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A Zoo of Radio Relics: Cluster Cores to Filaments

Ruta Kale[1,2,*] & K. S. Dwarakanath[1,†]
[1]*Raman Research Institute, Bangalore 560 080, India.*
[2]*Current address: Inter-University Centre for Astronomy and Astrophysics, Pune University Campus, Pune 411 007, India.*
[*]*e-mail: ruta@iucaa.ernet.in*
[†]*e-mail: dwaraka@rri.res.in*

Abstract. Radio relics in galaxy clusters can be electrons accelerated at cluster merger shocks or adiabatically compressed fossil radio cocoons or dying radio galaxies. The spectral evolution of radio relics is affected by the surrounding thermal plasma. We present a low frequency study of three radio relics representing environments of dense cluster core (A4038), cluster outskirts (A1664) and filaments (A786). The properties of the relics are found to be consistent with the effect of confinement by external medium if the effects of projection are ignored.

Key words. Galaxy clusters – relics.

1. Introduction

The term 'radio relics' refers to a broad class of diffuse radio sources (linear sizes $\sim$50 kpc$-$1 Mpc) that cannot be identified with any particular optically detected galaxy. The radio morphology of radio relics is typically elongated, filamentary, sometimes arc-like and also irregular. The radio relics could be shock accelerated electrons or old lobes of radio galaxies which are lurking or are revived by shock passage (eg. see Ferrari *et al.* 2008 for a review). We present a study of the effect of environment on the evolution of radio relics.

Three radio relics that represent environments such as dense cluster cores (relic in A4038), cluster outskirts (relic near A1664) and filaments (relic near A786) were chosen for study. Multi-frequency observations in order to sample their integrated spectra and spectral modelling using the framework of Enßlin & Gopal-Krishna (2001) were carried out.

2. Observations

Relic in A4038: GMRT at 150, 240, 610 and 1288 MHz.

Relic near A1664: GMRT at 150 and 325 MHz; image with the VLA in D array at 1.4 GHz from the NVSS was used.

Relic near A786: GMRT at 150 MHz, WSRT at 345 MHz and archival observation with the VLA in D configuration at 1.4 GHz was used.

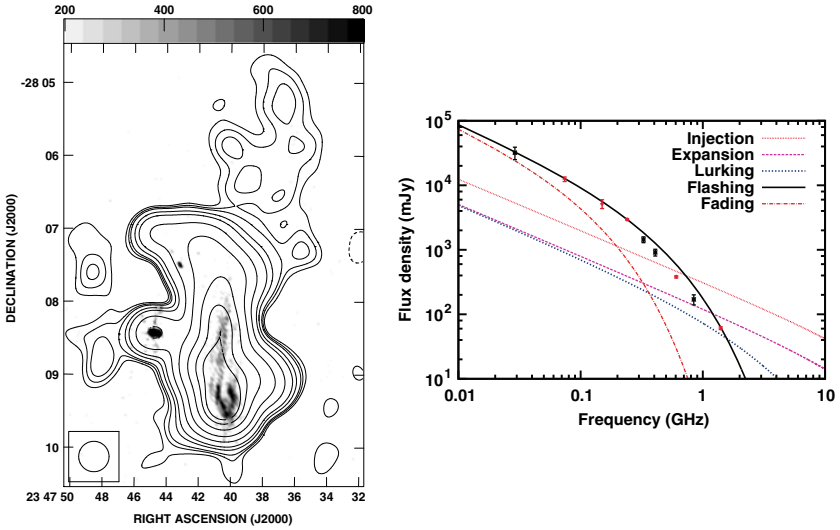

Figure 1. Radio relic in A4038 at 240 MHz (contours) and at 1288 MHz (grey-scale). Model fits (lines) to the integrated spectrum (points) of the relic in A4038.

3. Results and conclusions

GMRT low frequency images of the relic in A4038 led to the discovery of steep spectrum emission ($S \propto \nu^{\alpha}$, $\alpha \sim -1.8$ to -2.8) much larger in extent ($\sim$200 kpc) than was known from 1.4 GHz images ($\sim$56 kpc) (Fig. 1, left). The integrated spectrum of A4038 relic can be best fit by a model of adiabatically compressed plasma (Fig. 1, right). The spectra of relics in A1664 and A786 are best fit by a model of a fossil radio galaxy. The spectral indices of the relics progressively steepen as the environment becomes denser: relics in sparse environments, A786 ($\alpha \sim -1.0$) and A1664 ($\alpha \sim -1.1$) have flat spectra as compared to the relic at the center of A4038 ($\alpha \sim -1.8$). Similarly the sizes of the relics range from $\sim$ 200 kpc to 1.6 Mpc as one goes from dense ($n_e \sim 10^{-2} - 10^{-4}$ cm^{-3}) to sparse ($n_e < 10^{-4}$ cm^{-3}) environments. These trends are consistent with the expectation of steepening of spectral index due to confinement of the relativistic plasma by the intra-cluster medium if we assume that there is no effect of projection.

References

Enßlin, T., Gopal-Krishna 2001, *Astron. Astrophys.*, **366**, 26.
Ferrari, C. *et al.* 2008, *Space Science Rev.*, **134**, 93.