

# X-ray Sources in Groups of Galaxies

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## Abstract

We have undertaken an archival Chandra study to investigate the X-ray source populations in groups of galaxies. Our sample consists of 24 nearby groups ( $z < 0.04$ ) with relatively long Chandra observations. Detected X-ray sources are matched to galaxies with known redshifts in NED to confirm group membership. We generally find a couple of matches per group (outside the central galaxy) in the 12 groups with sufficient sky coverage to probe group regions outside of the central galaxy ( $R > 50$  kpc). Through a comparison to the Chandra PSF, we classify these sources as extended or point-like.

Recent Chandra observations have revealed a population of X-ray luminous AGN associated with clusters of galaxies not previously identified through their optical spectra (Martini et al. 2005). In 12 groups, we find two X-ray point sources outside of the group center with luminosities high enough to identify them as AGN ( $> 10^{41}$  ergs  $s^{-1}$ ), only one of which is a previously identified Seyfert 2. We also detect central X-ray point sources in most of the groups, indicating that nuclear activity is common in groups. We find that most of our groups also have central radio sources, similar to previous studies (Croston, Hardcastle, & Birkinshaw 2005). In several cases, we detect diffuse emission from group galaxies, particularly in groups with little group scale emission. The X-ray emission from galaxies in groups and clusters has been studied with previous X-ray satellites (e.g. Helsdon et al. 2001), but with Chandra we can separate point-like emission from diffuse emission.

## AGN in Groups

For the 12 groups with sufficient sky coverage to probe group regions outside of the central galaxy ( $R > 50$  kpc), we investigate the X-ray sources matching group member galaxies.

- We find 31 group sources (outside the central galaxy) in 12 groups with  $3.6 \times 10^{38}$  ergs  $s^{-1} < L_X < 1.6 \times 10^{42}$  ergs  $s^{-1}$ .
- We only find two X-ray luminous ( $L_X > 10^{41}$  ergs  $s^{-1}$ ) group AGN. One of these has been previously identified as a Seyfert 2 galaxy.

## NGC 741

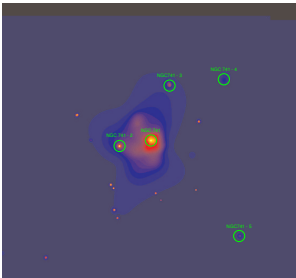


Fig. 1.— Smoothed Chandra image of NGC 741. X-ray sources matching group galaxies are labeled. NGC 741-2 (NGC 742) is one of two X-ray luminous AGN detected in these groups. It has a luminosity of  $1.6 \times 10^{42}$  ergs  $s^{-1}$ .

## Central Sources

Most of our groups show nuclear activity in the form of central X-ray and radio sources. A few groups also contain jets or X-ray holes.

- Of the 21 groups with a dominant central galaxy, 17 appear to have central X-ray point sources. These sources generally have  $L_X < 10^{41}$  ergs  $s^{-1}$ .
- 18 of these 21 groups have central radio sources, including all but one of the groups with central X-ray sources.

## NGC 383

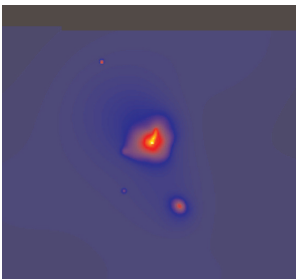


Fig. 2.— Smoothed Chandra image of the core of the NGC 383 group. NGC 383 contains a twin-jet radio source, and the Chandra image reveals both a central X-ray point source and a one-sided X-ray jet (Hardcastle et al. 2002).

## Group Galaxies

Comparison of the source extents to the Chandra PSF reveal that many of the group X-ray sources are extended (24 of 31 sources). Here we are detecting diffuse emission from the group galaxies, indicating that these galaxies still contain a significant amount of gas.

- In 5 of the 12 groups, we detect diffuse emission from all of the brightest group member galaxies. These groups show either very little group scale emission or other signs that they are still forming.
- We also detect extended X-ray emission in a few other groups, generally from the galaxies at larger radii.

## NGC 5171

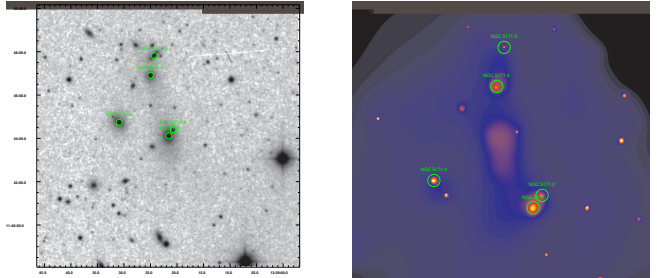


Fig. 3.— Left: DSS image of NGC 5171. Right: Smoothed Chandra image. X-ray sources matching group galaxies are labeled. With the exception of NGC 5171-5, these sources are extended. While this group contains relatively luminous diffuse emission ( $L_X > 10^{42}$  ergs  $s^{-1}$ ), this emission is not centered on any of the luminous group galaxies. Instead, it extends between NGC 5171 and NGC 5176. This group also has a non-Gaussian velocity dispersion, and it may be in the process of forming (Osmond, Ponman, & Finoguenov 2004).

## NGC 383

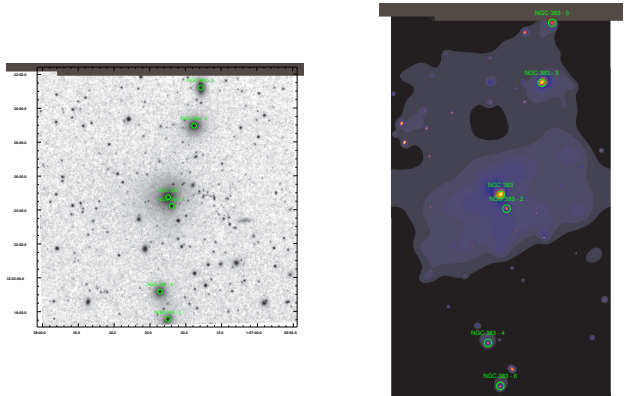


Fig. 4.— Left: DSS image of NGC 383. Right: Smoothed Chandra image. X-ray sources matching group galaxies are labeled. Diffuse emission is detected from all of the bright group galaxies in the Chandra field. These galaxies form part of a bright chain of galaxies, and their X-ray luminosities and spectra are consistent with thermal emission (Hardcastle et al. 2002; Komossa & Böhringer 1999).

## References

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