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Intrinsic jet parameters from multifrequency VLA polarization observations of archetypical FR-II quasars and radio galaxies

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Abstract. VLA observations of selected FR-II jets (3C208, 3C352, 3C434, 3C9 and 3C14) between 5 and 15 GHz are used to derive astrophysical properties in the jets of these radio sources. We interpret the results as giving support for unifying schemes of radio galaxies and quasars. We have also determined the Faraday rotation for jets and counter-jet sides. Rotation measures are used to constrain the internal density and mach numbers of the jets, obtaining values similar to those of quasar jets but higher than those of radio galaxies. The radio brightness can be explained by doppler boosting of the synchrotron radiation, giving evidence for orientation effects as an origin for the Laing-Garrington effect.

1. Introduction

Radio properties are a good indicator of central engine activity in X-ray selected quasars with a single visible jet since there is a tedency of high-power radio-selected DRAGNs to have higher X-ray luminosities (Tananbaum et al. 1993). An evolutionary relationship has also been proposed to unify radiogalaxies and quasars (Harvanek et al. 2001). Evolving radio structures are also expected from Fanaroff-Riley type II objects (FR-II), a few of them with detected superluminal motion within a few parsecs from the core component (Harvanek & Stocke 2002).

Radio sources with a double structure often show a single jet linking the core to the brightest hostpot in the jet side. A counter-jet side is defined as a region of radio emission opposed to the jet, and a counter-jet is rarely detected. The asymmetry in the jet position and brighness is thought to be due to relativisitic Doppler boosting, as the source is seen at an angle closer than 32° to the line-of-sight (Barthel 1989).

In this paper we attempt to derive limits for a jet density and kinematical parameters based on arguments of internal depolarization of the jets, using VLA measurements at 5 and 8 GHz of selected radio sources from the revised 3C catalogue (Laing et al. 1983).

2. The data

The data comprise VLA observations of selected radio sources at various configurations and epochs, mostly A and B arrays. These sources can be classified as FR-II radio source based on the 6-cm core luminosity to the integrated 21-cm radio luminosity, according to the Bridle (1986) classification of powerful jets, namely $P_{core}^{6\ cm} \geqslant 10^{23}$ W Hz^{-1} and $P_{tot}^{21\ cm} \geqslant 10^{24.5}$ W Hz^{-1}.

For the present time, we will limit ourselves to discuss the properties of the selected quasars and radio galaxies shown in figure 1, where radio images of the jet sides are given. A standard circular beam of 350 milliseconds of arc has been used to deconvolve the images to typical noise floors of about 65 μJy beam^{-1}. All these sources show the

Laing-Garrington effect between 21 and 6 cm observing wavelength at lower resolutions. The arm length ranges between 12 and 18 kpc, with the jet of the largest radio source in our sample, 3C336, having about 28 kpc total length (H_0=50 km s^{-1} Mpc^{-1}, $q_0 = 1/2$).

3. The results

Fracional polarizations along the jets are typically 12-22 % for the present sample, whereas the core components of 3C208 and 3C275.1 show only marginaly polarized emission ($< 4\%$). The amount of Faraday rotation between 5 and 8 GHz is very small, as it is the depolarization ratio, suggesting that higher resolutions at 18 and 21 cm is required to resolve the depolarizing medium in the jets and lobes.

We have run a computer simulation in which tangled magnetic fields with intensities close to equipartition values induce internal depolarization of the synchrotron radiation in cylindrical jets. If the tangling scale is adopted to be about 200 parsecs, we expect the jet to be in equilibrium with the intergalactic medium, if the jet density relative to the IGM particle density is less than 2×10^{-3}, as expected for light, hypersonic jets. Minimum internal pressures are within the 10^{-11} to 10^{-7} dyn cm^{-2}. The simulations require also very small particle column densities integrated along the line-of-sight to produce the observed rotation measures.

The jet brightness asymmetries seen in our sample can be explained by standard Doppler boosting analysis, giving the inclination to the line-of-sight angles smaller than 30°, which is consistent with unifying schemes based on relativistic arguments.

Although the jets are not resolved transversally by the VLA, some of them are good targets for polarization-sensitive VLBI observations, to look for superluminal motion at parsec scales.

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