RevMexAA (Serie de Conferencias), **40**, 125–125 (2011)

SPIRAL-ARM SUBSTRUCTURES IN THE INTRACLUSTER GAS

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We present a detailed analysis of nearby galaxy clusters observed with the *Chandra* X-ray satellite, focusing on the projected density and temperature distributions. Many of these objects have similar morphologies, which exhibit spiral-like substructure, analogous to those found in hydrodynamic simulations of cluster collisions with non-zero orbital angular momentum. These spiral-like structures may be caused by off-axis collisions that will lead to minor mergers. Since these features occur in regions of high density, they may confine radio emission from the central galaxy producing unusual radio morphology.

Clusters of galaxies, the largest collapse structures in the universe, provide a wealth of information on the cosmological assembly of matter. The mass-function of galaxy clusters provides strong constraints for Ω_M and σ_8. However, we do not observe cluster masses directly but either we must perform a detailed analysis (based on galaxy velocities or X-ray observation or gravitational lensing mass reconstruction), or use some proxy for the mass. We will focus here on the analysis of X-ray data, so that we can infer the intracluster plasma density and temperature distributions, and then diagnose the dynamical state of a galaxy cluster.

We choose a sample of nearby ($z < 0.06$, within 250 h_{70}^{-1} Mpc) with deep *Chandra* observation (exposure time larger than 30 ks); 15 objects were selected. Following the standard procedure[2] we generated exposure-map corrected images (surface brightness, SB) of each cluster in the [0.3–7.0] keV band and produced highly contrasted images of the residuals [the original SB subtracted by a 2D elliptical β-model, see Andrade-Santos et al. (2010) and Figure 1]. Temperature maps were made based on the hardness ratio, HR = (H-S)/(H+S), where the hard band H is [1.3–6.0] keV and the soft band S is [0.3–1.3] keV.

About half of our sample (7/15) shows an arm (spiral-like) substructure, all of them are in cool-core clusters. Such a substructure is easier seen in the residual map than in the temperature map. Temperature maps lack the spatial resolution and require spatial resolved spectral analysis. All clusters show substructures (not always arm like) to one degree or another in temperature and SB distributions.

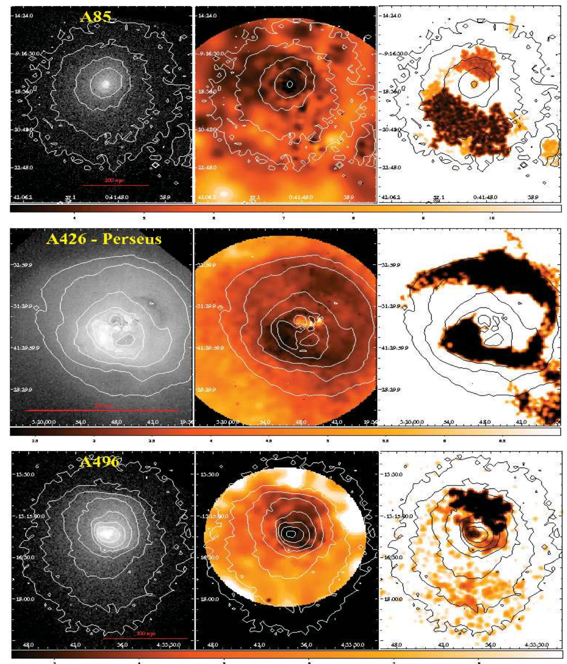

Fig. 1. From left to right: surface brightness map, temperature map, and substructure map, showing the most proeminent arm substructure. See Laganá et al. (2010) for details.

The arm substructure scale-length are larger than the central bubbles produced by the central radio activity. It is not clear if the mechanical work PdV done by the central AGN is enough to push the gas and generate this arm. Minor collisions (followed or not by mergers) may provide an alternative through tidal forces. Indeed, Ascasibar & Markevitch (2006) have shown with simulations that off-center, sub-sonic collisions may slosh the cool central gas and produce the arms we observe.

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