THE ASTROPHYSICAL JOURNAL, 173:L23–L25, 1972 April 1

ON THE CIRCULAR POLARIZATION OF HD 226868, NGC 1068, NGC 4151, 3C 273, AND VY CANIS MAJORIS

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Received 1972 January 31

ABSTRACT

No meaningful amounts of circular polarization were found on NGC 1068, NGC 4151, 3C 273, or on HD 226868 (the star sometimes identified with Cyg X-1). A small amount of circular polarization in the infrared appears to be present in VY CMa.

In a recent issue of this *Journal* (*Letters*), Nikulin, Kuvshinov, and Severny (1971) announced the finding of circular polarizations of various peculiar objects. Especially noteworthy seemed the possible X-ray source HD 226868, having rapid variations of circular polarization with time (between 1.2 and 2.1 percent). Circular polarizations of that magnitude are rare in the Universe, and this object would have been exceptional; the problem of optical identification of Cyg X-1 might have been solved.

I cannot, however, confirm the findings of Nikulin *et al.* At the Steward 229-cm reflector, the Wollaston polarimeter of Gehrels and Teska (1960) was used with a quarter-wave plate in front of the Wollaston prism with axes alternately at +45° and −45° to the Wollaston axis. Usually the measurements were made at two orientations of the Wollaston prism, differing by 90°. This is the same equipment as used by Cocke, Muncaster, and Gehrels (1971), who, incidentally, found no circular polarization for the optical pulsar NP 0532. Table 1 gives observations with a GG13 filter and S-13 photomultiplier tubes; this combination was chosen to reproduce the λλ4000–5800 region of Nikulin *et al.* The diaphragms for NGC 1068 and NGC 4151 were 5–10 arc seconds in diameter; the ones for HD 226868 and 3C 273 were 15–20 arc seconds. Table 1 also has a listing for VY CMa observed with diaphragms large enough to contain the whole object. A variety of filters was tried in addition to GG13 as follows: *G*reen, *I*nfrared, and *U*ltraviolet of Gehrels and Teska (1960), and *U* (notation here *U′*) and *V* of the *UBV* system.

The plus and minus signs in table 1 are for right- and left-handed circular polarization, respectively, in the sense by which the plus sign is called right-handed if the electric vector when approaching the observer is seen rotating clockwise; the sense was calibrated in the laboratory (Gehrels 1972). The corrections for instrumental polarization were usually determined for each object on a nearby star; the instrumental effects were on the order of 0.04 percent. For instrumental *de*polarization, an approximate correction has been applied. This was determined by occasionally inserting in the beam a piece of Polaroid HNCP 37 which presumably is good to about 97 percent polarization. With the GG13 filter, 89 percent was observed, and the correction of 97/89 = 1.09 has been applied; similarly, for the *V*-filter of the *UBV* system, the correction was 1.03, and for the *G*-filter 1.01; for the *I*- and *U*-filters, a correction factor of 1.05 has been assumed.

Further details and additional observations on these objects will be published elsewhere (Gehrels 1972), together with the results of a general search for circular polarization. That search was made on some 60 different objects with rather negative results. In the Universe, circular polarizations larger than 0.2 percent have thus far been found only on white dwarfs. VY Canis Majoris also has some circular polarization, but only in the infrared and not at shorter wavelengths (table 1). Strong linear polarizations have been reported by Serkowski (1969*a*, *b*) and Shawl (1969) for VY CMa.

TABLE 1

OBSERVATIONS OF CIRCULAR POLARIZATION

Object	Filter	Circular Polarization (percent)	Standard Deviation (percent)	Date U.T.
HD 226868	G	+0.00	±0.09	71.11.20
	V	-0.10	0.08	71.11.27
	GG 13	+0.01	0.07	71.11.28
	GG 13	+0.09	0.05	71.12.12
	GG 13	-0.00	0.08	71.12.13
	U'	-0.04	0.12	71.12.13
NGC 1068	GG 13	+0.11	0.14	71.12.12
	GG 13	+0.11	0.25	72.01.19
	U'	+0.46	0.55	71.12.13
NGC 4151	GG 13	+0.01	0.18	71.12.12
	GG 13	-0.02	0.16	72.01.19
	U'	-0.06	0.38	71.12.13
3C 273	GG 13	+0.07	0.48	71.12.12
	GG 13	+0.15	0.19	72.01.19
	U	-0.35	0.30	70.01.02
	U'	+0.09	0.28	71.12.13
VY CMa	I	+0.11	0.07	70.01.03
	I	+0.42	0.13	72.01.16
	I	+0.40	0.10	72.01.19
	I	+0.38	0.05	72.01.28
	I	+0.43	0.12	72.01.28[a]
	V	+0.03	0.28	69.04.25
	V	+0.09	0.09	71.12.12
	V	+0.08	0.05	72.01.16
	V	+0.08	0.10	72.01.19
	U'	+0.33	0.62	71.12.13[b]
	U	+0.4	±1.0	72.01.19

[a] with diaphragm of 3 arcsecs diameter on star.

[b] the red leakage of the filter probably was strong.

These may be transient phenomena, of course, but it seems unlikely that four of the objects of Nikulin *et al.* would have minimum effects now. I believe that they obtained spurious results because their coudé-plus-spectrograph instrumentation appears unsuitable for observations of circular polarization. At the coudé focus of the 229-cm reflector, for instance, we have observed appreciable instrumental circular polarizations that vary with declination and are strongly wavelength dependent.

TABLE 2

OBSERVED LINEAR POLARIZATION OF HD 226868

Filter	$1/\lambda$	Linear Polarization (percent)	Standard Deviation (percent)	Position Angle
I.....	1.06	3.15	±0.10	140°
R.....	1.21	3.57	0.10	139
G.....	1.93	4.84	0.09	141
B.....	2.33	4.91	0.04	141
U.....	2.78	4.69	0.22	141
U.....	2.78	4.33	0.28	141
N.....	3.03	4.52	±0.21	137

A few observations of linear polarization for HD 226868, listed in table 2, indicate a rather common interstellar polarization pattern. The observations were made with the Steward 229-cm reflector by Serkowski on 1971 July 18, except for the last two that I made on 1971 November 28.

This work is supported by the National Science Foundation.

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