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LINKS BETWEEN THE OPTICAL AND RADIO POLARIZATION OF AGNs

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Abstract. An earlier comparison of simultaneous optical and 6 cm VLBI observations of polarization showed a correlation of their position angles which were either aligned or perpendicular. Gabuzda et al. (2005) proposed that the radio cores with their polarization aligned with optical polarization were predominantly optically thin, while the radio cores whose polarization was perpendicular to optical polarization were optically thick. We present the first results from new coordinated optical and high-frequency VLBA polarization observations of 15 AGNs designed to test this hypothesis.

Key words: galaxies: active, nuclei, jets, BL Lacertae objects, polarization

1. INTRODUCTION

The continua of radio-loud active galactic nuclei (AGN) are dominated by nonthermal (synchrotron) emission, which is clearly associated with the relativistic jets in these objects, although the details of the jet structure and physics remain uncertain. BL Lac objects and optically violently variable quasars are sometimes collectively referred to as “blazars”.

Although it is believed that synchrotron radiation dominates over essentially the entire observed spectrum of blazars, it has usually been expected that there should be little correlation between observed properties in widely spaced wavebands, even if genuinely simultaneous measurements are compared. This is due in part to early attempts to search for optical and radio correlations that were unsuccessful or yielded ambiguous results (e.g., Kinman et al. 1974; Pomphrey et al. 1976; Rudnick et al. 1978). In addition, it seemed natural to suppose that the higher-energy optical emission was generated in more compact regions than the radio emission, closer to the base of the jet.

Gabuzda, Sitko & Smith (1996) have analyzed simultaneous optical polarization and 6 cm VLBI polarization measurements for eight blazars, primarily BL Lac objects. The 6 cm polarization angles were corrected for the integrated rotation measures, presumed to be of the Galactic origin (Pushkarev 2001). Although those results were not conclusive due to a small number of objects considered, there were indications of correlation between the optical polarization position angle χ_{opt} and the polarization position angle in the VLBI core χ_{core} .

Recently, Gabuzda, Smith & Garnich (2005) analyzed simultaneous optical and 6 cm VLBI polarization data for additional blazars, bringing the total number of objects for which such data are available to 15 (see Gabuzda 2003). These collected data show clear evidence for a correlation between χ_{opt} and χ_{core} , with χ_{core} nearly always being aligned with or perpendicular to χ_{opt} (in 11 of 13 measurements). A crude statistical test based on probabilities for a binomial distribution indicates that the probability of the observed distribution in $|\chi_{\text{opt}} \text{ vs. } \chi_{\text{core}}|$ coming about by chance is about 1%.

The bimodal behavior in the distribution of $|\chi_{\text{opt}} \text{ vs. } \chi_{\text{core}}|$ can easily be understood if (1) the optical and radio polarization are roughly co-spatial, and (2) the VLBI cores for which χ_{core} is aligned with and perpendicular to χ_{opt} are dominated by optically *thin* and optically *thick* emission, respectively. Placing constraints on co-spatiality of the optical and radio emission can provide useful input to jet models; for example, in their analysis of inhomogeneous synchrotron self-Compton models, Ghisellini et al. (1985) found that the radio and ultraviolet-optical-infrared emission can come from the same (outer) region of the jet, but only for certain combinations of jet geometry and particle flow acceleration.

2. OBSERVATIONS AND RESULTS

We obtained optical and 7 mm + 1 cm + 2 cm VLBA polarization observations of 14 AGN simultaneous to within about one day on 2002 August 7 (5 sources) and 2003 March 5 (9 sources) in order to test the hypothesis described above. The optical polarization observations were obtained on August 8 on the 60" telescope and on March 4 and 7 on the 90" telescope of the Steward Observatory. The VLBA total intensity and linear polarization calibration and imaging were done in AIPS using standard techniques.

We discuss here preliminary results for the 2 cm VLBA data for 2003 March 5. It was not possible to obtain the optical observations on that night due to bad weather at Kitt Peak, but we were able to obtain measurements one night earlier (March 4) and two nights later (March 7). In all cases the optical polarization angles χ_{opt} measured on these two nights agreed to within 25° , suggesting the optical polarization was not wildly variable near the time of the VLBA observations; in four cases, the two measurements agreed to within about 5° or less. We interpolated between the angles to estimate χ_{opt} on the night of the VLBA experiment.

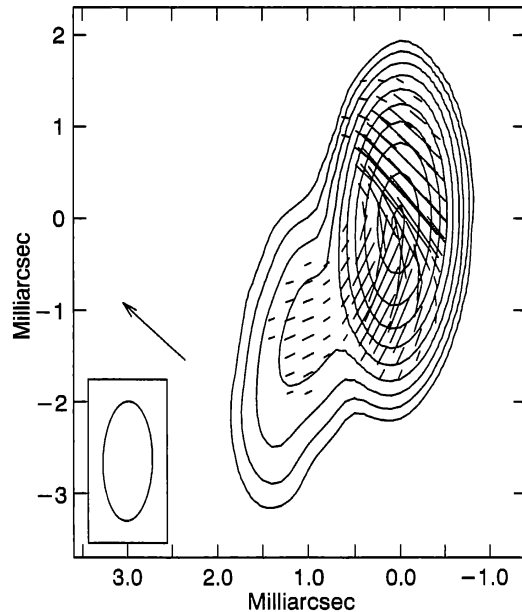


Fig. 1. I contours with polarization \mathbf{E} vectors and an arrow indicating χ_{opt} for 1334-127.

In six of the eight sources observed, χ_{opt} is either parallel or perpendicular to χ_{core} to within less than about 25° . In the case of 1147+245, there is no obvious relationship between χ_{opt} and χ_{core} , but χ in the innermost VLBI jet (within $\simeq 0.5$ mas from the core) is well aligned with χ_{opt} . Figures 1 and 2 show total-intensity maps with polarization **E** vectors superposed, together with a bold arrow indicating the orientation of the optical polarization, for two of the sources showing aligned χ_{opt} and χ_{core} .

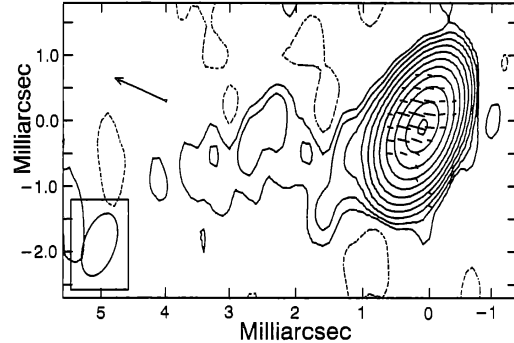


Fig. 2. The same as in Figure 1 but for 1732+389.

3. DISCUSSION

Although these results are still preliminary they appear to support the earlier findings of Gabuzda, Sitko & Smith (1996) and Gabuzda, Garnich & Smith (2004) that χ_{opt} and χ_{core} are very often either aligned or perpendicular.

When χ_{opt} was compared with the 6 cm VLBI core polarization, about half of the cores displayed χ_{opt} aligned with χ_{core} and half displayed χ_{opt} perpendicular to χ_{core} . If these two groups of sources are those in which the core polarization was emitted by optically thin and optically thick regions, we expect a higher fraction of sources to show $\chi_{\text{opt}} \parallel \chi_{\text{core}}$ as we consider VLBI data at shorter wavelengths. The results presented here appear to support this prediction: in 6 of the 7 sources showing evidence for correlations between χ_{opt} and χ_{VLBI} , the optical and radio χ 's are roughly aligned.

The 2 cm VLBA data for 2002 August 7 and the 7 mm and 1 cm VLBA data for both 2002 August 7 and 2003 March 5 are currently under analysis. The higher resolution provided by the 7 mm and 1 cm data will enable more reliable determination of the polarization angles in the core and innermost jet. In addition, we will be able to directly test the hypothesis that VLBI cores for which $\chi_{\text{opt}} \parallel \chi_{\text{core}}$ and $\chi_{\text{opt}} \perp \chi_{\text{core}}$ are predominantly optically thin and thick, respectively.

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