Less is More? Are Radiogalaxies Below the Fanaroff-Riley Break More Polarised on Pc-Scales?

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1 Introduction

Magnetic (B-) fields are believed to be instrumental in the formation and collimation of relativistic jets from radio-powerful active galaxies (Blandford & Payne 1982[1], Lovelace et al. 1987[6]). Ordered parsec-scale B-fields have been detected in the nuclei of several of the Doppler-beamed BL Lacs and quasars via VLBI polarimetry (Gabuzda et al. 1994[3]). However, such evidence is meagre in radio-loud galaxies whose jets are purportedly closer to the sky plane and therefore not heavily Doppler beamed. (Taylor et al. 2001[8], Middelberg et al. 2003[7]). In particular, there have been no detections of parsec-scale nuclear polarisation for any galaxy below the Fanaroff-Riley (**FR**) luminosity break (Fanaroff & Riley 1974[2]) that broadly separates radio galaxies with plume-like structures from those with well-collimated jets terminating in hot spots. Here we present our detections of nuclear parsec-scale polarisation in four FRI galaxies, and discuss their implications in the framework of Unification.

2 Observations and Results

We observed the four FRI radio galaxies *viz.*, 3C 66B, 3C 78, 3C 264 and 3C 270, at 8.4 GHz (λ 3.6cm) on 1 March 2002 with a global VLBI array consisting of the Very Large Baseline Array (VLBA)[4] and five stations of the European VLBI Network.[4] The calibration and imaging were done using standard techniques.

The spatial resolution is $\sim$0.5 mas, corresponding to $\sim$0.2–0.4 pc. Polarisation of 0.4–1% was detected from the inner parsec of all the galaxies (Fig. 1). In each case, the brightest component has a flat or inverted spectral index as inferred from comparison with images at other frequencies (e.g., Giovannini et al. 2001[4], Jones & Wehrle

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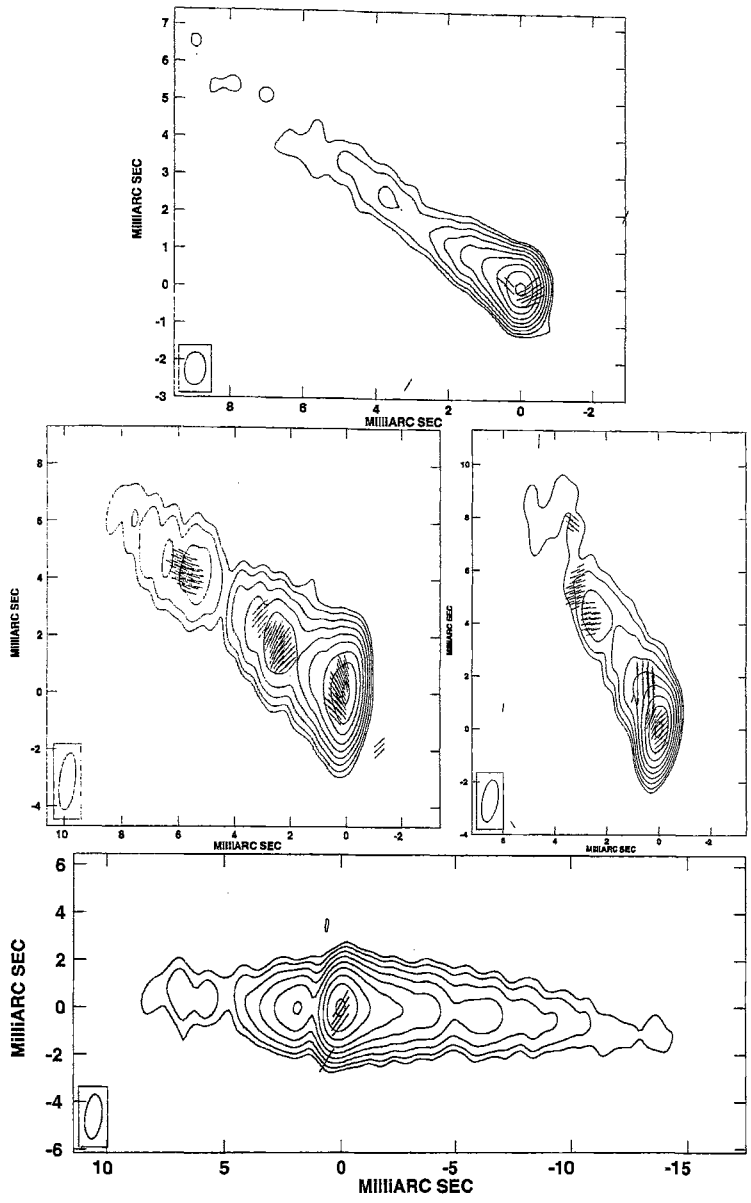

Fig. 1. Total intensity radio maps of the galaxies with polarisation electric vectors superimposed. Top: 3C 66B; Middle: 3C 78 & 3C 264; Bottom: 3C 270. The surface brightness peaks in are 118.2, 285.9, 165.3 & 136.3 mJy/beam respectively. The lowest contour is $\pm 0.35\%$ of the peak surface brightness, and the contour levels are in percentage of the peak, increasing in steps of two. The polarisation measured is $\simeq 0.4 - 1\%$, in the cores, rising to $\simeq 5 - 10\%$ in the inner jet ($\lesssim 1$ pc from the core), and reaching 60% in a knot about 1.5 pc from the core of 3C 264.

1997[5]), and can therefore be identified as the VLBI "core." 3C 270 has no detected polarisation beyond its core.

3 Conclusions

1. The fractional polarisation is comparable to the corresponding values in BL Lacs and quasars, indicating the presence of appreciably ordered B-fields in the inner parsec of FRI galaxies and little depolarisation.
2. Albeit for a small number, our 100% detection rate is higher than that for narrow-lined FRII galaxies (only 1/4 detected: Taylor et al. 2001[8], Middelberg et al. 2003[7], Zavala & Taylor 2002[9]). If this trend is due to depolarisation by the inner ionized edge of an obscuring torus, it would imply that the FRIs lack such ionized material in their inner pc.
3. The inner-jet polarisation is parallel to the local jet in at least 3C 66B and 3C 78, implying a transverse B-field as is typical of BL Lacs. In 3C 264 and 3C 270, the nuclear B-field orientation cannot be unamibigously inferred due to possible resolution and/or Faraday rotation effects. A longitudinal B-component develops further along the jet in 3C 78 and 3C 264, and there are regions of alternating B-field orientation in 3C 78, similar to BL Lacs. On the whole, the qualitative and quantitative similarities between these polarisation structures and those of BL Lacs are striking, and our images are thus consistent with the prediction of the simple unification in which FRIs are the parent population of BL Lacs.
4. The two galaxies with the highest jet-to-counterjet ratios (*i.e.*, the highest implied Doppler-beaming), *viz.*, 3C 78 and 3C 264, have more detected polarisation and structure in their jets.
5. The ordered nuclear B-field in 3C 66B is on a scale $\sim$0.3 pc, and therefore within $\sim$1650 Schwarzschild radii of the putative black hole, based on its estimated black-hole mass of $\sim 2 \times 10^9 M_\odot$ (Noel-Storr et al.'05, preprint).

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