POLARIZATION OF THE COMPACT RADIO STRUCTURE OF 3C 454.3

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1. INTRODUCTION

The polarization structure of synchrotron sources provides information about the magnetic field structure and thermal particle distributions near the source. Such information is critical to a full understanding of compact sources in the nuclei of galaxies and quasars. VLBI maps of these objects are frequently interpreted as showing jets even though the maps are dominated by a few bright regions. If these sources do indeed contain jets then the jet should have a relatively well-ordered component of the magnetic field. The presence of this ordered magnetic field, as well as the presence of thermal plasma in and around the jet, should be revealed by the polarized radiation. We present below the results of the first successful VLBI measurements of the polarized emission from an extragalactic compact radio source.

2. OBSERVATIONS

Insufficient sensitivity and inadequate equipment have plagued previous attempts at measuring polarization structure by means of VLBI. To avoid some of these problems, we made observations at 13 cm with the 64 m antennas of the DSN at Goldstone and Madrid, which could record both right and left circular polarization, together with antennas at Onsala, Haystack, Green Bank and Ft. Davis which could record only right circular polarization.

3. RESULTS

The milliarcsecond structure of 3C 454.3 at an observing wavelength of 13 cm is dominated by two bright regions aligned at a position angle (PA) of about 115°. On the basis of VLBI observations at other frequencies, we conclude that the more compact (SE) region has a very optically thick spectrum and is probably the core. There is also a hint of an underlying jet which, for discussion, we shall assume to be present.

D. S. Heeschen and C. M. Wade (eds.), Extragalactic Radio Sources, 301–303.

Since the source was not resolved in the ~N-S direction, we present the observations in Figure 1 as projected onto the line at PA = 115°. The total and polarized intensities are shown normalized to the peak brightness of 2.8 Jy/beam. The position angle of the E-vector is shown relative to PA = 115°.

The smoothness of the polarized intensity indicates the presence of a well ordered component of the magnetic field, especially since the fractional polarization reaches 20%. However, because both bright regions are weakly polarized we infer that either the magnetic field there is quite disordered or thermal plasma there is depolarizing the radiation.

The change of almost 90° in the PA of the E-vector might be due to either differential Faraday rotation, reordering of the magnetic field, or a change in the optical depth from thick to thin. Although none of these possibilities can be ruled out with certainty, the third seems the most consistent with all data including spectral information obtained from the literature. If a variable optical depth is primarily responsible for the observed rotation of the E-vector, then the magnetic field is oriented primarily along the jet. Further, if differential Faraday rotation is not important, then it is unlikely that there is much thermal plasma around the jet.

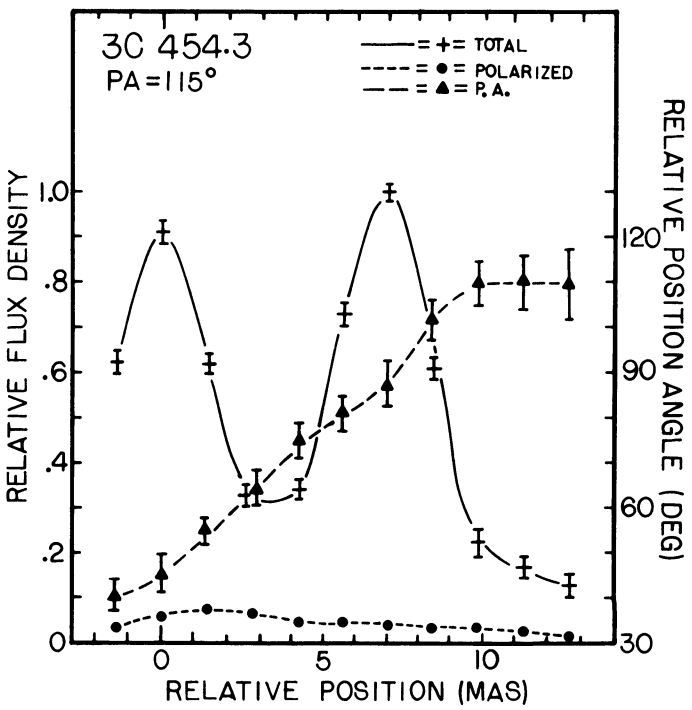

Figure 1. Polarization properties of 3C 454.3 at 13 cm

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DISCUSSION

SHAFFER: What is the rotation measure of 3C 454.3?

COTTON: The integrated rotation measure is about -30 radians/m^2, which is similar to nearby sources. If the apparent rotation of the polarization E-vector is due to Faraday rotation, then internal differences 2.5 times as large are required.

LAING: In 3C 286, the degree of polarization is high and must come primarily from a region which is optically thin. The rotation measure is small, and we may reasonably infer the direction of the B-field from integrated polarization measurements. The projected B-field is perpendicular to the VLB structure.

COTTON: Due to various calibration uncertainties, we cannot completely exclude the possibility that the magnetic field is perpendicular to the jet, but our data are much more consistent with the magnetic field being oriented along the jet.

JONES: Rudnick and I have observed the integrated polarization of 3C 454.3 on several occasions at both centimeter and millimeter wavelengths. In the 1977-1980 interval, we saw a systematic change in the polarization angle between $\chi \sim 0°$ at long wavelengths to $\chi \sim 60°$ at 9 mm and 3 mm. Therefore, your rotation seems likely to be a structural effect.

COTTON: At 13 cm the effects you suggest should be relatively unimportant. The integrated spectrum of the jet at wavelengths near 13 cm are also consistent with the optical depth interpretation of the polarization angle rotation.

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