LETTERS TO THE EDITOR

ASTRONOMY

Observed Limits to the Circular Polarization of Nine Quasars at Radio Frequencies

Sciama and Rees[1] have suggested that the radio emission of compact quasars will show appreciable circular polarization ($\gtrsim 1$ per cent) at frequencies greater than about 1,000 MHz. This suggestion is based on assumed magnetic fields within the variable components of these objects as large as 1 to 100 gauss. At 10·6 cm wavelength, Seielstad[2] has set upper limits of between 1 per cent and 3 per cent on the circular polarization of fourteen objects of which five are known to be quasars. We now report measurements of the circular polarization of nine quasars and thirty-seven radio galaxies and unidentified sources at frequencies of 437 MHz, 630 MHz and 1,410 MHz. In no case was any significant component of circular polarization detected.

The observations at 437 MHz were made during March 1966 with the Parkes interferometer[3] and consisted of measurements of residual fringe amplitude made with "crossed" linearly polarized feeds. The antenna spacing was approximately 400 ft. north–south and the effective bandwidth 20 MHz. Instrumental effects were estimated from observations of Hydra *A* and the *HII* region Orion *A*.

At 630 MHz (in February 1967) and 1,410 MHz (in December 1966) the observations used the 210 ft. radio telescope at Parkes with receivers employing polarization switching. In each case, the bandwidth was about 10 MHz. For these observations, the instrumental effects were estimated by assuming that the circular polarization averaged over all sources was zero. Observations of the planet Jupiter at these two frequencies indicated a circularly polarized component which varied sinusoidally with the system III longitude of the central meridian; its amplitude was about 1 per cent.

For the radio galaxies and unidentified sources, the upper limit to the measured circular polarization is in all cases less than 0·74 per cent at 1,410 MHz, 0·94 per cent at 630 MHz and 1·5 per cent at 437 MHz. It is less than 0·2 per cent at 1,410 MHz for seven of these sources—*PKS* 0518-45 (Pictor *A*), *PKS* 0521-36, *PKS* 0624-05 (3*C*-161), *PKS* 1228+12 (*M*87), *PKS* 1322-42 (Cen *A*), *PKS* 2152-69 and *PKS* 2356-61. (Parkes catalogue numbers are prefixed by the letters *PKS*.)

The results for the quasars, given in Table 1, are very similar. (The sources *CTA* 21 and *PKS* 1934-63 have also been included, for their spectra suggest that the radio emission originates in a region of very small dimensions[4].) The errors quoted in Table 1 are approximately ninety percentiles, but the values marked with asterisks may be subject to larger errors due to solar interference.

Table 1. MEASURED PERCENTAGE CIRCULAR POLARIZATION OF NINE QUASARS AND TWO COMPACT SOURCES

	437 MHz	630 MHz (R.H.)	1,410 MHz (R.H.)
PKS 0237-23		−0·07 ± 1·39	
PKS 0316 + 16 (*CTA* 21)			−0·03 ± 0·24
PKS 0408-65 (*MSH* 04-61)	0·2 ± 0·3	+0·15 ± 0·27	0·00 ± 0·11
PKS 0518 + 16 (3*C* 138)	0·5 ± 0·6		
PKS 1226 + 02 (3*C* 273)	−0·15 ± 0·2	+0·07 ± 0·04	−0·10 ± 0·05
PKS 1253-05 (3*C* 279)	−0·1 ± 0·5	+0·18 ± 0·21	+0·47 ± 0·25*
PKS 1416 + 06 (3*C* 298)	0·2 ± 0·6	−0·15 ± 0·22	
PKS 1934-63	$\lesssim$1·0	−0·22 ± 0·47	0·00 ± 0·10
PKS 2223-05 (3*C* 446)			−0·10 ± 0·28
PKS 2230 + 11 (*CTA* 102)		1·29 ± 0·85*	−0·25 ± 0·24
PKS 2251 + 15 (3*C* 454·3)	−0·3 ± 0·5		+0·05 ± 0·04

* These results may be unreliable because of solar interference.

Because the 1,410 MHz radiation is more likely to arise in the compact and often variable component of the source where the magnetic field is believed to be strongest, we should expect the highest value of circular polarization at this frequency. For all the quasars observed, the upper limit to circular polarization at 1,410 MHz is less than 0·8 per cent, and for 3*C* 273, *PKS* 0408-65, *PKS* 1934-63 and 3*C* 454·3 it is less than 0·2 per cent. Thus the results provide no evidence for the strong magnetic fields envisaged by Sciama and Rees.

The field strengths proposed by these authors cannot be entirely ruled out, however, because our observations may not have been made at the optimum time. Sciama and Rees suggest that circular polarization is most likely to be observed when the flux density has just passed through its maximum, because at this time the source has a relatively low optical depth. For the sources *PKS* 0316+16, *PKS* 1226+02, *PKS* 1253-05 and *PKS* 2251+15 there is no evidence of any decrease in flux density during our observation period, and for some of these sources there may have been an increase. It is also, of course, possible that circular polarization can only be detected at considerably higher frequencies.

We thank B. Harris for providing spectral data before publication.

M. M. KOMESAROFF
F. F. GARDNER
D. MORRIS
J. A. ROBERTS
J. B. WHITEOAK

CSIRO Division of Radiophysics,
Sydney, Australia.

Received March 4, 1968.

[1] Sciama, D. W., and Rees, M. J., *Nature*, **216**, 147 (1967).
[2] Seielstad, G. A., *Astrophys. J.*, **150**, L147 (1967).
[3] Cole, D. J., *Proc. Austral. Astro. Soc.*, **1**, 36 (1967).
[4] Kellermann, K. I., *Austral. J. Phys.*, **19**, 195 (1966).

Population Type of Cygnus *X*-2

Burbidge, Lynds and Stockton[1] and Kristian, Sandage and Westphal[2] have shown that the point X-ray source Cyg *X*-2 is very probably binary. Kraft and Demoulin[3] further suggest that a third object may be present, for their radial velocity observations do not seem to repeat, but the observational uncertainties are such that this possibility will not be considered here.

There has been considerable controversy about the population type of Cyg *X*-2. Gursky, Gorenstein and Giacconi[4] interpret the distribution in galactic latitude of the point X-ray sources as characteristic of population I objects. Kristian, Sandage and Westphal[2] found a γ-velocity of −250 km/s on the assumption that the emission and absorption spectra were separately produced by two stellar components of a binary system. Because this γ-velocity is close to that due to reflected solar motion, they assigned the object to population II. Kraft and Demoulin[3] came to a similar conclusion on finding only negative radial velocities in several nights' observations. We shall show here that unless there is a gross violation of the mass–luminosity relation, the population kinematics of Cyg *X*-2 must be intermediate between I and II. If accretion on a white dwarf is the mechanism for generating the X-rays, this conclusion is independent of the mass–luminosity relation.

Because highly eccentric orbits are not to be expected in close binary systems, we have assumed circular orbits. For an orbital inclination of 90°, Kepler's third law gives

$$m_1 + m_2 = 4 \cdot 3 \times 10^{-9}\, v_2^3 \left(1 + \frac{m_2}{m_1}\right)^3 P \qquad (1)$$