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ANALYSIS OF LINEAR POLARIZATION IN TWO WOLF-RAYET BINARY SYSTEMS

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RESUMEN

Analizamos observaciones de luz linealmente polarizada de los sistemas binarios WR+O HD 94305 y HDE 320102, realizadas con el fotopolarímetro VATPOL en el telescopio de 2.15-m del CASLEO, San Juan, Argentina. Ambos sistemas binarios muestran variaciones de polarización asociadas con la fase orbital. El análisis de esas variaciones en el marco del modelo de un sistema binario, indica valores elevados de las inclinaciones orbitales. Este resultado contradice lo esperado para el valor de la masa de la componente tipo O del sistema HD 320102 y, junto con otros parámetros derivados de los mismos modelos, sugiere la existencia de componentes adicionales de la polarización debidas a los vientos estelares del sistema.

ABSTRACT

We have performed linear polarization observations of the WR+O binary systems HD 94305 and HDE 320102 with the VATPOL photopolarimeter attached to the 2.15-m telescope in CASLEO, San Juan, Argentina. Both binary systems show phase-locked variations in their polarization. Analysis of these variations in the framework of the binary model yields rather high orbital inclinations for both systems. This is in conflict with the expected mass-value for the O-type component in HD 320102. We postulate an extra contribution for the polarization due to the winds of the binary components.

Key words: **BINARIES: SPECTROSCOPIC — POLARIZATION — STARS: INDIVIDUAL (HD 94305; HD 320102) — STARS: WOLF-RAYET**

1. INTRODUCTION AND OBSERVATIONS

HD 94305 and HDE 320102 are massive WR+O type binary systems. Orbital parameters have been previously reported from spectrographic observations (Niemela et al. 1983; 1995). In both systems minimum masses for the components were determined, and an estimate of the orbital inclination was made based on the expected masses of the stars according to their spectral types. HD 94305 is classified as a WC6+O6-8 binary, and appears to have relatively high minimum masses, thus a large orbital inclination is expected. HDE 320102 is a WN3-4+O5-7 system with rather low minimum masses of the components, according to their spectral types, suggesting a low orbital inclination.

Orbital inclinations in hot binary stars may be determined by studying the modulation of the linear polarization as a function of the orbital phase. We have made observation of linearly polarized light of these systems and determined the orbital inclination applying the the binary model of Brown, McLean,& Emslie (1978; hereafter BME) using the algebraic equations of Drissen et al. (1986).

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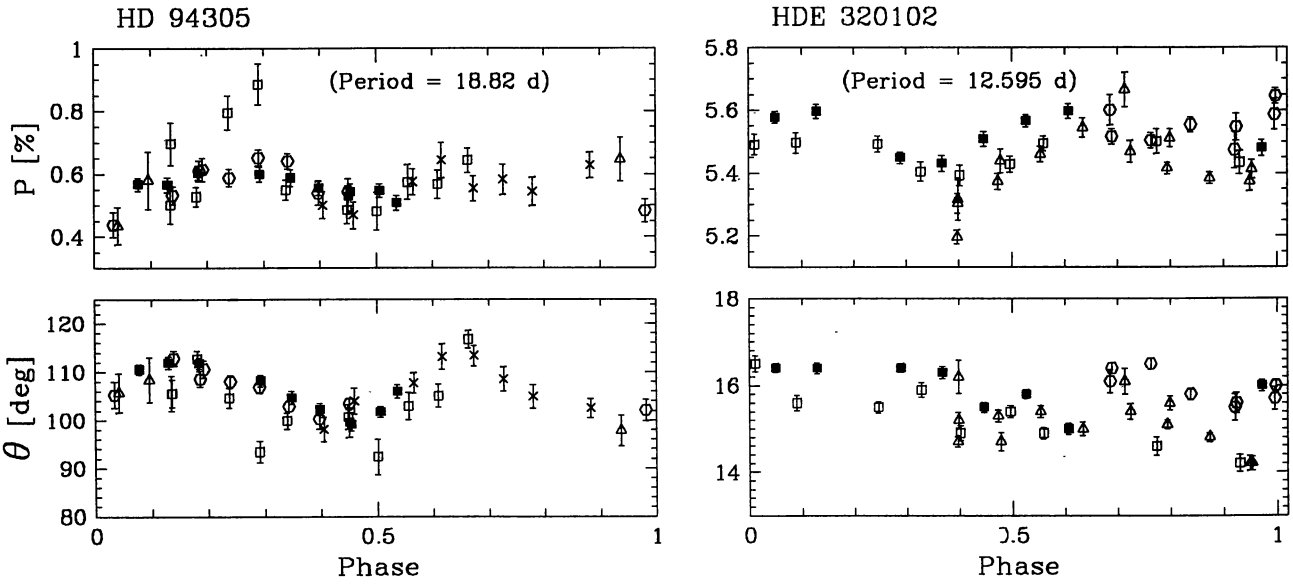

Fig. 1. Observed linear polarization, P, and polarization angle, θ, vs. the orbital phase of the WR+O binaries HD 94305 and HDE 320102. Point styles indicate different observing years: triangles: 1987; squares: 1988; crosses: 1989; filled squares: 1990 ; circles: 1991. The orbital periods indicated in the figure are from Niemela et al. (1983; 1995).

The observations were made with the Vatican Polarimeter (Magalhaes et al., 1984) attached to the 2.15-m telescope of Complejo Astronómico El Leoncito (CASLEO) [5], San Juan, Argentina, during several periods from August 1987 to June 1991.

2. RESULTS AND THEIR DISCUSSION

In Figure 1 the linear polarization observations are plotted versus the orbital phase of the binary systems, showing that phase-locked variations are present in both systems. The orbital inclination of a binary can be deduced from the Stokes parameters light curves produced by the intrinsic polarization in the system (BME). These curves for HD 94305 and HDE 320102 are shown in Figure 2; they were obtained by adjusting to the observations the coefficients of a Fourier series up to second harmonics by a method of least-squares. The interpretation of the phase-locked variations of the linear polarization (see Figs. 1 and 2) given by the binary model of BME, indicates that orbital inclinations are: i=107° for HD 94305 and i=80° for HDE 320102. If these values of inclinations were correct, then the masses of the binary components would be:

HD 94305:	M(WC6) =	17 $M_\odot$	M(O6-8) =	36 $M_\odot$
HDE 320102:	M(WN3-4) =	2.4 $M_\odot$	M(O5-7) =	4.7 $M_\odot$

For the O-type component of HDE 320102 the mass is an order of magnitude too low for its spectral type, then, an additional source of polarization other than those considered by the binary model of BME, has to be present.

Although the observational errors are rather large for both binaries, preventing us to make any conclusive statement about parameters describing the systems, some general remarks can be given.

For HD 94305 the orbital inclination is in agreement with spectroscopic observations. Second harmonic variations are more important than any other, as can be seen in the fit of the Stokes parameters. This is also evident from the value of quantity A (see Drissen et al. 1986), which equals 13 for this system indicating that the scattering material is rather concentrated in the orbital plane and symmetrical about it.

[5]CASLEO is operated under contract with CONICET, SeCyT, Universities of La Plata, Córdoba and San Juan, Argentina.

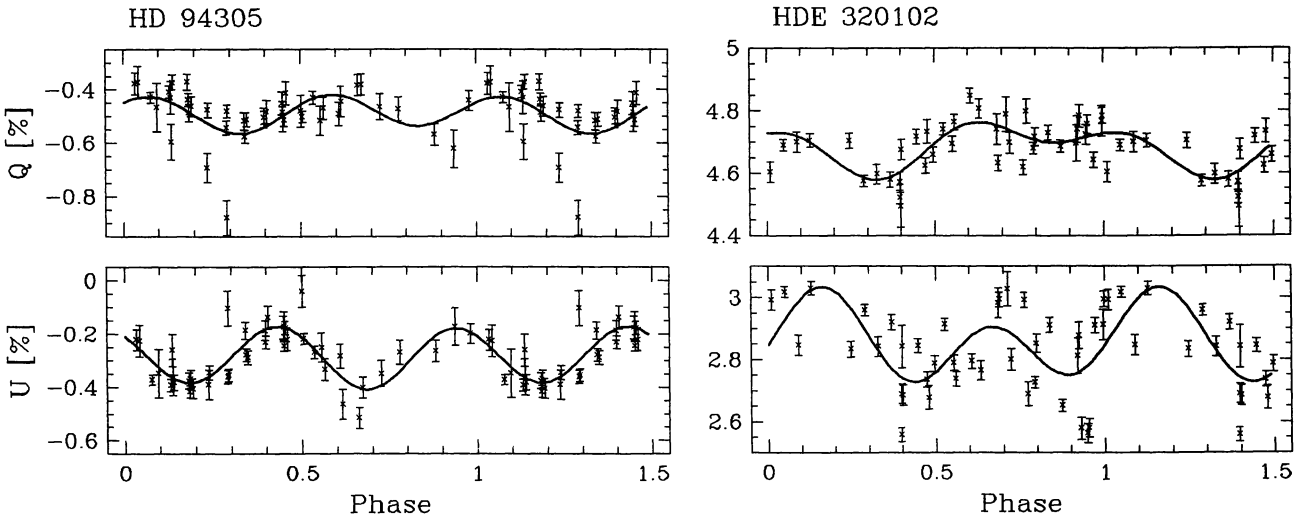

Fig. 2. The variation of the Stokes parameters, Q and U, plotted vs. orbital phase of the binaries. The solid lines are the best fit to a Fourier series up to second-harmonic terms.

For HD 320102, the value for A is 3, and the first harmonic has some non negligible relevance in the polarization variations. A large value for the angle λ_1, which measures the direction of the concentration of material from the line joining the two stars (see Drissen et al. 1986), is indicating that the scattering particles are distributed in a preferred but unusual direction (λ_1 =33 deg.). This fact, together with the low value for A, is possibly related to streaming effects in the colliding winds of the binary components, which may also introduce additional polarization.

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REFERENCES

Brown, J.C., McLean, I.S., & Emslie, A.G. 1978, A&A, 68, 415
Drissen, L., Lamontagne, R., Moffat, A.F.J., Bastien, P., & Seguin, M. 1986, ApJ, 304, 188
Magalhaes, A.M., Benedetti, E., & Roland, E.H. 1984, PASP, 96, 383
Niemela, V.S., Cabanne, M.L., & Bassino, L.P. 1995, RevMexAA, 31, 45
Niemela, V.S., Mendez, R.H., & Moffat, A.F.J. 1983, ApJ, 272, 190