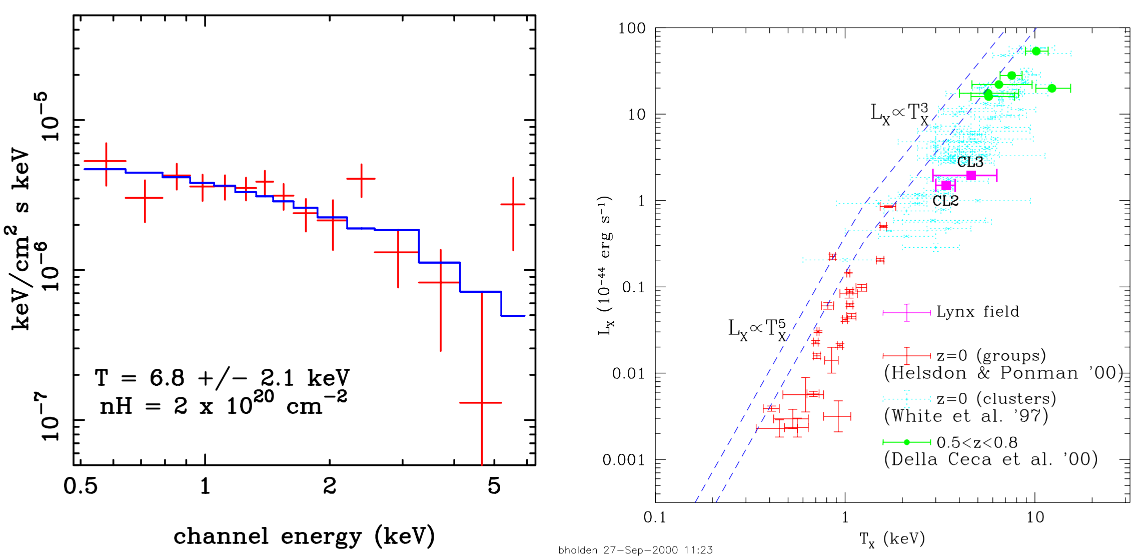

Figure 2: (left) ACIS-I spectrum of RX0849+4452 at $z = 1.26$ with fitted model spectrum. (right) L_x vs T_x for galaxy clusters. The numerous points in red and blue show groups and clusters (respectively) at $z < 0.1$ clusters. Moderate redshift clusters are shown by the green points. The points for RX0849+4452 at $z = 1.26$ and the low-redshift $z = 0.58$ Lynx cluster RX0848+4456 from our ACIS-I observation are shown labelled in pink as cl3 and cl2, respectively. The two dashed lines bracket the L-T evolution between $z = 0.5$ and $z = 1$ that is required to reconcile the RDCS number counts and redshift distribution with an $\Omega_m = 1$ Universe (Borgani et al. 1999).

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4 References

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