Low Frequency Radio Studies of Halos and Relics

Abstract: Radio observations toward clusters reveal the presence of diffuse, steep spectrum emission (halos and relics) associated only with clusters displaying evidence of merger activity. The observed connection between cluster mergers and diffuse radio emission points toward the potential use of these enigmatic radio sources as signposts to identify merging systems in large samples of clusters. One exciting possibility is that the radio properties may provide a proxy for correcting the cluster mass estimates for the effects of the merger boosts. Due to their steep radio spectrum, diffuse radio halos and relics are best studied at low frequencies where single observations are able to cover large areas of the sky efficiently. We present new low frequency radio observations of the relics in Abell 133 and Abell 2443 and discuss the features seen in these images and spectral index maps. Detailed spectral studies of these systems are a key component to identifying and understanding the origin(s) of the emission as well as probing the details of cluster formation and evolution. We also present an overview of a new study which uses the VLA Low Frequency Sky Survey (VLSS) to probe the shape of the radio spectrum for known clusters with diffuse emission.

Abell 133

- Luminous, nearby (z = 0.0566) cluster with optical and X-ray merger evidence
- Chandra and XMM data show complex X-ray morphology including an X-ray plume (Fujita et al. 2002, 2004)
- Radio emission reveals steep spectrum relic (Figure 1A, Slee et al. 2001)
- New 1400, 330, and 74 MHz data reveal large scale radio structure not previously reported (Figure 3 B, C, D, and E)
- Radio structure is likely a giant radio galaxy associated with a z=293 background system, the northern lobe of which may overlie the radio relic in A133
- Our new deep Chandra data reveal an outer surface brightness edge which is consistent with a sloshing cold front in the core (Figure 3) ~ recent merger
- X-ray spectral fits suggest that the wings are formed by gas displacement from AGN lobes rather than a weak shock passage through the cool core

Abell 2443

- Rich, intermediate redshift (z = 0.108) cluster with optical subclumps nearby
- Wen et al. (2007) identified 289 cluster members along a NW to SE distribution
- 74 MHz VLSS (Cohen et al. 2007) revealed diffuse steep-spectrum radio emission
- Deep 1425, 325, and 74 MHz images (Figure 1) show complex structure with several head-tail galaxies and an extended region of emission visible only at the lower frequencies

Low Frequency Spectrum of Halos and Relics

- Undertaking a re-reduction of the 74 MHz VLSS data (Cohen et al. 2007)
- Initial tests show an anticipated 40% increase in source counts, a decrease in the rms of 15%, and sensitivity to extended emission on scales larger than 17 arcmin
- Pilot fields were selected on all known radio halo and relic clusters to study the low frequency spectral index
- Preliminary results reveal that at least some of the sources show spectral flattening to 74 MHz
- Results have implications for cluster detection using the new generation of low frequency instruments such as the Long Wavelength Array (LWA) and the Low Frequency Array (LOFAR) as well as the upcoming low frequency upgrade on the Expanded Very Large Array (see Kassim et al. poster)

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