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Milliarcsecond-scale polarization structure in the quasars 3C 279 and 3C 454.3

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ABSTRACT
Polarization-sensitive global VLBI observations at $\lambda = 6$ cm of the quasars 3C 279 and 3C 454.3 are presented; these observations offer resolution ~ 0.5 mas, corresponding to linear scales in the sources ~ 2 pc. In both sources, the polarization associated with the jet emission indicates that the predominant jet magnetic field is longitudinal. In 3C 454.3, the magnetic field maintains alignment with the local jet direction even in places where the jet is highly curved. The degree of polarization in the jets ranges from 2 to 29 per cent, and is typically ~ 15 to 20 per cent, indicating that the jet components are optically thin. The core of 3C 279 is rather weakly polarized (< 1.6 per cent), while that of 3C 454.3 is more strongly polarized (~ 4.6 per cent), suggesting that 3C 454.3 may have been in the process of giving birth to a new VLBI component at the epoch of our observations. Both sources were imaged at epochs at which new components had recently emerged from the core. The magnetic field in the innermost knot in 3C 279 appears to be aligned with the local jet direction, as is typical of quasars, while that in the innermost knot in 3C 454.3 seems to be perpendicular to the local jet direction, suggesting that this new component is associated with a transverse shock.

Key words: techniques: polarimetric – galaxies: active – galaxies: jets – quasars: general – quasars: individual: 3C 279 – quasars: individual: 3C 454.3.

1 INTRODUCTION

Our knowledge of the properties of the milliarcsecond-scale jets in active galaxies has been greatly enhanced as the result of polarization-sensitive VLBI observations (Gabuzda et al. 1992, 1994; Cawthorne et al. 1993a,b; and references therein). For example, clear differences have emerged between the polarization properties of the parsec-scale jets in quasars and in BL Lacertae objects. In particular, the inferred magnetic fields in quasar jets tend to be parallel to the local jet direction whereas those in BL Lacertae object jets tend to be orthogonal to the local jet direction. It is usually supposed that the longitudinal magnetic fields in quasars are due to shear. Perhaps the most natural interpretation of the transverse magnetic field structure observed in BL Lacertae objects is that the polarized jet components are associated with relativistically moving shocks that enhance both the transverse component of the magnetic field and the synchrotron brightness of the jet plasma (Laing 1980; Hughes, Aller, & Aller 1989).

We present here VLBI polarization images of the quasars 3C 279 and 3C 454.3. For 3C 279 these are the first such images to be made. For 3C 454.3 an early polarization image was made at wavelength 18 cm by Cotton et al. (1984). However, since those authors noted major discrepancies between their total intensity image and other published images, we shall attempt no comparison between their results and those presented here. The polarization in both sources indicates that the predominant jet magnetic field is aligned with the local jet direction, as is typical for quasars. This alignment is maintained in 3C 454.3 even in regions in which the jet is rather highly curved; this appears to be evidence for fluid motion along streamlines rather than ballistic motion of components outwards from the core. Our results suggest that the magnetic field in a recently born jet component in 3C 454.3 is transverse to the jet direction. This is somewhat unusual in quasars, but ought to be occasionally seen if transverse shocks make an appreciable contribution to the emission in the knots in these objects, as suggested by Cawthorne et al. (1993b).

2 OBSERVATIONS

The observations of 3C 279 were made in 1987 May (1987.4) and those of 3C 454.3 in 1988 March (1988.2), both using the same global VLBI array consisting of 8 antennas. With the

Table 1. Antennas used in both sets of observations described by this paper.

Antenna	Location	Diameter (m)	Polarization 1987.4	Polarization 1988.2
Medicina	Bologna, Italy	32	R,L	R,L
Effelsberg	Bonn, Germany	100	L	R,L
Phased WSRT	Dwingeloo, Netherlands	14×25	R,L	R,L
Haystack	Westford, Massachusetts	37	R,L	R,L
Green Bank	Green Bank, West Virginia	43	R,L	R,L
Fort Davis	Fort Davis, Texas	26	R,L	R,L
Phased VLA	Socorro, New Mexico	27×25	R,L	R,L
OVRO	Big Pine, California	40	R,L	R,L

exception of Bonn in 1987.4, both right and left circular polarizations were recorded at each station; Bonn recorded only left circular polarization during the 1987 observations. The observations were made at 4985 GHz with a total bandwidth of 14 MHz in each circular polarization; some parameters for the antennas used are summarized in Table 1.

Both sets of observations were made under the auspices of the US and European VLBI networks. The data were recorded using the MkIII system, and all data were subsequently correlated using the Mk IIIA correlator at Haystack Observatory. The polarization calibration of these data was performed as described by Roberts, Wardle & Brown (1994). Hybrid maps of the distribution of total intensity I were made using a self-calibration algorithm similar to that described by Cornwell & Wilkinson (1981). Maps of the linear polarization* P were made by referencing the calibrated cross-hand fringes to the parallel-hand fringes using the antenna gains determined in the hybrid mapping, Fourier transforming the cross-hand fringes, and performing a complex CLEAN. One byproduct of this procedure is to register the I and P maps to within a small fraction of a beam-width, so that corresponding I and P images may be directly superimposed.

3 RESULTS AND DISCUSSION

In each of the images that are shown, the restoring beams are shown as crosses in a corner of the image. For the linear polarization images, the contours are those of polarized intensity p, and the plane of the electric vector is indicated by the polarization position angle vectors that are superimposed.

There is always the possibility that the observed polarization position angles include some contribution due to Faraday rotation along the line of sight to the emission region. In the absence of simultaneous multi-wavelength VLBI polarimetry, the only Faraday correction that may be applied is one based on integrated measurements. However, it is not possible to know to what extent integrated rotation measures are appropriate for VLBI components. Because the integrated rotation measures for both sources are not large (27 rad m^{-2}, corresponding to a rotation of +5°, for 3C 279 and −44 rad m^{-2}, corresponding to a rotation of −9°, for 3C 454.3: Rusk 1988), and because these integrated measurements may be strongly influenced by larger scale polarization (see Cawthorne et al. 1993b, for example), we have decided not to apply Faraday corrections to our VLBI polarization measurements.

Models for the source structure at each epoch were derived by fitting the complex I and P visibilities that come from the hybrid mapping process as described by Roberts, Gabuzda & Wardle (1987) and Gabuzda, Wardle & Roberts (1989). The model fits are shown in the tables.

3.1 3C 279

3C 279 has a redshift $z = 0.538$ (Burbidge & Rosenberg 1965; Lynds, Stockton & Livingston 1965). With respect to its VLBI properties, it is a somewhat unusual source: it is classified as an optically violently variable quasar, but appears to exhibit some properties more characteristic of BL Lac objects. For example, the components in its VLBI jet, which lies at $\theta \sim -135°$, exhibit relatively 'slow' superluminal speeds (Unwin et al. 1989). In addition, there is evidence from integrated cm-wavelength monitoring data (Aller et al. 1985; Hughes et al. 1989) that relativistic shocks dominate the integrated emission in at least some highly polarized radio outbursts; as noted above, symptoms of shocks are often evident in the VLBI jets of BL Lacertae objects but are less apparent in quasars.

I and P images for 3C 279 are shown in Fig. 1. The u–v coverage obtained was somewhat sparse, partially because of the source's low declination and partially because it was added to the VLBI schedule rather late, when it was learned that the source was undergoing a highly polarized optical outburst (Balonek et al. 1989; Teräsranta et al. 1992). The VLBI jet in structural position angle $\sim -135°$ is clearly visible; model fitting and the distribution of CLEAN components indicate the presence of three jet components, one barely resolved from the core (C4). Because of the relative sparsity of the u–v coverage, we are unable to assign reliable sizes to these components, and we have modelled them and the core as points, consistent with the fact that the distribution of CLEAN components shows them to be compact. It is plausible that these three jet components correspond to the jet components C2, C3, and C4 of Unwin et al. (1989), and so we have labelled them according to this scheme in Table 2. The positions of the knots at separations of 4.43 and 1.01 milliarcsec from the core agree well with those expected for C2 and C4. The position for the remaining knot is somewhat further from the core (2.86 mas) than the expected separation at our epoch for C3 (roughly

* $P = pe^{2i\chi} = mIe^{2i\chi}$, where $p = mI$ is the polarized intensity, m is the fractional linear polarization, and χ is the position angle of the electric vector on the sky.

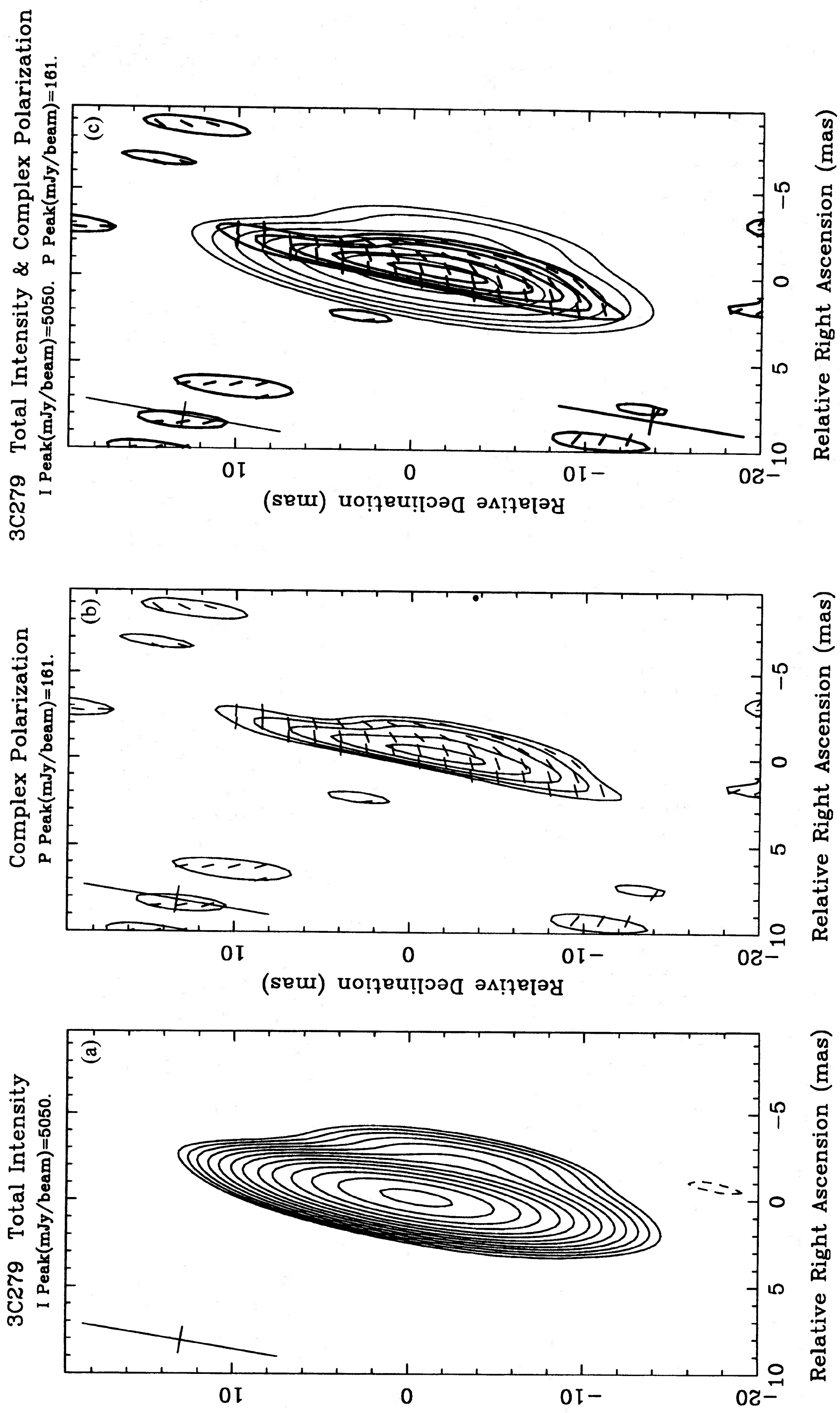

Figure 1. VLBI hybrid maps of 3C 279 at 5 GHz, epoch 1987.4. (a) Total intensity, with contours at −1.4, 1.4, 2.0, 2.8, 4.0, 5.6, 8.0, 11.0, 16.0, 23.0, 32.0, 45.0, 64.0, and 90.0 per cent of the peak brightness of 5.05 Jy $beam^{-1}$. (b) Linear polarization, with contours of polarized intensity at 22, 31, 44, 62, and 88 per cent of the peak brightness of 161 mJy $beam^{-1}$, and χ vectors superimposed. (c) Polarization as in (b) shown by bold lines superimposed on total intensity contours at 2, 4, 8, 16, 32 and 64 per cent of the peak. The total intensity beam (full width half maximum) is 11.3×1.5 mas^2 in position angle −8°. The polarized intensity beam is 10.8×1.5 mas^2 in position angle −9°.

Table 2. *I* and *P* model for 3C 279.

Component	I (mJy)	p (mJy)	χ (deg)	m (%)	r^a (mas)	Δr (mas)	θ^a (deg)	$\Delta\theta$ (deg)
Core	2437	<40	—	< 1.6	—	—	—	—
C4	3953	240	−81	6.1	1.01	0.03	−120	2.2
C3	688	167	−10	24.3	2.86	0.14	−142	2.2
C2	326	48	+0	14.7	4.43	0.24	−135	3.2

[a] Separations, and structural position angles with respect to the core. All components in this model are points.

2 mas), but we consider it to be likely that this is an artefact of our rather poor *u–v* coverage and the poor N–S resolution.

Polarization was detected in all three *I* jet components; the two innermost jet components C3 and C4 are most clearly visible in the polarization map (Fig. 1b). Offsets between the positions for the *P* components and those of the corresponding *I* components are all $\sim$ 0.15 times the beam half width half maximum or less, consistent with the *I–P* position registration errors expected for sources imaged using relatively sparse *u–v* coverage (Roberts et al. 1994). The component positions listed in Table 2 are those for the *I* model. We have derived an upper limit to the polarization of the core based on the noise level on the *P* image. This indicates that the core is less than 1.6 per cent polarized, as is typical for quasars. It is interesting that, at first glance, χ in the three jet components does not seem to bear a clear relationship to the VLBI jet direction. The structural position angles θ of C2, C3, and C4 are about −135°, −142° and −120°, respectively, so that $|\theta - \chi|$ for these components is $\sim$ 40° − 45°. However, closer examination of the χ values and the positions of the VLBI knots (Fig. 2) suggests that there are relationships between χ and the local jet direction. The solid lines in Fig. 2 show χ, while the dashed lines show θ_{in} (the direction from the next knot inward toward the core) and θ_{out} (the direction toward the next knot outward from the core) for each component. For C4, the direction of χ is almost perpendicular to that from C4 toward C3; for C3, the direction of χ is almost perpendicular to that from C3 toward C2 (both within $\sim$ 20°). Since the inferred magnetic field direction at each knot on the assumption that the emission is optically thin is perpendicular to χ, this suggests that the magnetic field in these knots is parallel to the *local* jet direction. Furthermore, we note that the inferred magnetic fields at C3 and C4 align better with θ_{out} than with θ_{in} (see also Table 3). Below we note a similar effect for several components in 3C 454.3. One possible origin for this difference in offsets could in principle be uniform Faraday rotation; this does not appear to be the case in 3C 279, however, since it is impossible to improve the agreement between θ_{in} and $\chi - 90°$ for all components by rotating χ by a constant amount.

In C2, χ is similar to that in C3, and it is plausible that the magnetic field is also parallel to the jet direction at C2. This view is supported by the alignment of the structural position angle of C2 with the position angle of the kiloparsec-scale jet to within 15° (Unwin 1987), suggesting that only a gentle change in direction occurs beyond C2.

The polarization position angle in C4 is close to that measured nearly simultaneously at optical wavelengths (Gabuzda & Sitko 1994), suggesting that the radio knots in at least some active galactic nuclei can be sources of optical emission, and that C4 was the site of the optically polarized outburst that was occurring in 3C 279 at the epoch of our VLBI observations (Balonek et al. 1989; Teräsranta et al. 1992). It is interesting that Unwin et al. (1989) showed that an earlier outburst in 3C 279 also occurred in a VLBI jet component rather than in the VLBI core. One natural way in which a

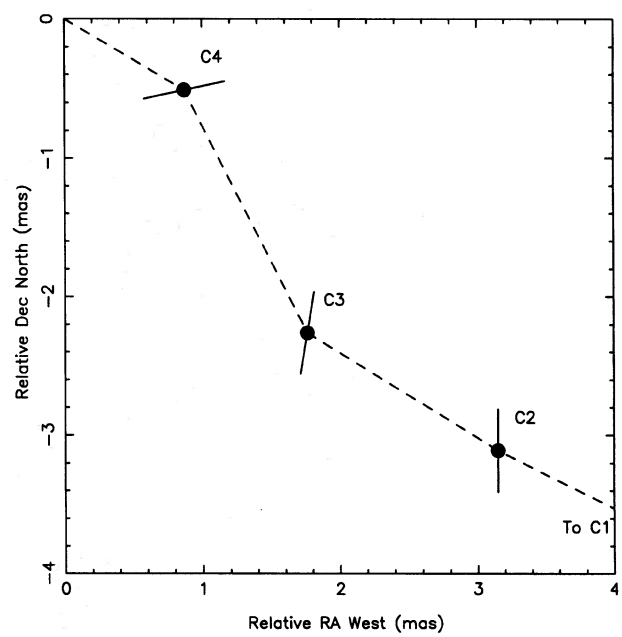

Figure 2. Plot of the positions of each of the components for the 3C 279 model in Table 2, with χ for each component shown by a single vector at the position for that component.

Table 3. Offsets between magnetic field and local jet direction for 3C 279.

Component	$\chi - 90° - \theta^a_{in}$ (deg)	$\chi - 90° - \theta^a_{out}$ (deg)
C4	−51	−18
C3	+53	+21
C2	+31	—

[a] θ_{in} = direction from the next inner component
θ_{out} = direction to the next outer component

connection between the optical and radio polarizations might arise is if a substantial fraction of the optical polarization originates in compact, highly energetic shocks as they form and move outward from the core, as suggested by Gabuzda & Sitko (1994). However, the fact that the optical and radio χ values imply a *longitudinal* rather than transverse magnetic field in C4 suggests that this is not always the case.

3.2 3C 454.3

3C 454.3 has a redshift $z = 0.859$ (Schmidt 1968). VLBI images of this source at wavelengths from 18 cm to 1.3 cm have been made by Pauliny-Toth et al. (1987). From observations at wavelength 2.8 cm between 1981 and 1985 Pauliny-Toth (1987) reported somewhat unusual variations in its VLBI structure: rapid expansion with apparent speed (in units of c) $\beta_{\rm app} \sim 8.9$ was followed by a period in which little motion was seen. No comparison of these results with the images presented by this paper is attempted because of the rather different resolutions and epochs of the two datasets.

The I and P images for 3C 454.3 are shown in Fig. 3. The component positions listed in Table 4 are those corresponding to the I model. The coordinates of components Core, K7, K6 and K5 determined by fitting the I and P visibilities were in good agreement, although the P coordinates for the remaining components were located somewhat north of the I positions, as is visible in the superimposed I and P images (Fig. 3c). The offsets are $\sim 1-2$ mas, or about 0.15–0.3 times the beam half width half maximum in the north–south direction. This appears to be somewhat larger than expected I–P position registration errors (Roberts et al. 1994), although it is still possible that the displacement is due to instrumental effects, since it is observed along the direction in which our resolution is comparatively poor. None the less, it is also possible that the observed I–P offsets indicate actual physical displacements between the I and P flux peaks in these jet components in 3C 454.3; one possible origin for such an I–P displacement is suggested below. To facilitate discussion of the relationship between the path of the jet and polarization position angles in specific components, the positions of the model components are shown on a plot of relative right ascension versus relative declination in Fig. 4. The χ values are shown by vectors plotted through the component positions.

Fig. 4 shows that χ in the core of 3C 454.3 differs by almost 90° from the direction toward K7, the innermost knot. The degree of polarization of the core, $m \sim 4.6$ per cent, is somewhat higher than is typical for quasars, for which VLBI core polarizations are usually ~ 2 per cent or less (Cawthorne et al. 1993b). At some epochs, the core polarization of 3C 345 has been observed to be enhanced prior to the emergence of a new component (Brown, Roberts & Wardle 1994), suggesting that the core of 3C 454.3 may have been giving birth to a new component at our observing epoch.

Table 4 can be used to compare $\chi - 90°$ (the inferred magnetic field direction on the assumption that the emission is optically thin) with the structural position angle of displacement from the core for each of components K7–K2. We find that this alignment is quite good for the outer three components K4–K2; however, for the inner three components K7–K5 the misalignment is large, typically about 40°. It is clear from Figs 3 and 4 that the jet is highly curved in some places. Although the true local jet direction cannot be found directly from the model component positions or from our images, it is probably a reasonable approximation to consider the directions from the next inner component, $\theta_{\rm in}$, and towards the next outer component, $\theta_{\rm out}$, as for 3C 279 above; these are shown in Fig. 4 as dashed lines. χ for K7 is nearly aligned with the direction from K7 to K6. At K5, K4 and K3 χ is nearly perpendicular to both $\theta_{\rm in}$ and $\theta_{\rm out}$, while for K2 χ is nearly perpendicular to $\theta_{\rm out}$ but not to $\theta_{\rm in}$. The local jet direction at K6 is very uncertain: the direction from K7 to K6 ($\theta_{\rm in}$) is $\sim 105°$ from the direction from K6 to K5 ($\theta_{\rm out}$). Nevertheless, since for K6 $\chi - 90°$ is close to the mean of $\theta_{\rm in}$ and $\theta_{\rm out}$, it is plausible that the direction of the jet at the position of K6 is roughly east–west (Fig. 4), and that χ at K6 is perpendicular to the local jet direction. Thus, assuming that the jet components are optically thin, we can make the reasonable hypothesis that the inferred magnetic field for all components with the exception of K7 is aligned with the local jet direction.

The apparent misalignment of the local jet direction and magnetic field at K7 is of interest. The close alignment of the electric field of polarization (χ) with the direction from K7 to K6 suggests the possibility that the magnetic field is perpendicular to the jet at this point. If this is the case then we can suggest two possible causes. We note that this knot is only 2 per cent polarized, and could therefore be optically thick. In this case, the projected magnetic field would be parallel to χ, and so parallel to the local jet direction, as for the other knots. Alternatively, it has been suggested (Cawthorne et al. 1993b) that knots in the jets of quasars are caused by weak shocks that brighten the jet and enhance the transverse component of magnetic field, as in BL Lacertae objects (Gabuzda et al. 1992). In the presence of a sufficiently strong longitudinal magnetic field, the net observed magnetic field will still be longitudinal; however, the overall percentage polarization at the knots will be reduced due to partial cancellation of polarized emission between regions of enhanced transverse field and longitudinal field within the shocked region. Such behaviour may be observed in some quasars (e.g., 4C 71.07, Cawthorne et al. 1993b; 3C345, Wardle et al. 1994). If this picture is correct, then we should expect occasionally to observe a net *transverse* magnetic field in quasar knots for which the shocks are sufficiently strong that the resulting transverse field dominates the underlying longitudinal field: this may be the case for K7 in 3C 454.3.

As with 3C 279, we find that for some components, notably K7 and K2, the direction of polarization is either closely aligned with (K7) or perpendicular to (K2) the direction specified by $\theta_{\rm out}$, while corresponding alignments for $\theta_{\rm in}$ are poor (see Table 5). It is not possible to add a constant angle, corresponding to correction for hypothetical uniform Faraday rotation on the scales probed by these observations, to all χ values in such a way as to bring the inferred magnetic field direction $\chi - 90°$ for some components in better agreement with $\theta_{\rm in}$ without disturbing the alignment for the other components. We therefore do not consider this a plausible origin for the observed difference in alignments between $\chi - 90°$ and $\theta_{\rm in}$ and $\theta_{\rm out}$.

Overall, the observations suggest a jet with a rapidly changing structural position angle within a few milliarcsec of the core, which becomes less strongly curved at larger distances. Although we cannot be entirely sure of the local jet direction from C to K5, reasonable estimates can be made, and the changes in polarization position angle along the jet

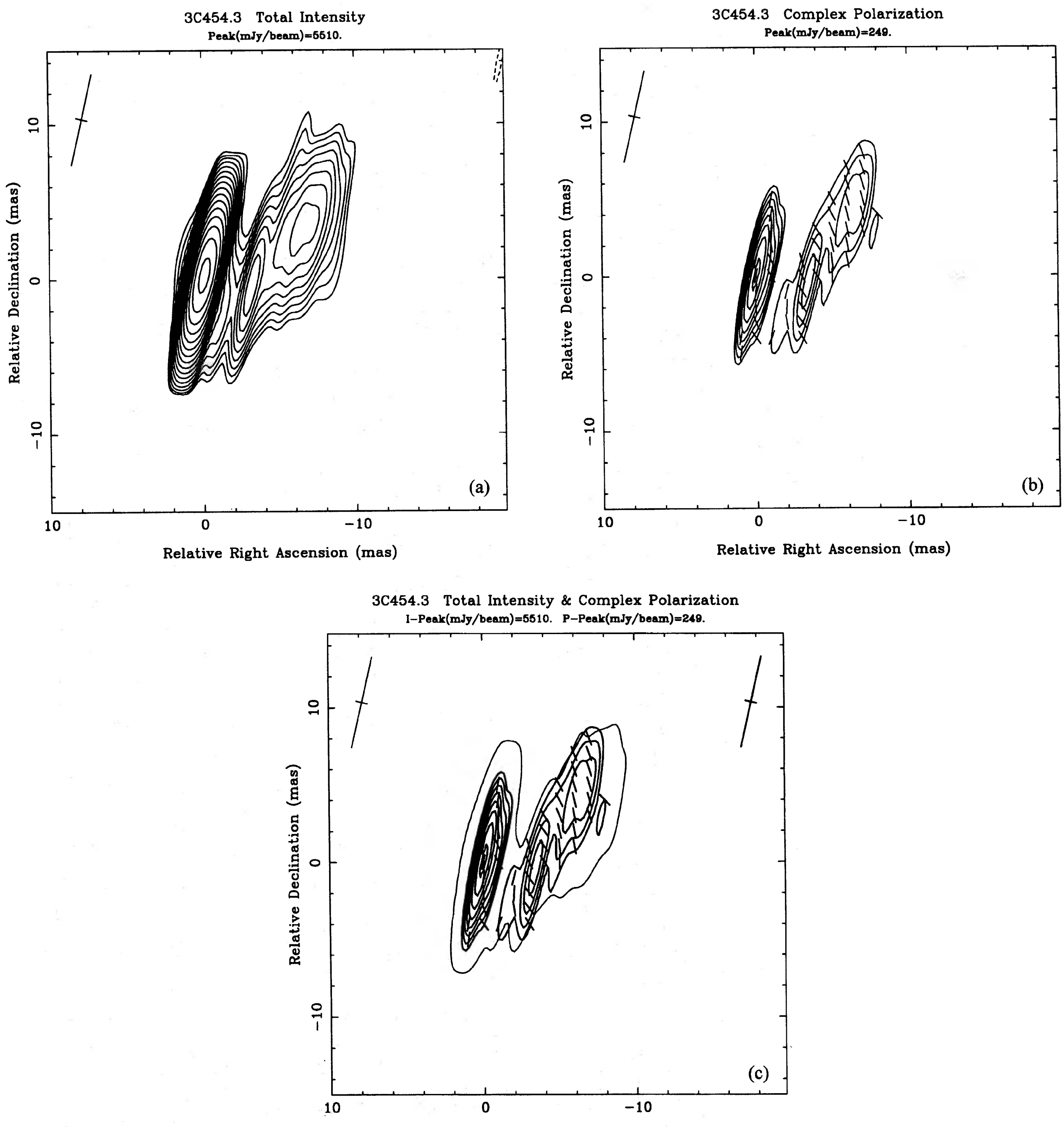

Figure 3. VLBI hybrid maps of 3C 454.3 at 5 GHz, epoch 1988.2. (a) Total intensity, with contours at −0.5, 0.5, 0.7, 1.0, 1.4, 2.0, 2.8, 4.0, 5.6, 8.0, 11.0, 16.0, 23.0, 32.0, 45.0, 64.0, and 90.0 per cent of the peak brightness of 5.61 Jy beam^{-1}. (b) Linear polarization, with contours of polarized intensity at 8, 11.3, 16, 22.6, 32, 45.2, 64 and 90.4 per cent of the peak brightness of 250 mJy beam^{-1}, and χ vectors superimposed. (c) Linear polarization in bold lines as above with one contour of total intensity plotted at 1 per cent of the peak for registration. Both images were restored with clean beams of 6×0.75 mas^2 in position angle −13°.

are consistent with a magnetic field that curves so as to remain parallel to the local jet direction. To demonstrate these alignments conclusively would require following the motion of components in this region of the jet over many epochs of observation; to our knowledge such results have not yet been published. The apparent tendency of the magnetic field to follow the local jet direction is understandable if the field is ordered by shear and if the direction of motion of the components is along the ridge line of the jet rather than along the direction from C. The influence of shear, which is likely to be

Table 4. *I* and *P* model for 3C 454.3.

Component	I (mJy)	p (mJy)	χ (deg)	m (%)	r^a (mas)	Δr (mas)	θ^a (deg)	$\Delta\theta$ (deg)	FWHM (mas)
Core	5226	241	−12	4.6	—	—	—	—	0.54
K7	4511	88	+29	2.0	0.65	0.07	−104	2.1	0.51
K6	168	49	−8	29.2	2.48	0.21	−142	3.8	0.23
K5	613	108	+34	17.6	3.40	0.03	−95	1.0	0.88
K4	621	99	+19	15.9	6.14	0.05	−67	1.0	1.49
K3	331	72	+19	21.8	7.55	0.05	−64	1.0	1.01
K2	438	30	+44	6.8	8.30	0.04	−67	0.5	0.99
K1	214	< 20	—	< 9.3	10.13	0.20	−65	2.3	1.50

[a] Separations and structural position angles with respect to the core. Components fitted are circular Gaussians with size FWHM.

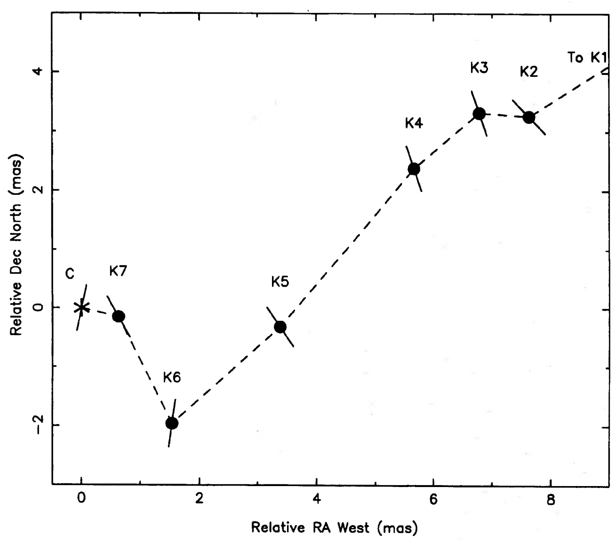

Figure 4. Plot of the positions of each of the components for the 3C 454.3 model in Table 4, with χ for each component shown by a single vector at the position for that component.

Table 5. Offsets between magnetic field and local jet direction for 3C 454.3.

Component	$\chi - 90° - \theta_{in}$ (deg)	$\chi - 90° - \theta_{out}$ (deg)
Core	—	+ 2
K7	+42	+92
K6	+55	−50
K5	− 8	−16
K4	−31	−22
K3	−22	+23
K2	+48	+12
K1	—	—

[a] θ_{in} = direction from the next inner component
θ_{out} = direction to the next outer component

important near the edge of the jet, could also explain why the polarizations of K4–K2 are displaced northward from the *I* component positions.

These results for 3C 454.3 are similar to recent results for 3C 345 presented by Brown et al. (1994) and discussed in more detail by Wardle et al. (1994). In that source, components observed within 1 mas of the core have been followed over many epochs of observation and found to move outward along different trajectories (Biretta, Moore & Cohen 1986; Zensus, Cohen & Unwin 1995). At distances greater than about 1 mas from the core, components appear to follow a common trajectory, with the magnetic field reasonably well aligned with this trajectory. Similarly, in 3C 454.3, the orientation of χ in K2–K6 is perpendicular to the jet ridge-line, suggesting a longitudinal magnetic field and flow along a fixed, curved channel. Nearer the core the 2.8-cm monitoring of Pauliny-Toth et al. (1987) suggests rather more complex behaviour for the components.

4 CONCLUSIONS

The 6-cm *I* and *P* images presented here have shown both 3C 279 and 3C 454.3 to display VLBI polarization properties characteristic of quasars. In particular, they both have dominant jet magnetic field parallel to the local jet direction. The degrees of polarization of the jet components are appreciable: $\sim 5-20$ per cent in 3C 279 and $\sim 2-30$ per cent in 3C 454.3. Such relatively high degrees of polarization indicate that the magnetic fields are reasonably well-ordered, probably by shear.

At the epochs presented here, both 3C 279 and 3C 454.3 have jet components that have only recently emerged from the core. It appears likely that χ in these new components is transverse to and aligned with the local jet directions in 3C 279 and 3C 454.3, respectively. Thus, the orientation of χ in K3 in 3C 279 is that typical of quasars, with inferred magnetic field aligned with the jet. If the new component K7 in 3C 454.3 is optically thin, its χ implies that the underlying magnetic field is *perpendicular* to the jet, suggesting that this component may be associated with a transverse shock. There is good evidence that such shocks play a dominant role in forming the emission from the jets of BL Lacertae objects, but their role in the jets of quasars is less apparent; this tentative identification of a shock in the inner part of the jet of 3C 454.3 supports the idea (Cawthorne et al. 1993b) that transverse shocks are sometimes present in the jets of quasars, but either are not strong enough to dominate the underlying longitudinal magnetic field, or are easily disrupted by the strength of the jet flow and/or by interactions with the surrounding medium that reinforce the longitudinal field components.

We note that, in several components in these two sources, the alignments between the inferred magnetic field direction and the direction to the next component outward from the core θ_{out} are very good, while the alignments between the field and the direction from the next component inward towards the core θ_{in} are rather poor. Table 3 and Table 5 show that in only two out of nine jet components in the two sources is the alignment between the inferred magnetic field and θ_{in} better than 25°; while in only one out of eight jet components is the alignment between the inferred magnetic field and θ_{out} worse than 25° (for component K7 in 3C 454.3 we have considered alignments between the inferred magnetic field and the normals to the directions θ_{in} and θ_{out}). A similar effect was noted earlier in the quasar 3C 380 (Cawthorne et al. 1993a). In that source the knot K3 marks the position of a sharp change in the jet direction. The polarization at K3 indicates a magnetic field that is well aligned with the direction of the jet downstream from K3, and misaligned by some 35° with the direction towards the core. To us these results suggest the possibility that the mechanism responsible for bending jets also brightens them, so that what is observed is predominantly material beyond the bend, as it heads downstream.

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