X-Ray and Radio Emissions of AWM and MKW Clusters

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Abstract

A grasp of the life-cycles of large-scale structures is critical to understanding the Universe. This can be accomplished through the study of poor clusters-- that is, younger clusters that are likely evolving to another state. The selected clusters are significant in that they are poor but also possess a type-cD galaxy. This brighter central galaxy suggests that these clusters may be dynamically evolved and are potential candidates for fossil groups. In order to more fully understand the structure and behavior of poor galaxy clusters, 12 clusters were selected and analyzed. Using data from the Sloan Digital Sky Survey, Chandra X-Ray Archive, and the VLA FIRST Survey, we present x-ray profiles and radio observations of these 12 galaxy clusters.

Procedure

As discussed by Hanisch and White (1981), the type-cD galaxy within the AWM or MKW cluster will have individual x-ray and radio sources (Bagchi & Kapahi, 1994). Further, Bagchi et al argues that the position of the type-cD galaxy and the evolutionary state of the cluster are factors for the radio brightness of the type-cD galaxy. The clusters examined were AWM1, AWM2, AWM3, AWM4, MKW1s, MKW4, MKW4s, MKW5, MKW7, MKW8, MKW10, and MKW12. To reduce contamination by foreground and background sources, each x-ray and radio emission must be matched with the corresponding galaxy. Using the SDSS, the redshift of the galaxy could be used to determine if the emission was indeed from a member of the cluster or if the emission was from a foreground or background source. Following the removal of the contaminant emissions, an accurate survey of x-ray and radio emissions was found.

X-Ray Emission

X-ray data from the Chandra X-Ray Data Archive was found for 5 of the AWM & MKW clusters: AWM4, MKW1s, MKW4, MKW4s, and MKW8. MKW4 and MKW4s feature an extended x-ray source [figure 1] centered around the type-cD galaxy. AWM4 has an extended x-ray source in the center of the cluster, but not around the type-cD galaxy [figure 2]. While MKW1s and MKW8 do not have extended x-ray sources, both clusters have pointlike x-ray emission from the type-cD galaxy. X-ray radial profiles were then produced by eliminating point sources and calculating the surface brightness of 38 concentric annuli from the center of the source. The brightest of these sources is MKW4s [figure 3], and as a significant source of diffuse x-ray emission is from cluster collisions (Yusef-Zadeh et al, 2003), this further indicates that MKW4s is a collision of two clusters. When examining the radial profiles of the extended emission sources, MKW4s is the brightest at the source, but rapidly decreases in

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brightness. AWM4 and MKW4 have significantly flatter brightness profiles, maintaining brightness to a farther radii [figure 4].

Radio Emission In Poor Clusters

Radio data from the VLA FIRST Survey was used in conjunction with optical data to find radio sources in AWM and MKW clusters. Radio emission is usually found from individual galaxies rather than from the cluster as a whole, and the strongest sources are typically type-cD galaxies located in the center of the cluster (McHardy, 1979). Radio sources were detected within AWM1, AWM4, MKW4, MKW4s, MKW5, MKW7, MKW8, MKW10, and MKW12 [figure 5]. Further, AWM1, MKW4s, and MKW8 had radio emission from the type-cD galaxy, located in the center of the cluster.

AGN In Poor Clusters

Large-scale radio features indicating an active galactic nucleus were found in AWM4, MKW4, MKW4s, MKW7, and MKW8 [figure 6]. No type-cD galaxies were determined to be active, but the extended x-ray emission of AWM4 was also centered on an AGN.

Results

From previous Wisconsin Space Grant Consortium research, AWM2, AWM3, MKW1s, MKW4, MKW5, and MKW10 were determined to be in dynamically equilibrium and AWM1, AWM4, MKW7, and MKW8 are still undergoing galactic accretion. MKW4s and MKW12 were determined to be merging clusters. From the radio data, we can see that the only clusters that lack radio emission (AWM2, AWM3, MKW1s) are all in dynamical equilibrium. Further, the clusters with type-cD emission (AWM1, MKW4s, and MKW8) are not in dynamic equilibrium. AGN were found exclusively in clusters not in dynamical equilibrium with the exception of AWM4. With the surface brightness of the x-ray sources, a temperature estimation can be made if applied to the proper model. The strong extended x-rays in MKW4s further indicate that it is indeed a merger of two clusters.

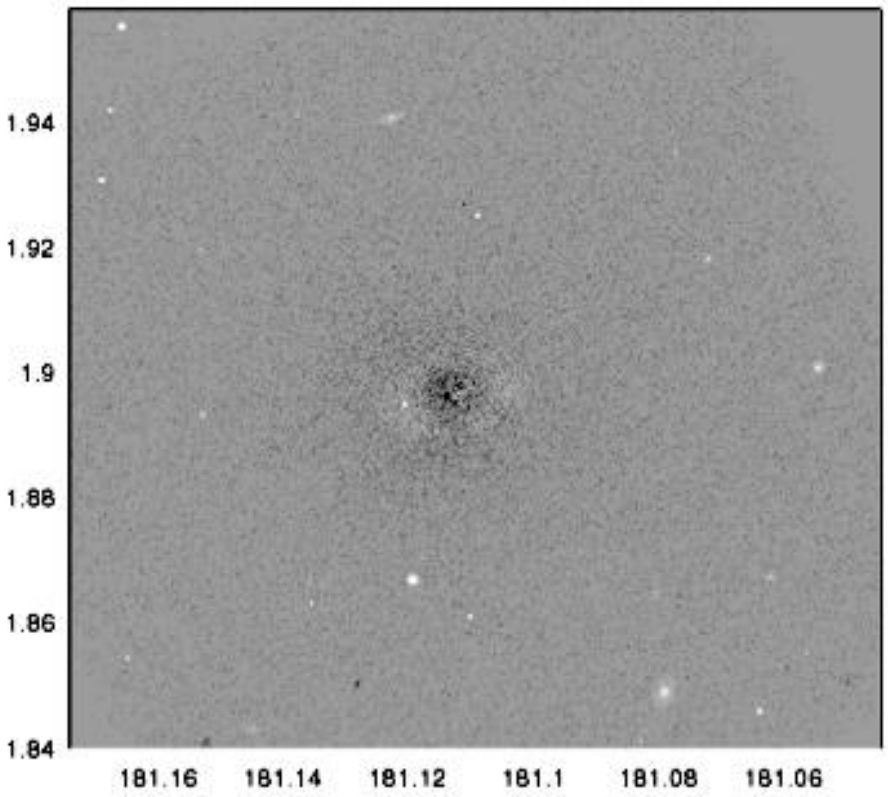

FIGURE 1: X-ray HSV Plot of MKW4

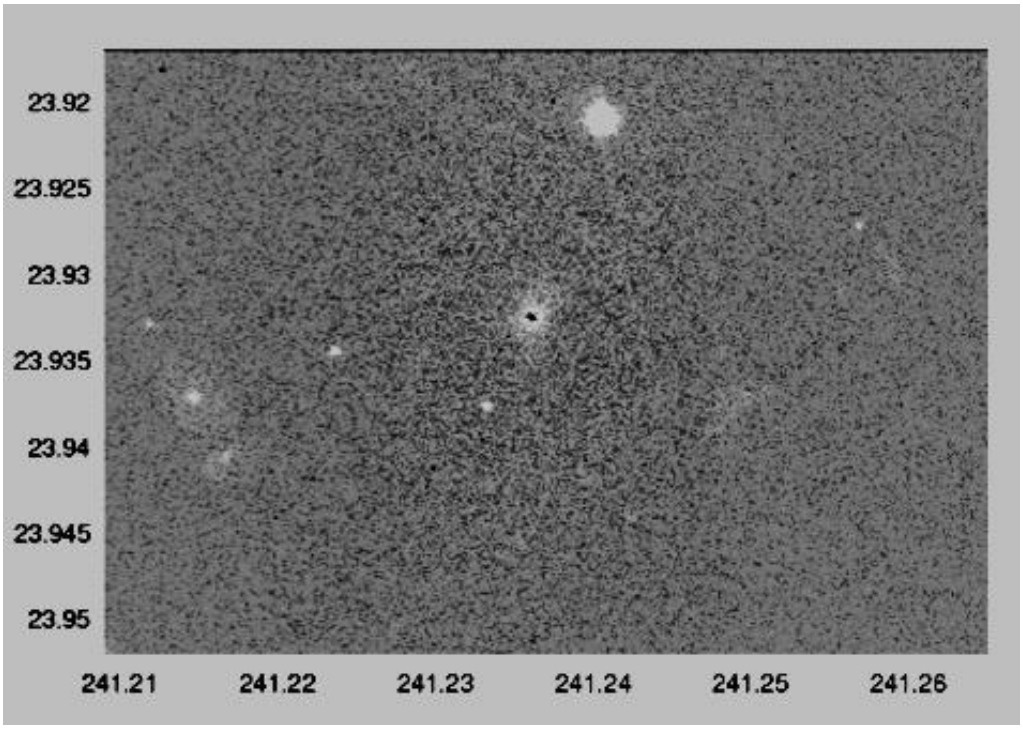

FIGURE 2: X-ray HSV Plot of AWM4

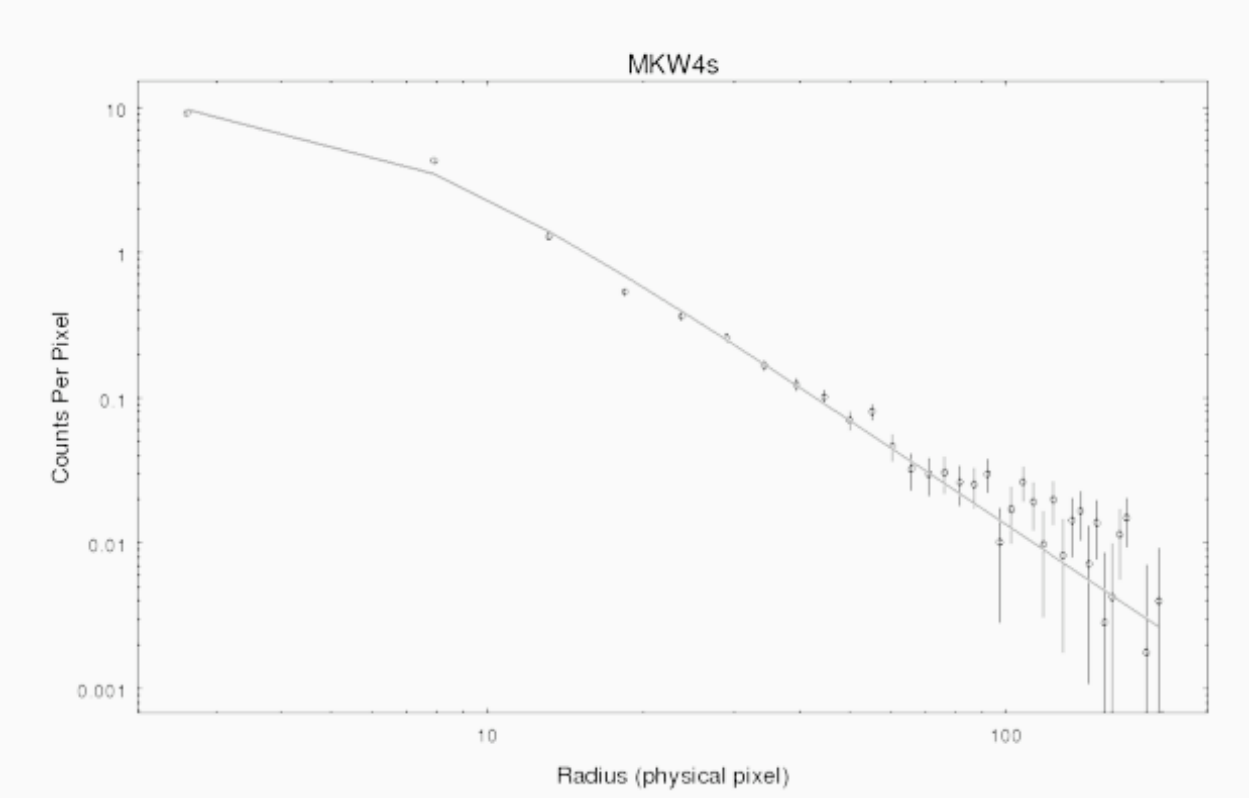

FIGURE 3: Radial Profile of MKW4s

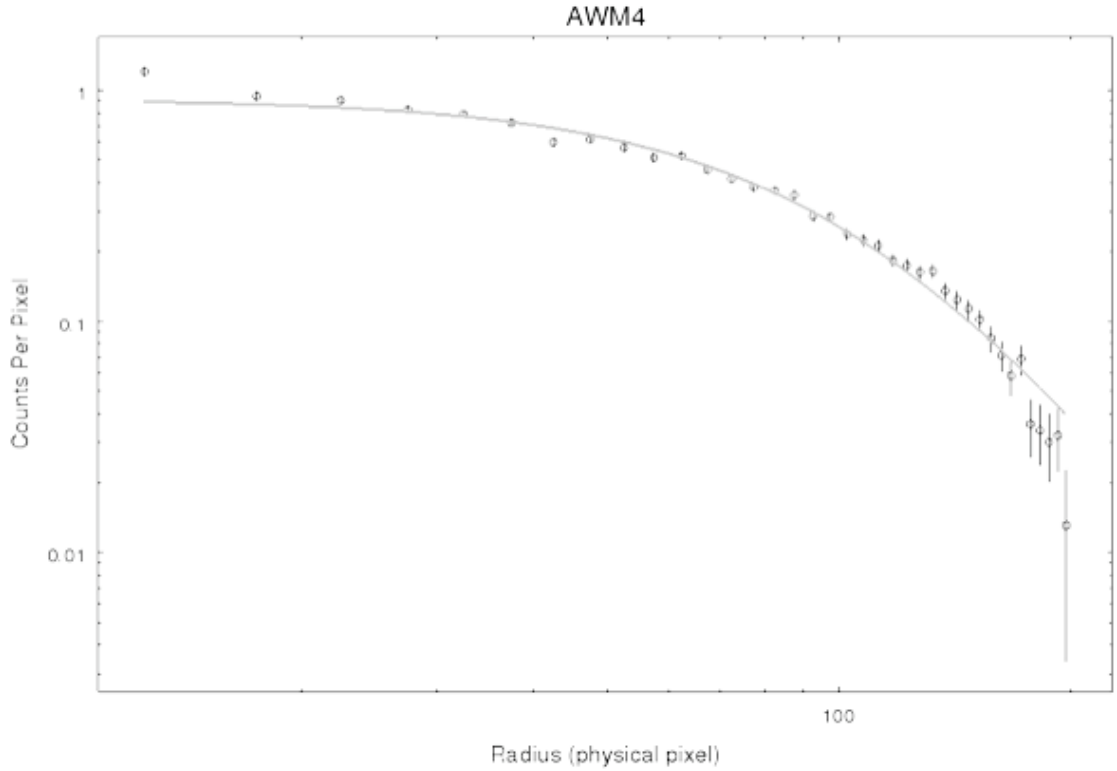

FIGURE 4: Radial Profile of AWM4

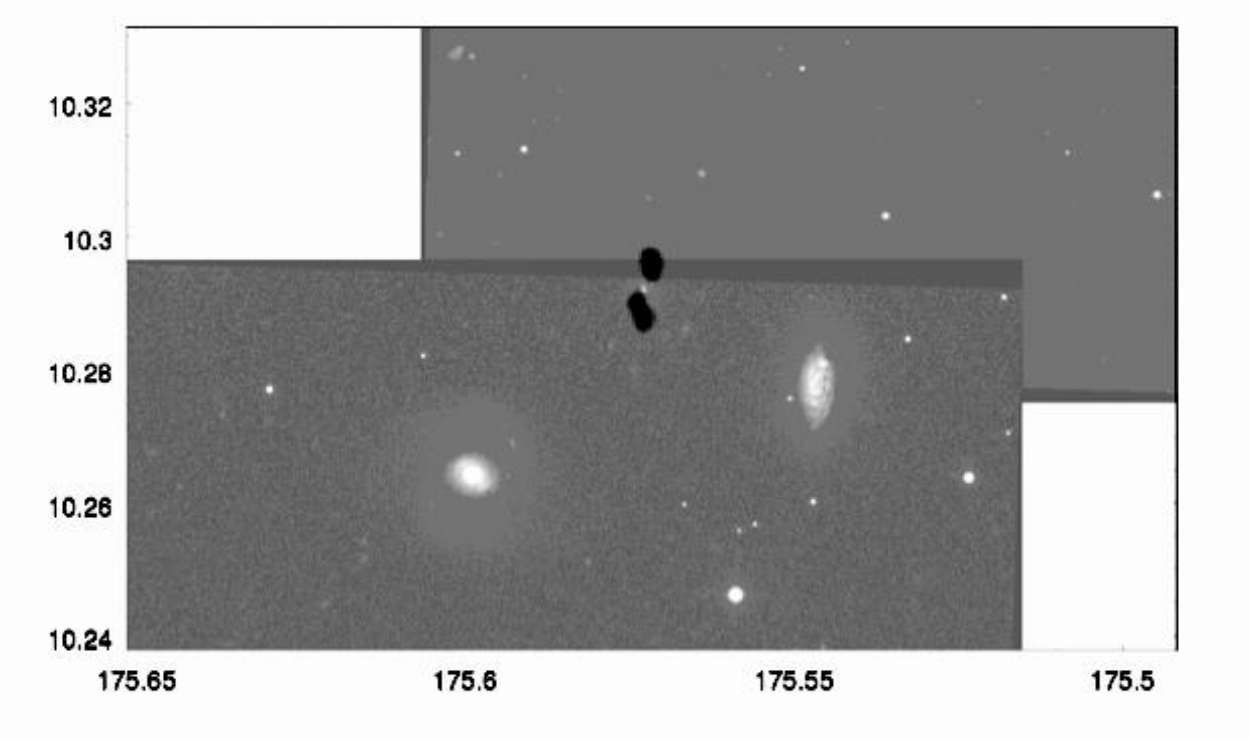

FIGURE 5: Radio Plot of MKW10

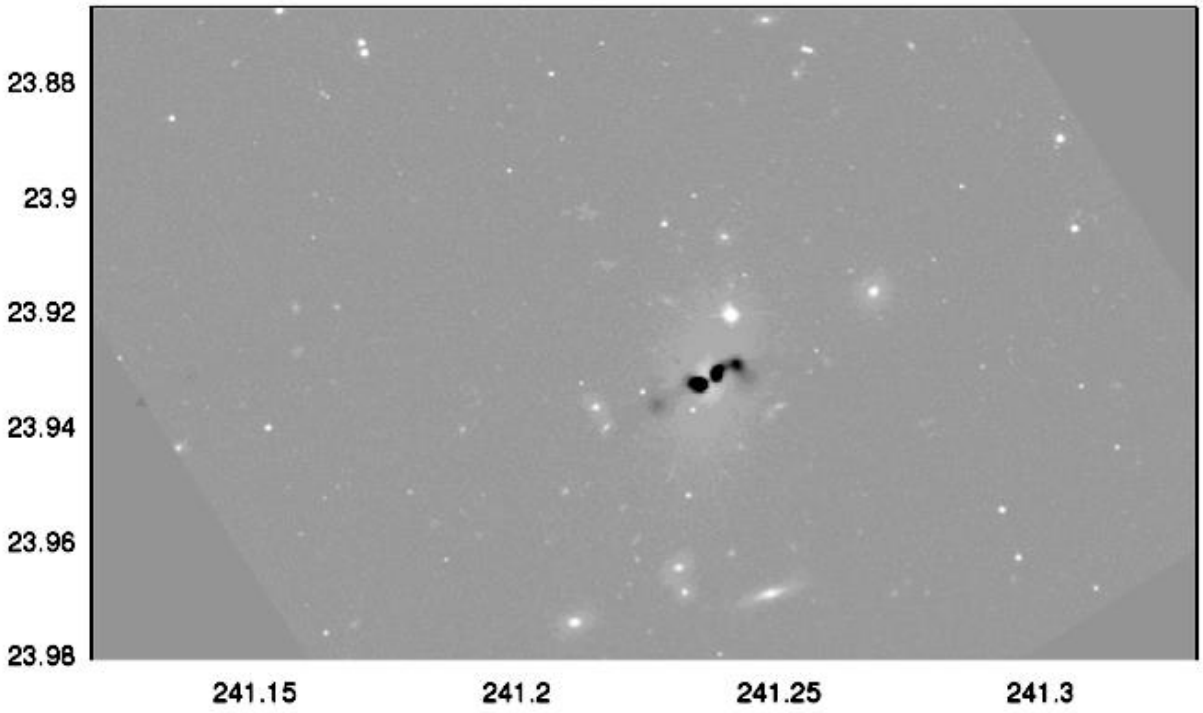

FIGURE 6: Radio Plot of AWM4

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