VLBI polarimetric observations of 3C147

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Abstract. We present multi-frequency VLBI observations of the Compact Steep-spectrum Quasar 3C147 (0538+498) made with the VLBA at the four frequencies in the available 5 GHz band and at 8.4 GHz (still under analysis), from which we derived millarcsecond-resolution images of the total intensity, polarization, and rotation measure distributions. The source shows a core-jet structure, with a compact feature and a jet, extending about 200 mas to the South-West. We detect polarized emission in two bright features in the inner jet; the rotation measure of this features ($\sim$ -1630 rad m^{-2}, $\sim$ -540 rad m^{-2}).

1. Introduction

Compact Steep-spectrum Sources (CSSs) seem to be a scaled-down version of large-sized double radio sources. They have linear sizes $< 20\ h^{-1}\ kpc$ ($q_0 = 0.5$ and $H_0 = 100\ h$ km s^{-1} Mpc^{-1}) and steep high-frequency radio spectra. It is now generally believed that most of them are *young* radio sources, with life-time $< 10^{3-5}$ year, whose radio lobes have not had time to grow to kilo-parsec scales (Fanti et al. 1995).

Among them there is a subclass of quasars characterized by very luminous jets which often show polarized emission and high integrated Faraday rotation.

Owing to their small sizes these objects are fully immersed in the host galaxy ISM and their distorted, complex morphologies (like in 3C119, 3C343) show evidence of strong interaction of the jets with the dense ambient medium.

Here we report VLBA polarimetric observations at 5 GHz of the CSS quasar 3C147. These observations are part of a program aimed at studying the polarization characteristics of the core regions, jets and lobes and possibly the jet-cloud interactions in CCSs.

2. General information

3C147 (0538+498) is a prominent CSS source at $z = 0.545$ with a total angular extent of 0.6 arcsecond, corresponding to a projected linear size of $\sim 2.2\ h^{-1}\ kpc$.

On the sub-arcsecond scale it displays a very asymmetric double-lobed radio structure with a prominent central component (Akujor & Garrington 1995; Junor et al. 1999) which is resolved out from VLBI observations into a compact core with a jet emerging from it toward the South-West (Alef et al. 1990).

This object shows a very large integrated rotation measure, RM~ -1500 rad m^{-2}, (Inoue et al. 1995), suggesting that the radio source may be surrounded by a dense ionized medium.

3. Observational results

We observed 3C147 for about 12 hours at 5 GHz and 8.4 GHz with the VLBA in May 2001. The data were correlated with the NRAO VLBA processor at Socorro and calibrated, imaged

and analysed using the AIPS package. Images obtained from our data are shown in Fig. 1– 2. The rms noise level is about 0.2 mJy, but we use a first contour level greater than 3σ because of the presence of minor but significant residual calibration errors, probably due to the difficulty in imaging complex structures having both compact features and very extended emission.

On the mas-scale 3C147 shows a one-sided core-jet structure. The observed structure can be divided into two parts: the complex compact region (which probably contains the core and the head of the jet) and the jet, extending to the South-West, which is followed out to a distance of about 200 mas from the compact component. It widens soon without loosing its collimation, shows several gentle wiggles and turns toward the North near the end of its length. No signs of counter-jet are seen. Fig. 1 shows two compact components embedded in a more diffuse emission: one at the position of the peak (B) and one to the North-East of the peak (A) as in Nan et al. (2000). We find a total flux density of 4.70 Jy. Total and polarized flux densities integrated on the same regions for the compact components are given in Table 1. Polarized emission has been detected from both components.

Table 1. Source parameters.

Component	IF MHz	S mJy	p mJy	χ °	%pol
A	4619	345	3.3	8.4	$\sim$ 1.0
	4657	332	3.0	-1.0	$\sim$ 0.9
	4854	339	3.1	12.3	$\sim$ 0.9
	5090	330	2.9	27.2	$\sim$ 0.9
B	4619	707	9.6	-46.5	$\sim$ 1.4
	4657	688	11.6	-44.5	$\sim$ 1.7
	4854	693	13.6	-13.3	$\sim$ 2.0
	5090	671	11.6	+21.8	$\sim$ 1.7

In Nan et al. (2000) there are indications that component A is not polarized and, based on its weak polarization, they identify it as the core. The spectral index we derive for component
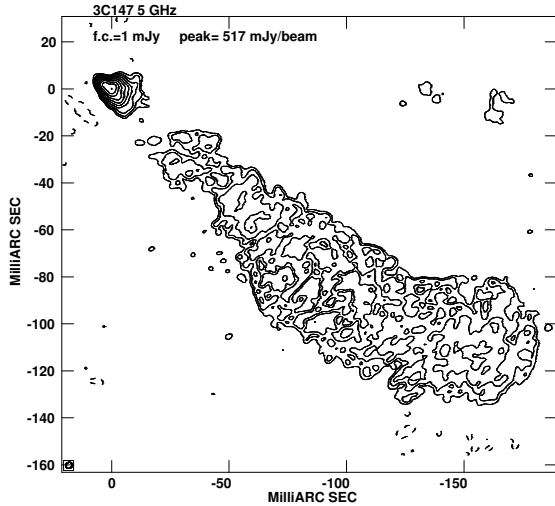
Fig. 1. 5 GHz image of 3C147 with a restoring beam of 2.8 x 2.5 mas at -40° and 4 IFs. Contour levs increase by a factor of 2.
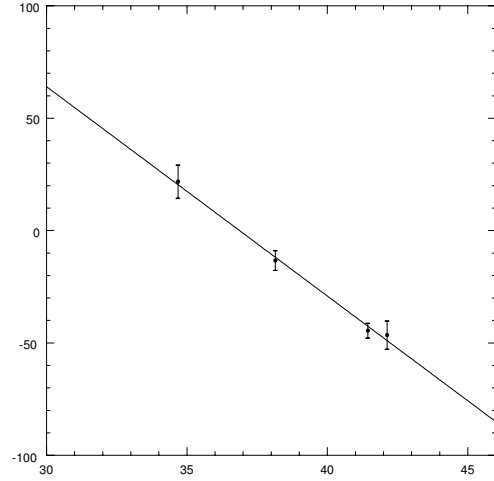

Fig. 3. Plot of the observed χ values for the polarization of component B as a function of λ^2 for the four wavelengths.
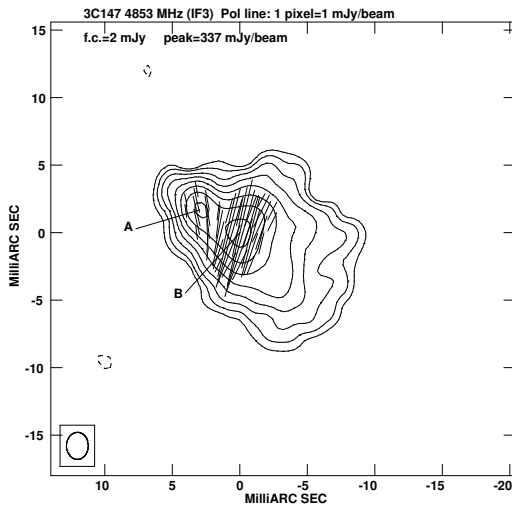

Fig. 2. 4.85 GHz image of the central compact component of 3C147 with polarization angle sticks for the IF 3 superimposed. Contour levs increase by a factor of 2.
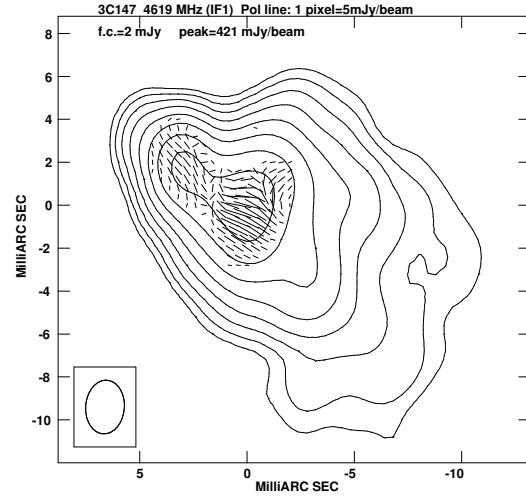

Fig. 4. 4.6 GHz image of the central compact component of 3C147 with the intrinsic orientation of the magnetic field vectors superimposed. Contour levs increase by a factor of 2.

A is $\alpha_5^{8.4} \sim 0.3$. We suggest that the polarized emission we detect at 5 GHz for component A comes from the head of the jet and that we have not enough resolution to resolve the real core. In Table 1 we give the polarization angle values at each of the four frequencies. We used that values at the peak of the polarized flux density of the four p maps to estimate the RM for components A and B. A best squares fit to this data gives an integrated RM of -1630 ± 110 rad m^{-2} for component B (see Fig. 3) and of -540 ± 110 rad m^{-2} for A component, where uncertainties due to both the calibration and the image noise levels have been considered. No redshift corrections have been applied to the wavelength, so the RMs in the rest of frame of 3C147 results of about -3900 ± 260 rad m^{-2} for the B component and -1290 ± 260 rad m^{-2} for the A component. In order to establish the orientation of the magnetic field we have extrapolated the polarization angle to $\lambda = 0$ and have found $\chi \sim -16° \pm 23°$. As a result, the magnetic field vectors should be oriented along the direction of the jet (see Fig. 4), but a more accurate study of the magnetic field orientation could be done only when the 8.4 GHz information will be available.

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