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POLARIMETRIC OBSERVATIONS OF SOUTHERN BINARY SYSTEMS

H.G. Luna[1]

Universidad Nacional de La Plata
Observatorio Astronómico
Argentina

RESUMEN

Desde el año 1978 se están realizando observaciones polarimétricas de sistemas binarios del hemisferio austral con el polarímetro del Observatorio Astronómico de La Plata. Aquí se presenta un programa de 23 sistemas observados con el fin de detectar variaciones temporales de la polarización, producto de la dispersión de la luz sobre las envolturas gaseosas presentes en estos sistemas. Sobre el total de los observados, un alto porcentaje mostró variaciones en la polarización, indicio de la presencia de material circunestelar. Las variaciones de la polarización con la fase orbital permiten, en base a un modelo propuesto por Brown *et al.* (1978), calcular las inclinaciones de los planos orbitales y las propiedades generales de la envoltura. De los sistemas presentados aquí, sólo en uno, bien observado, se obtuvo la inclinación del plan orbital. Por otra parte, se presentan algunos trabajos en sistemas binarios particulares actualmente en desarrollo.

ABSTRACT

In 1978 we started a systematic program for the observation of binary systems in the southern hemisphere with the polarimeter available at La Plata Observatory.

The present paper shows the results for 23 systems. A high percentage of the observed stars showed polarimetric variations. Using the model proposed by Brown *et al.* (1978) it is possible to compute the inclination of the orbital plane.

Key words: STARS-BINARIES – POLARIZATION

I. INTRODUCTION

In close binary systems the light emitted by the components is linearly polarized due to scattering by ions, electrons or molecules present in the gaseous envelopes which surround the binaries. When the density in the envelope is sufficiently high and the distribution of the gas is the proper one, a net linear polarization in the observed flux exists. This linear polarization has a dependence with wavelength which is different from the wavelength dependence of the interstellar polarization. The latter has its origin in the dust grains aligned in the magnetic field of the Galaxy. So, the intrinsic polarization in binary systems can be detected observing at different wavelengths and comparing its dependence with the well established relation between interstellar polarization and wavelength (Coyne *et al.* 1974). The intrinsic polarization can also be detected by the time variation of the percentage of polarization, because the interstellar polarization in generally constant.

If the gaseous envelope surrounding a binary system remains static, then the rotation of the system produces a phase-locked variation. Several systems have been found with this property (see Rudy and Kemp 1978). Under certain assumptions these phase-locked variations can be adjusted by a model proposed by Brown *et al.* (1978) and it is possible to derive general properties of the envelope, as well as the inclination of the orbital plane, the orientation of the orbit with respect to the North-South directions, and the sense of revolution of the system (as in the case of a visual system).

The derived inclinations allow us to calculate the masses of the components of the binary systems, even for those without eclipses. The mass is a fundamental parameter in astrophysics, especially in stars of particular interest as Wolf-Rayet, X-ray sources, etc. On the other hand, the determination of the orientation of the orbital plane and of the sense of revolution opens the possibility of studying the binary systems in open clusters and associations from a dynamic point of view.

In a few systems of the northern hemisphere the phase-locked variations are well determined (see Rudy 1979).

In 1978 the author started at La Plata Observatory a programme for the determination of intrinsic polarization and the possible phase-locked variations in binary systems of the southern hemisphere.

We report here the results of the preliminary survey for 23 systems which cover a wide spectral region. The periods of the systems are shorter than 20 days. In the

1. Fellow of the Comisión de Investigaciones Científicas de Provincia de Buenos Aires.

next section we show the results, and in §III we describe the work in progress.

II. OBSERVATIONS

All the observations were done between July and December 1978 with the 83-cm telescope at La Plata Observatory using a digital polarimeter with a rotating polaroid. This instrument has been described by Marabini and Marraco (unpublished). We used a lP21 photomultiplier and the observations were not filtered. The polarization values are obtained in terms of the Stokes parameters, Q and U, defined as: $Q = P \cos 2\theta$ and $U = P \sin 2\theta$ where P is the percentage of polarization, and θ is the angle between the plane of vibration of the electric field and the direction to the north measured through the east.

Table 1 lists the observed systems; all of them belong to the *Seventh Catalogue of Orbital Elements of Spectroscopic Binary Systems* (Batten 1978). The first column gives the name, and the second the HD numbers. The third column indicates the number of observations for each system and column 4 through 7 give the mean square deviation and the average of the errors for Q and U, respectively.

The last column summarized the conclusions con cerning variability of the polarization: "v" means vari able and "pv", possibly variable. To include a system a: variable we compared the mean square deviation witl the average of the errors (i.e., column 4 with 5 and col umn 6 with 7).

We consider as variable a system in which at least Q oı U have a mean square deviation 2.5 times larger than the average error. π^4 Ori and VV Ori are two exceptions tc this criterium. In both cases only one observation is very discrepant and we have not considered it to be signifi cant. However, we need more observations of both sys tems. In Table 1 we have included as possibly variable systems those whose mean square deviation are not very large compared with the errors. These systems presen phase-locked variations in Q and U. This may be due tc the fact that the gaseous envelopes remain static withou density variations during the periods of observation. We marked with an asterisk those systems with a very clea phase-locked variation. These are the best candidates fo more observations.

Three systems of short period, ϵ CrA, H Vel and S Ant, have been observed in detail with the aim of de termining the phase-locked variations precisely. These allow us to derive inclinations of the orbital planes adopting the model of an optically thin envelope witl

TABLE 1

OBSERVED BINARIES

Name (1)	HD (2)	No. observ. (3)	σ(Q) (%) (4)	Error (Q) (%) (5)	σ(U) (%) (6)	Error (U) (%) (7)	Polarization variability (8)
...	3405	6	0.06	0.04	0.06	0.04	...
...	6619	12	0.09	0.05	0.08	0.03	pv
ζ Phe	6882	13	0.10	0.03	0.07	0.03	v*
ρ Tuc	4089	13	0.07	0.04	0.08	0.03	v*
...	16589	12	0.04	0.03	0.09	0.04	pv
ζ Hor	16920	13	0.09	0.04	0.10	0.03	v*
ζ Eri	20320	12	0.07	0.03	0.08	0.03	pv
τ^5 Eri	22203	13	0.08	0.03	0.06	0.03	v
τ^9 Eri	25267	13	0.08	0.03	0.08	0.03	v*
41 Eri	27376	11	0.08	0.04	0.07	0.04	...
μ Eri	30211	8	0.11	0.04	0.09	0.04	v
π^4 Ori	30836	9	0.14	0.05	0.11	0.03	...
66 Ori	32964	8	0.08	0.04	0.05	0.03	...
η Ori	35411	8	0.13	0.04	0.10	0.03	v
δ Ori	36486	8	0.07	0.04	0.08	0.04	pv
VV Ori	36695	7	0.11	0.03	0.13	0.03	...
H Vel	76805	31	0.04	0.03	0.05	0.03	...
S Ant	82610	37	0.05	0.04	0.04	0.04	...
ε CrA	175813	29	0.09	0.04	0.08	0.04	v*
δ Cap	207098	10	0.09	0.04	0.05	0.04	pv
...	216494	10	0.09	0.04	0.05	0.04	...
...	224113	10	0.06	0.04	0.07	0.04	pv
42 Cap	206301	11	0.11	0.04	0.07	0.04	v

* System with a very clear phase-locked variation.

Thompson scattering, which rotates with the same angular velocity as the systems. The model has been proposed by Brown *et al.* (1978). Only in the first system (ϵ CrA) we found significant phase-locked variations in the Q and U parameters. The observations of this system have been already published (Luna 1980).

The system ζ Phe was observed by other authors. Pfeiffer and Koch (1977) have catalogued this system as non evolved with a low percentage of constant polarization. But this conclusion is based on only five observations (Serkowski 1970). The values of Table 1 for ζ Phe indicate that this system has variations in polarization larger than the individual errors, and our observations agree with those of Serkowski and indicate a possible phase-locked variation. Serkowski (1970) also gave some observations of the system S Ant and they do not show variations in agreement with ours.

Three systems with Am components and one with an Ap are indicated as variables or possible variables in Table 1. It is possible that other mechanisms different than Thompson scattering were responsible for their polarization. In particular, the system τ^9 Eri (Ap Si) is worth more detailed study.

From Table 1 it is possible to conclude that the probability of detecting circumstellar material in close binary systems is high because, from 23 systems observed, possibly 15 show variable polarization. Thus, polarimetry is a powerful method for studying close binary systems and their associated envelopes.

III. OUR FUTURE WORK

Since 1979 we are observing some binary systems of particular interest. Among others we are observing the binaries in the Sco OBl association (Hill *et al.* 1974) and those in the open cluster NGC 6475. We will be able to study the inclinations of the orbital planes of the binaries in an open cluster. It is important to establish if the inclinations are distributed at random or aligned in a preferential direction.

The star HD 162679 is a member of NGC 6475 and has been observed in detail. We found phase-locked variations of short period and this probably implies that the mass of the secondary is small. The results for this object will be published soon.

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REFERENCES

Batten, A.H., Fletcher, J.M., and Mann, P.J. 1978, *Pub. D.A.O.*, **XV**, No. 5.
Brown, J.C., McLean, I.S., and Emslie, A.G. 1978, *Astr. and Ap.*, **68**, 415.
Coyne, G.V., Ghrels, T., and Serkowski, K. 1974, *A.J.*, 79, 581.
Hill, G., Crawford, D.L., and Barnes, J.V. 1974, *A.J.*, 79, 1271.
Luna, H.G. 1980, *Pub. A.S.P.*, **92**, 79.
Pfeiffer, R.J. and Koch, R.H. 1977, *Pub. A.S.P.*, **89**, 147.
Rudy, R.J. 1979, *M.N.R.A.S.*, **186**, 473.
Rudy, R.J. and Kemp, J.C. 1978, *Ap. J.*, **221**, 200.
Serkowski, K. 1970, *Ap. J.*, **160**, 1083.

DISCUSSION

Popper: In a recent issue of *Astronomy and Astrophysics* there is a discussion concerning the sizes of error boxes for the inclination angles obtained from polarization analysis. The claim was made that the true error boxes are so large that little information about masses in binary systems can be obtained.

Luna: Kemp y Rudy han observado varias binarias durante un lapso de tiempo muy amplio y pueden haber ocurrido cambios en la envoltura. Sus observaciones presentan una dispersión mayor que los errores individuales tal vez como consecuencia de ello. Nuestras observaciones tratan de distribuirse cubriendo el menor número posible de revoluciones.

Sajo: ¿Cuál es la magnitud típica del porcentaje de polarización medida? y ¿cuál es el error en la medición de esos porcentajes?

Luna: La magnitud típica es de aproximadamente el 0.7% y el error es de 0.03%.

Rayo: ¿Cuántas estrellas WR has incluido en tu programa de observación?

Luna: Sólo una, HD 152270 en Sco OB-1.

Torres-Peimbert: ¿Tiene usted la certeza de que no hay un efecto instrumental en la variación de la polarización medida causado por la variación de la intensidad?

Luna: Hemos demostrado que no hay variaciones en la polarización instrumental por las variaciones de intensidad.

Sahade: Deseo hacerle una pregunta y un comentario: ¿Cómo eligió el programa de binarias? Polarización variable no significa necesariamente que nos encontramos con un sistema binario; bastaría que hubiera una envoltura no simétrica.

Luna: Las estrellas seleccionadas fueron aquellas con un período menor que 10 días. Estoy de acuerdo, la polarización en HD 162679 puede no ser producida por una estrella binaria.

Homero Luna: Universidad Nacional de La Plata, Observatorio Astronómico, Paseo del Bosque s/n, 1900 La Plata, Argentina.