LETTERS TO THE EDITOR

PHYSICAL SCIENCES

Proper Motion Search for Pulsars

An attempt has been made to identify optically three pulsars by proper motion surveys in the vicinity of the radio positions. An object at a distance of 100 pc having a velocity of 200 km s^{-1} perpendicular to the line of sight would have a proper motion of 0·4 arc s yr^{-1} and should therefore, if bright enough, be identifiable from a pair of photographs taken 10 or 20 yr apart.

The results have been completely negative. If we assume this is because pulsars are fainter than our limit of detection, then we can set upper limits to their luminosity. Adopting the distances given by Lyne and Rickett[1] and the detection limits in column 4 of our table, we have derived the absolute magnitudes given in the final column. These are expressed on the B scale of the UBV system. *CP* 0950 has already been discussed by Bailey and Mackay[2], who derived $M_V = 16^m{\cdot}5$. Our absolute magnitudes place *CP* 0834 and *CP* 1133 also in the extreme dwarf range or beyond, in conformity with current ideas[3].

For our first epoch photograph we reproduced portions of the Palomar Sky Survey prints. The area was photographed on 35 mm film which was then contact printed on to a plate (Ilford *N* 50) suitable for clamping up in the measuring machine. The images had therefore passed through altogether five photographic processes before measurement: original negative in telescope, glass positive, paper print, film positive and finally glass negative. Distortions introduced at each stage will influence the final results, but these effects are not serious as can be seen from columns 5 and 6 of Table 1, which give the r.m.s. relative proper motion components obtained from the field stars. Considering that each proper motion is derived from only two measurements over a baseline of 13 to 17 yr, these r.m.s. values are satisfactorily low.

Table 1. LIMITS OF SURVEY, STANDARD DEVIATION IN PROPER MOTION COMPONENTS AND LUMINOSITIES

Field	Area (R.A. × Dec.)	No. of stars	Limiting apparent magnitude (B)	$<\mu_\alpha \cos\delta>$ (arc s yr^{-1})	$<\mu\delta>$ (arc s yr^{-1})	Absolute magnitude M_B
0834	5·6′ × 37′	108	19	0·027	0·028	> 13·6
0950	8·4′ × 7·1′	6	17	0·021	0·013	—
1133	7·1′ × 38′	49	19	0·028	0·040	> 15·6

Our second epoch photographs were taken with the Cambridge 43/61 cm *f*3·8 Schmidt telescope using blue sensitive (Ilford *SRO*) plates without filter. The limiting apparent magnitudes in column 4 were derived from estimates of image diameter on the Palomar prints using a graticule and the calibration published by Perek[4]. These limits may be in error by $\pm 0^m{\cdot}5$. They are the faintest we were able to achieve in a relatively bright evening sky under not very good conditions of transparency.

The areas searched had the dimensions given in column 2. These exceed the radio error rectangle dimensions by factors of about 2. The radio positions on which the areas were centred were taken from Bailey and Mackay[2] for *CP* 0950, and from Lyne and Rickett[1] for the other two. The numbers of stars measured are in column 3.

In not a single case did we find a significantly large relative proper motion. If pulsars are not more than 100 pc distant, they must either have remarkably low transverse velocities or their intrinsic luminosity in optical wavelengths (averaged in time) must be very small.

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Radio Sources opposite Quasars as a Cosmological Test

In a previous communication[1] I discussed the possibility of having a closed universe model with the pole at a red-shift $z \simeq 1{\cdot}7$. One possible observation in such a universe would be images in opposite or near opposite directions to the original object, if the object is not too far from the pole. I showed that this may happen for a few radio sources listed in the 4*C* radio catalogues[2]. Another possible observation is to look for radio sources opposite known quasars. To illustrate such an investigation I will refer to a cosmological model with a pole at red-shift 1·7, deceleration parameter $q_0 = -1{\cdot}4$ and a density parameter $\sigma_0 = 0{\cdot}085$. In this model objects must have lifetimes of the order of $1\text{–}10 \times 10^9$ yr to be seen in two directions, because of the difference in light travel time. This lifetime is too long for a quasar, but it may be possible to observe the object in a pre-quasar or post-quasar stage as a radio source or even as a faint optical object.

A comparison of the optical positions of 103 quasars, from the list of Barbieri *et al.*[3], with radio sources in opposite directions was made. For this test radio sources in the 4*C*[2] and the Parkes[4] radio catalogues within 1° from the position opposite the quasar were considered. The frequency distribution of pairs is shown in Fig. 1, where the number of radio sources is given as a function of the separation *a* of the radio position and the opposite quasar position. Compared with what we expect from a random distribution of the objects (dashed line) we find an excess

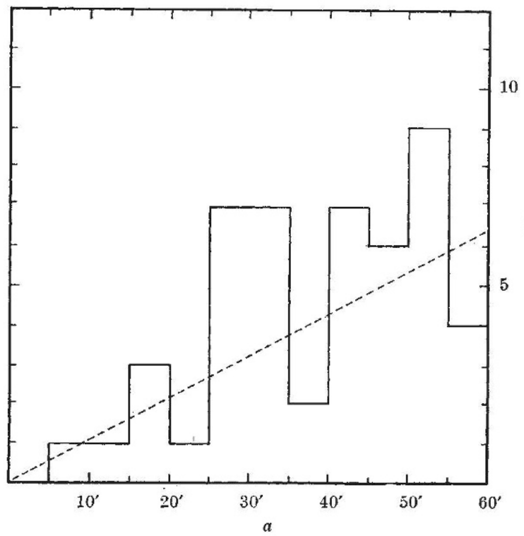

Fig. 1. The number of pairs as a function of the separation *a* between the radio position and the position of the nearest opposite quasar. ----, Expected from random distribution.