The Universe at Low Radio Frequencies
IAU Symposium, Vol. 199, 2002
A. Pramesh Rao, G. Swarup and Gopal-Krishna, eds.

A Large Diffuse Radio Source in a Cluster of Galaxies at $z = 0.13$

Gopal-Krishna[1], V.K. Kulkarni[1], J. Bagchi[2] and J. Melnick[3]

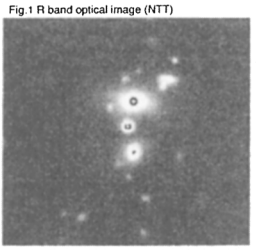
[1] *NCRA-TIFR, Pune University Campus, Pune 411007, India.*
[2] *IUCAA, Pune University Campus, Pune 411007, India.*
[3] *ESO, Casilla 19, Santiago, Chile*

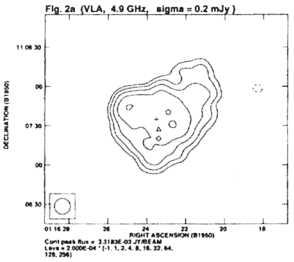
Abstract. Discovery of a diffuse ultra-steep spectrum radio source of size $\sim$ 0.3 Mpc, possibly a radio halo, in a cluster of galaxies at $z = 0.13$ is reported hilighting the presence of a giant radio spiral within the halo.

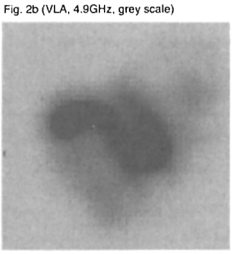
We present GMRT and VLA radio maps and NTT optical image/spectrum of an ultra-steep-spectrum ($\alpha \sim -1.3$), highly diffuse radio source 0116+111 found in the Ooty Lunar Occultation Survey (Joshi & Singal, 1980). Its spectrum is derived from measured flux densities of $920 \pm 24mJy$ at 327 MHz (Joshi & Singal, 1980), $810 \pm 60mJy$ at 408 MHz (Large et al, 1981), $448 \pm 12mJy$ at 610 MHz (present work), $147 \pm 8mJy$ at 1.4 GHz (Condon et al, 1998), $60 \pm 9mJy$ at 2.7 GHz (Effelsberg telescope, present work), $30 \pm 5mJy$ at 4.9 GHz (Gregory et al, 1996) and $35 \pm 4mJy$ at 4.9 GHz (present work). Earlier, our C-array VLA map revealed an amorphous radio emission ($\sim$ $1'$ at 5 GHz), without any unresolved component above 1 mJy. Based on a R-band NTT image (Fig. 1), the source is identified with a $\sim$ $17 - mag$ cD galaxy (α_{1950} = 01 16 23.52, δ_{1950} = +11 07 35.0), which appears to be the dominant member of a distant cluster. A slit-spectrum taken with the grism-3 optics of the NTT gave a redshift z = 0.1316, based on the absoption lines of Na(λ5893), Mgb (λ5169), Hβ, G-band (λ4304), the H,K break and a probable [O II]λ3727 emission line. Also, the bright elliptical $\sim 15''$ south of the cD is found to have $z = 0.1309$.

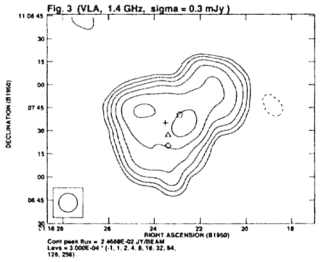
The VLA maps (Figs. 2 & 3) show two warm spots straddling the cD along PA $\sim$ 50^o, indicating a jet-like outflow from the cD. The amorphous radio structure underlying these peaks has an overall extent of $2'$ in the GMRT map at 610 MHz (i.e., $\sim$ 0.3 Mpc ,for H_o = 65 Kms^{-1}.Mpc^{-1}; Fig. 4). Much of this diffuse radio emission lies to the noth-west of the cD and has no detected optical counter parts (See Fig. 1). Thus, it probably represents parts of a radio halo associated with this distant cluster. If so, its luminosity ($\sim$ 1.10^{25} W.Hz^{-1} at 610 MHz) would place it among the most luminous radio halos known.

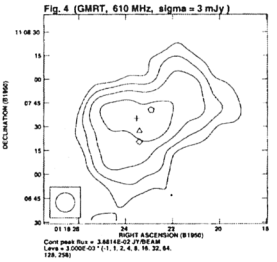
From Figs. 2-4, it is seen that the orientation of the two radio peaks undergoes a systematic clockwise progression with frequency. In fact, the two peaks appear to be part of a radio ridge emanating form the cD and extending well beyond the two peaks, taking the form of a huge radio 'barred spiral' with a diameter of $\sim$ 100 kpc (Fig. 2b). Quite plausibly, such an edge-darkened morphology of radio jets facilitates leakage of their relativistic particles which can fill the giant radio halo. Further in-situ particle acceleration within the halo could occur in the turbulent wakes of the cluster galaxies (Jaffe 1977) and/or in the shocks caused by merger of sub-clusters (De Young, 1992; Tribble, 1993).











Acknowledgments. The VLA is operated by the National Radio Astronomy Observatory (NRAO) for Associated Universities Inc. under a licence from the National Science Foundation of the USA.

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