X-ray Properties of Clusters with Wide-Angle Tail Radio Sources: Abell 562 and Abell 1446

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ABSTRACT

Named for their characteristic C-shape, wide angle tail (WAT) radio sources are understood to be formed by the interaction between the radio jets and the intracluster medium in which they are embedded. We present Chandra observations of two clusters that host WAT radio sources, Abell 562 and Abell 1446. While both clusters display relatively isothermal radial temperature profiles and a typically smooth decline in pressure and density with radius, each exhibit evidence for some degree of merger activity and WAT/ICM interaction. We find that the clusters have an excess of emission offset from the cluster core and WAT hosting galaxy. There is significant two-dimensional temperature substructure within the central regions of the clusters as is consistent with infalling clumps or galaxy groups, while the surface brightness distribution of the inner regions of the clusters reflects that of unrelaxed systems. It is possible that this merger activity may be leading to the shaping of the bent radio sources within each cluster. In addition there is evidence that the lobes of both WAT sources have carved out cavities within the intracluster gas. At the redshifts of the clusters 1" ≈ 2 kpc.

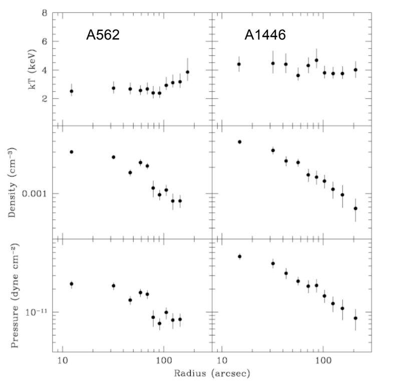

Fig. 2: Radial profiles of **temperature, density,** and **pressure** of clusters A562 and A1446.

Abell 562: Relatively isothermal temperature profile showing a slight increase with increasing radius, possibly consistent with a disrupted cooling flow.

Profiles of density and pressure are generally smooth with a slight enhancement between 60"-70" followed by a sudden decrease. Such a feature may be an indication of a weak shock associated with a small scale cluster merger.

Abell 1446: Isothermal temperature profile.

Profiles of density and pressure display a relatively smooth decline with increasing radius. No significant jumps are seen as would be expected if a large scale cluster merger were occurring in the plane of the sky.

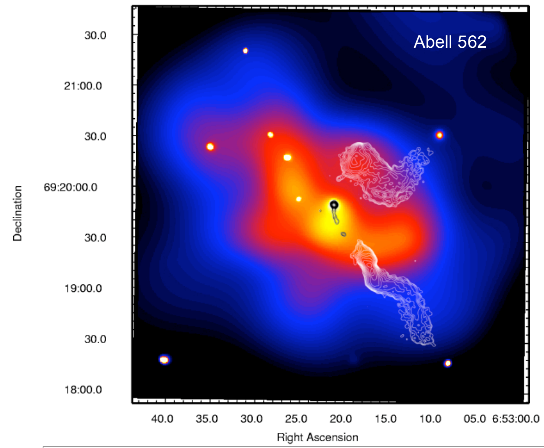

Fig. 1 (left): Above is a 480 x 480 kpc^2 adaptively smoothed ***Chandra* ACIS-S3 image** of the **X-ray emission** from the intracluster medium of the galaxy cluster **Abell 562** (z = 0.11). The image has been corrected for effects of background and exposure. The energy range extends from 0.3 - 5.0 keV. Overlaid are contours of the WAT radio source 0647+693. The emission appears to be elongated along the line that bisects the WAT. This is consistent with the WAT morphology resulting from the induced ram pressure of the intracluster medium during a cluster merger (Gomez 1997).

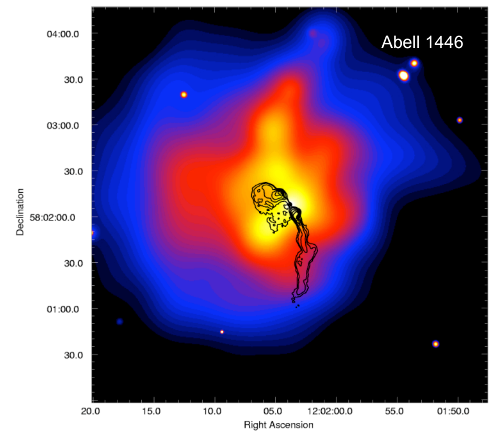

Fig. 1 (right): Above is a 500 x 500 kpc^2 adaptively smoothed ***Chandra* ACIS-S3 image** of the galaxy cluster **Abell 1446** (z = 0.1035). The energy range extends from 0.3 - 5.0 keV. Overlaid are contours of the WAT radio source 1159+583. The X-ray emission is relatively circularly symmetric about the cluster center. Anisotropies in the surface brightness distribution are evident in a filamentary clump north of the WAT and an excess of emission between the lobes. Within the merger scenario for the formation of WATs, this cluster may represent a cluster merger with a large portion of the activity occurring along the line-of-sight.

The northern radio lobes of both sources are coincident with decrements in the X-ray emission consistent with the radio source carving out a cavity within the ICM.

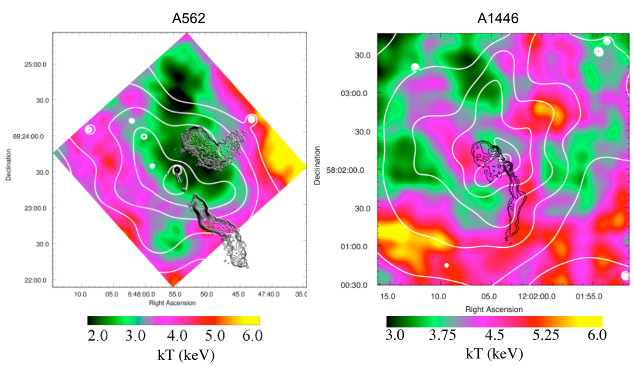

Fig. 3: Temperature maps about the cluster centers of Abell 562 (left) and Abell 1446 (right). Both clusters show anisotropic temperature distributions within the central ~200 kpc.

Cool Regions North of the AGN

Abell 562: Examined with *acisspec* in *CIAO*, this region was found to be **kT = 2.49 ± 0.32 keV** as opposed to the surrounding regions where **kT = 3.64 ± 0.28 keV**.

Abell 1446: **kT = 3.19 ± 0.43 keV** as compared to the surrounding gas at **kT = 4.29 ± 0.56 keV**.

Hot Region along the Line that Bisects the WAT

Abell 1446 displays temperature enhancements along the line that bisects the WAT. The hotter region to the southeast of the AGN was measured to be **kT = 5.93 (+2.06/-1.21) keV** as compared to the surrounding **kT = 3.72 ± 0.47 keV** gas. Within the merger scenario for WAT production, shocks are expected to form along the line that bisects the WAT / merger axis (Roettiger 1996; Gomez 1997).

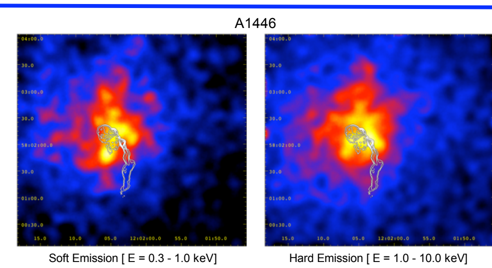

Fig. 5: To the left are 4" Gaussian smoothed images of the **soft** (left) and **hard** (right) **X-ray emission** associated with the inner ~200 kpc of **Abell 1446**. In the soft image a clear overdensity of emission (at the 2.85σ level) can be identified as the bright region to the southeast of the AGN. Such an excess in this location is consistent with a wake of cooler galactic material having been stripped by the same ram-pressure that is bending the WAT source. In this case the ram pressure is thought to be supplied by a small-scale cluster merger (Sakelliou et al. 2004) .

Alternatively, the excess may be the remnant cool core of the pre-merger cluster or a cool core of an infalling group. The number of counts is not great enough to determine the density and temperature of this excess and distinguish between these possibilities.

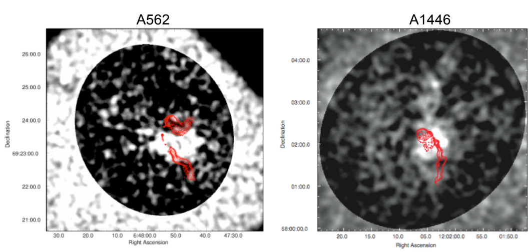

Fig. 4: Images of **excess cluster X-ray emission** created by subtracting isophotal models from a 4" Gaussian smoothed image of each cluster. The models were created using the *ellipse* task in IRAF.

Abell 562 (left): shows evidence of excess emission to the southwest of the cluster core between the WAT radio lobes. The location of this excess, along the line that bisects the WAT, is consistent with a merger occurring along the WAT axis.

Abell 1446 (right): displays excess emission in a filamentary clump directly north of the cluster center. This excess, coincident with the region of cooler gas seen in Fig. 2, may be associated with an infalling subcluster or galaxy group. Such an infalling system may be contributing to the bending of the WAT radio source.

The excess in both clusters is offset from the WAT host galaxy and center of the large scale X-ray emission.

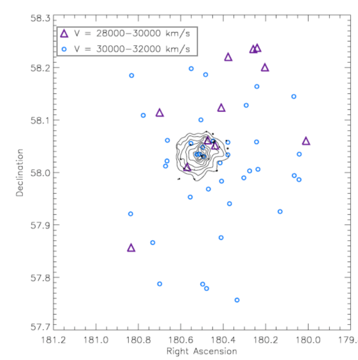

Fig. 6: Positions on the sky of ~50 galaxies within **Abell 1446** with spectroscopically determined redshifts from **SDSS**. The plot shows galaxies separated between higher and lower line-of-sight velocities. A concentration of galaxies with similarly low velocities (triangles) is apparent along the line that bisects the WAT. By fitting a 2-component Gaussian to the velocity data the difference between the peaks of the two populations was found to be Δv ~ 1500 km/s. This indicates some component of a merger occurring along the line-of-sight and is consistent with the relatively circularly symmetric large scale distribution of the X-ray emission. We are planning additional spectroscopic observations of this cluster to increase the sample size to 150-200 galaxies.

Summary

We have presented *Chandra* observations of the WAT hosting galaxy clusters Abell 562 and Abell 1446. Both clusters exhibit evidence that they may be the site of a small scale merger. Abell 562 displays an elongation of the X-ray emission along the line that bisects the WAT as well as a slight enhancement in its radial profile of pressure that may indicate a weak merger driven shock. Abell 1446 shows a region of hotter gas (possible shock) along the WAT axis and a soft excess between the radio lobes. Both clusters exhibit cooler regions to the north of their cluster cores and an excess of emission offset from the cluster centers. Additionally, the SDSS spectroscopic data for A1446 exhibits a population of galaxies with similarly low velocities along the WAT axis. These observations are consistent with both clusters currently undergoing a merger with a subcluster or galaxy group . It is expected that the ram pressure of the ICM induced in these mergers results in the bending of the WAT radio source.