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Radio galaxies in cooling clusters. The milliarcsecond properties of 3C 317

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Abstract. 3C 317 is a low luminosity radio galaxy, classified as FRI, associated with the cD galaxy UGC09799, at the centre of the cooling flow cluster of galaxies A2052. We observed this source with the VLBA simultaneously at three different frequencies: 1.6 GHz, 5 GHz and 8.4 GHz in polarimetric mode, in order to image the milliarcsecond structure of the source, and to carry out the spectral study of the various components. Our observations allow also the study of the magnetic field distribution and Rotation Measure. Here we present our preliminary results and discussion. We use H_0= 50 km s^{-1} Mpc^{-1}, q$_0$= 0 and $S \propto \nu^{-\alpha}$ throughout the paper. For 3C 317 1 mas $\sim$ 1 pc.

1. The current knowledge of 3C 317 properties

The radio galaxy 3C 317 (z = 0.035) is associated with the cD galaxy UGC9799, located at the centre of the cooling flow cluster of galaxies A2052. Its total power is P_{tot} (1.4 GHz) = 5.4×10^{24} W Hz^{-1}, and the core luminosity is P_{core} (5 GHz) = 2.2×10^{24} W Hz^{-1}. It falls in the range of low luminosity radio galaxies and is classified as Fanaroff-Riley Type I (FRI). The classical morphology of FRIs is characterised by a core, two symmetric jets and low brightness lobes, while 3C 317 could be classified as a core-halo. It consists of a compact region surrounded by a steep spectrum low brightness radio halo, with an angular extent $\sim 1.5'$ ($\sim$ 90 kpc), all embedded within the optical galaxy.

Its optical counterpart shows several emission line filaments, co-spatial with the radio emission (Burns 1990). The optical spectrum is typical of FRI galaxies, dominated by the stellar continuum with weak, low-ionisation lines (Tadhunter et al. 1993).

3C 317 shows peculiar radio properties. Its integrated radio spectrum is steep ($\alpha \sim 1.4$); furthermore the source has a high integrated rotation measure: $RM \sim -800\,\mathrm{rad\,m^{-2}}$ (Taylor et al. 1992). These last two features suggest that a high density, ionised medium surrounds the compact radio emission.

When observed at high resolution, from sub-arcsecond (Zhao et al. 1993) to mas scales (Venturi et al. 2000), the source shows a counter-clockwise bent morphology, in a spiral-like shape. Furthermore, VLBI observations show that the source does not have a steep spectrum on the milliarcsecond scale: the parsec–scale emission has a convex spectrum with a peak at a frequency of 5 GHz.

The integrated rotation measure is suggestive of a high density, magnetised medium, but the literature information does not establish whether it is intrinsic to the source or due to an external screen located between the source and the observer.

The flat spectrum of the sub-arcsecond core suggests that the core is young and active now, and that the emission presently radiated from the core is not related to the steep spectrum halo, for which an old age has been derived ($\alpha = 1.66 \pm 0.06, t \sim 10^8$ yr) (Spagnesi, master thesis).

A detailed analysis of the parsec-scale properties of this source is necessary to study how 3C 317 fits into the current evolutionary models for radio sources and if the external environment affects the radio properties on the parsec scale. Here we present VLBA observations which address these important questions.

2. Observations

Observations have been carried out with the VLBA and one VLA antenna, simultaneously at three different frequencies: 1.6 GHz, 5 GHz and 8.4 GHz, in polarimetric mode. At 5 and 8.4 GHz we spaced the frequency of the two IFs in order to optimise the u-v coverage and to derive the Rotation Measure from four points.

The standard data reduction for VLBI polarimetric observations was carried out using the AIPS data reduction package.

Table 1 summarises the main parameters of the observations; in particular, for each frequency we report the bandwidth, the frequency of the two IFs, the total time on source, the beam parameters and the r.m.s of the final images.

3. Preliminary results

The data reduction is still in progress. At present we have processed the data at 1.6 GHz and 5 GHz. We present here the images of 3C 317 at these two frequencies, shown in Figs. 1 and 2.

At 1.6 GHz the source is dominated by a barely resolved nuclear component, with two symmetric faint jets

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Table 1. Parameters of observations and images

Band	Total Bandwidth[a] MHz	IF1 GHz	IF2 GHz	t hrs	FWHM, PA mas, °	r.m.s. mJy/beam
L	16	1.658	1.667	2.30	10 × 5 (mas) at -2.33°	0.19
C	16	4.860	4.995	2.30	3.4× 1.7 (mas) at - 3.21 °	0.07
X	16	8.213	8.421	2.30	–[b]	–[b]

[a] The total bandwidth is the sum of the bandwidth of IF1 and IF2.
[b] The data at 8.4 GHz have not been reduced at the time of writing.

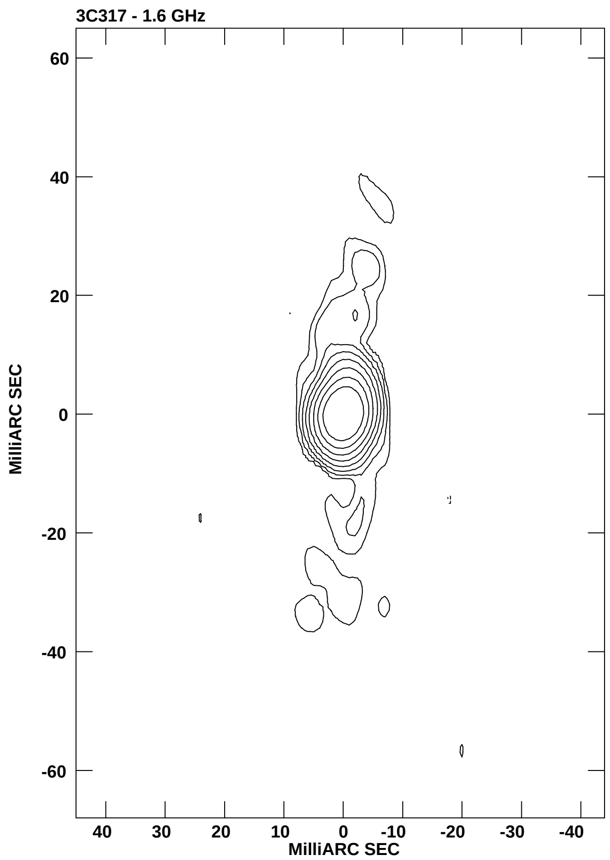

Fig. 1. 1.66 GHz image of 3C 317. Peak: 274 mJy/beam. Contours: 0.7 mJy ×(-1, 1, 2, 4, 8, 16, 32, 64, 125). Restoring beam FWHM: 6 × 5 (mas) at 0°.

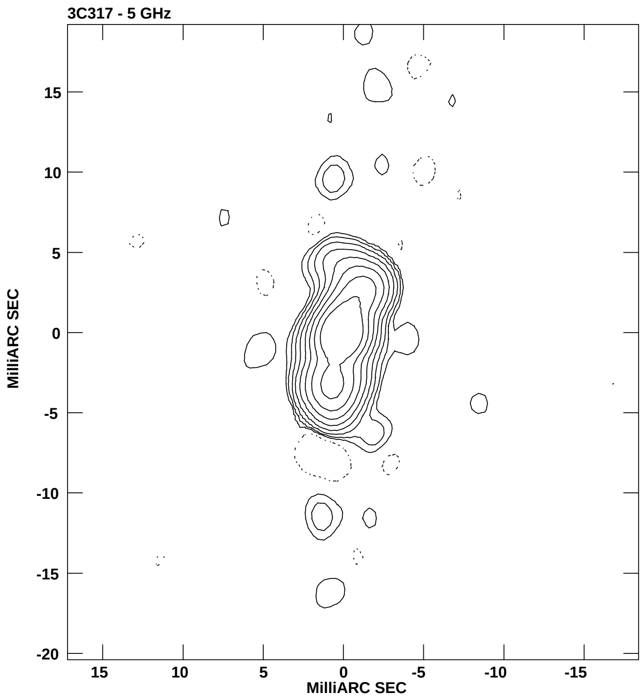

Fig. 2. 5 GHz image of 3C 317. Peak: 155 mJy/beam. Contours: 0.3 mJy × (-1, 1, 2, 4, 8, 16, 32, 64, 125). Restoring beam FWHM: 2 × 1.76 (mas) at 0°.

elongated in the N–S direction. The surface brightness of these two jets decreases quite smoothly.

The 5 GHz image is consistent with the 1.6 GHz one. The source is elongated N–S, with two symmetric jets. There is some indication that both jets bend at ∼ 5 mas from the peak, in an S-shaped structure. This milliarcsecond scale structure is very similar to the arcsecond scale imaged in Burns (1990).

At 5 GHz we have studied the magnetic field structure in the source. Our preliminary data reduction shows a considerable difference in the polarisation between the two IFs, which is higher for the IF2 (higher observing frequency). The magnetic field vector rotates by $\Delta\Theta_{average} \sim -30°$ between the two IFs, leading to local RM of a few thousands rad m^{-2}. These two results suggest that the rotation measure is intrinsic to the source, and not due to an external magnetised screen. The reduction of the 8.4 GHz data will allow us to complete the study of the RM and other nuclear properties in the source.

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