2.16   MEASUREMENT OF THE CIRCULAR POLARIZATION
OF PULSAR NP 0532

J. R. P. ANGEL*

Columbia Astrophysics Laboratory, Columbia University, New York, N.Y., U.S.A.

D. HEGYI**

NASA Goddard Institute for Space Studies N.Y,, New York, U.S.A.

J. D. LANDSTREET†

Department of Astronomy, Columbia University, New York, N.Y. U.S.A.

Abstract. The polarizer is briefly described. The polarization of the whole pulse is not significantly different from zero (-0.15 ± 0.70 per cent). Polarization measurements of the leading edge and trailing edge of the main pulse are also given.

1. Observations and Instrumentation

We present below the results of measurement of the optical circular polarization of the pulsar NP 0532. The observations were made on 11/12 February 1970 with the 82-in. telescope of McDonald Observatory.

The instrument used was the Cassegrain photoelectric polarimeter described by Angel and Landstreet (1970) and designed specifically for measuring circular polarization, together with a data handling system assembled for the occasion. The basic polarimeter consists of a KD*P electro-optic crystal (a Pockels cell) used as a reversible quarterwave plate, followed by a Wollaston prism which directs the light into two Channeltron photomultipliers. A periodically reversing square wave voltage is applied to the Pockels cell which causes one photomultiplier to measure alternatively the intensity of right and left circularly polarized light. The polarization of a star can thus be determined from the output of either photomultiplier alone.

The Pockels cell was set for quarter-wave retardation at about 5000 Å. The 1-mm S-20 photocathodes of the Channeltrons were unfiltered, but the dispersion of the beam by the Wollaston prism limits the light falling on the photocathodes to approximately the 4000–7000 Å range. The error in retardation in the Pockels cell for wavelengths other than 5000 Å lowers the sensitivity of the system to circular polarization only a few percent.

The output signals from the photomultipliers were fed into two Northern 512 channel analyzers, one for each photomultiplier. The analyzers were used in a multiscaling mode; the channel address was advanced by a signal from a General Radio frequency synthesizer which was set to scan through the 511 data channels in exactly two pulsar periods. The voltage on the Pockels cell was reversed at the first and at

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* Alfred P. Sloan Research Fellow.
** Present address: Department of Astronomy, Boston University, Boston, U.S.A.
† Present address: Department of Astronomy, University of Western Ontario, London, Canada.

the 257th channels. Each multichannel analyzer thus recorded a full pulsar period in
one circular polarization followed by a full period in the other polarization. It was
not necessary for our purposes to go to great lengths to insure exact registration of
the superposed data, but we may estimate from the data that even during the longest
run (40 minutes) the phase error was no more than 2 or 3 channels, or less than 2%.

Because this is a two-channel instrument, with measurements of both handednesses
of circular polarization being done essentially simultaneously and through the same
optical and electronic train, the systematic zero-point errors are extremely low (less
than 0.05%) and the measurement is not adversely affected by variations in trans-
parency or background light. Our accuracy is thus limited mainly by statistical
fluctuations in the signal and in the background light, which was primarily moonlight
and whose amplitude equalled the peak height of the pulse.

The system was checked periodically by putting a circular polarizer (a piece of
polaroid followed by a quarter-wave plate) in the beam before the Pockels cell. We
also measured the circular polarization of comparison stars believed to be unpolarized.
With the circular polarizer in the beam, we generally measure a polarization of more
than 90%, while the measured circular polarization of an unpolarized star is always
less than 0.05%.

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TABLE I

Polarization of primary pulse of NP 0532

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Component of pulse	Measured polarization (%)
Leading edge	-0.19 ± 0.89
Trailing edge	-0.09 ± 1.10
Whole pulse	-0.15 ± 0.70
Leading minus trailing edge	-0.08 ± 0.70

2. Analysis and Results

The fractional circular polarization was determined for the leading and trailing edges
of the pulse separately by the following formula. Let the total number of counts in
the leading edge of the pulse (which was taken to be the 15 channels (1.9 msec) before
the peak) be $N(l, R)$ and $N(l, L)$ in right and left circularly polarized light, and
$N(b, R)$ and $N(b, L)$ be the corresponding numbers of counts of background light
as given by the same number of channels, centered about 6 msec before the main
pulse. Then the fractional polarization is

$$V(l) = \frac{[N(l, R) - N(b, R)] - [N(l, L) - N(b, L)]}{[N(l, R) - N(b, R)] + [N(l, L) - N(b, L)]}$$

with a standard deviation given by

$$\sigma(l) = \frac{\sqrt{N(l, R) + N(b, R) + N(l, L) + N(b, L)}}{[N(l, R) - N(b, R)] + [N(l, L) - N(b, L)]}$$

Similar expressions apply for the trailing edge of the pulse, which is taken to be the 10 channels following the peak.

The resulting circular polarization from all runs summed together is shown in Table 1 for the leading and trailing edges of the primary pulse separately, for the whole pulse, and for the leading minus the trailing edge (this would be non-zero if the circular polarization changed sign at the peak of the pulse). It is seen that the circular polarization is zero to within the errors of measurement. This is in agreement with the previous results of Wampler *et al.* (1969), who find $V = 3.9 \pm 4.9\%$, and with the results of Cocke *et al.* (1969), who measure $V = 2 \pm 1\%$. The background nebula light is also found to be unpolarized.

This measurement was greatly reduced in accuracy by the fact that we made our observations on a moonlit night. We intend to repeat the measurement in the fall and expect to be able to reach a limit of no more than 0.1% uncertainty.

Acknowledgements

References

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