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PHOTOMETRIC AND POLARIMETRIC OBSERVATIONS OF THE WOLF-RAYET ECLIPSING BINARY HD 5980 IN THE SMALL MAGELLANIC CLOUD

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RESUMEN

Presentamos resultados de observaciones fotométricas y fotopolarimétricas de HD 5980, la binaria eclipsante Wolf-Rayet HD 5980 en la Nube Menor de Magallanes, que sufrió una inesperada erupción a mediados del año 1994. transformando su espectro en uno típico de una Variable Luminosa Azul. Las observaciones fotométricas, obtenidas de imágenes con detector CCD. fueron realizadas durante la fase declinante de la erupción. Las observaciones fotopolarimétricas pre-erupción fueron efectuadas entre 1987 y 1991, y post-erupción, desde mayo de 1995.

ABSTRACT

We present results of photometry and photopolarimetry of the Wolf-Rayet eclipsing binary system HD 5980 in the Small Magellanic Cloud, which underwent an unexpected eruption during 1994, transforming its spectrum into a Luminous Blue Variable-like one. CCD photometry was performed during the post-outburst declining phase. Pre-outburst photopolarimetric observations were collected between 1987 and 1991, and post-outburst after May 1995.

Key words: **BINARIES: CLOSE — STARS: INDIVIDUAL (HD 5980) — STARS: MASS-LOSS — STARS: VARIABLES: OTHER (LUMINOUS BLUE VARIABLES) — STARS: WOLF-RAYET**

1. INTRODUCTION

HD 5980 is a Wolf-Rayet (WR) eclipsing binary system in the Small Magellanic Cloud, with an orbital period of 19.3 days. Remarkable long-term variations have been reported in its spectrum (Barbá & Niemela 1994a; Koenigsberger et al. 1994). In October 1994, Barbá & Niemela (1994b) reported a sudden outburst-like behavior of HD 5980, when the WR type spectrum changed dramatically to a Luminous Blue Variable (LBV) type. Post-outburst evolution of the optical spectrum is discussed in Barbá et al. (1996).

Here we report preliminary results of photometric and polarimetric observations of HD 5980 obtained at La Plata Observatory, in Buenos Aires, and Complejo Astronómico El Leoncito [7], in San Juan, Argentina.

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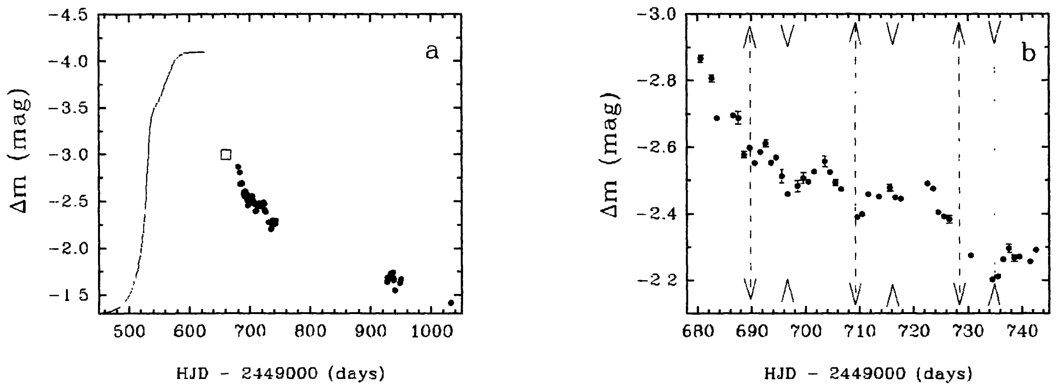

Fig. 1. a) Schematic differential (HD 5980-Sk 80) light curve of the outburst. The line is a free-hand approximation to the visual observations reported by Bateson & Jones (1994), the open square represents the V magnitude from Barbá et al. (1995), and dots are "white light" CCD observations obtained at La Plata Observatory. b) Light curve obtained at La Plata between Dec. 1994 and Jan. 1995 (zoom from Fig. 1a). Dashed and dotted vertical lines represent dates of expected primary and secondary eclipses, respectively, as predicted from ephemeris given by Breysacher & Perrier (1980).

2. PHOTOMETRY

Observations: Direct CCD images of the HD 5980 field were obtained during 55 nights between November 1994 and November 1995, with the 0.83-m reflector at La Plata Observatory. A *Photometrics* CCD detector was used, with a 250 000 electrons full-well capacity and a typical readout noise of 40 electrons. The amplifier gain was set to 18 e^-/ADU. Bias substracting and flat-fielding were done in a standard way. Typically, 10 frames were obtained each night; the field ($1\rlap{.}'9 \times 2\rlap{.}'8$) included both HD 5980 and the nearby Of type star Sk 80. No filter was used and the resulting band-pass of the CCD-telescope combination is similar to an integrated V and R Johnson bands. All frames from a given night were processed individually and then combined in order to improve the signal-to-noise ratio.

The outburst light curve: Aperture photometry with the *Apphot* package of IRAF software was performed on the average frames, and the magnitude difference (Δm) between HD 5980 and Sk 80 was computed for each night. Figure 1a shows a sketch of the complete light curve of the outburst. Figure 1b shows a zoom of the former, covering the two months of continuous CCD observations at La Plata Observatory. After its sudden outburt in mid 1994, the brightness of HD 5980 has been steadily decreasing. As seen in Fig. 1b, superimposed on this general trend, the light curve shows variations associated with the known orbital period of this eclipsing binary star, although the minima are shallower than previously observed (e.g., Breysacher & Perrier 1991). In addition, there is a hint for erratic variations that may be causing some minima to appear diluted.

3. POLARIMETRY

Observations: Pre-outburst linear polarimetry of HD 5980 was obtained during several runs between 1987 and 1991, with the Vatican Polarimeter (VatPol), and post-outburst observations were performed during 1995 with the Torino Five Channel Photopolarimeter, both attached to the 2.15-m telescope at CASLEO.

Pre-outburst status: Figure 2 shows the observed U and Q Stokes parameters, for the period 1987–1991, versus the orbital phase of HD 5980, and the corresponding wave and double wave Fourier fits. Phase-locked variations of the linear polarization in HD 5980 are obvious in this figure.

All the linear polarization observations of HD 5980 in the $U - Q$ Stokes space are shown in Figure 3. The center of the pre-outburst observations (open circles) coincides with the observed polarization toward Sk 80 (filled square with error bars), suggesting that this is the value of foreground polarization vector.

Post-outburst status: After the outburst, the observed polarization vectors are larger and have notably different center in the $U - Q$ Stokes space (Fig. 3: filled circles), indicating that the circumbinary material has been increased by the ejecta, also changing the foreground polarization toward the binary system. With these observations, a modeling is in progress, in order to obtain orbital parameters and to study the geometry of the ejecta.

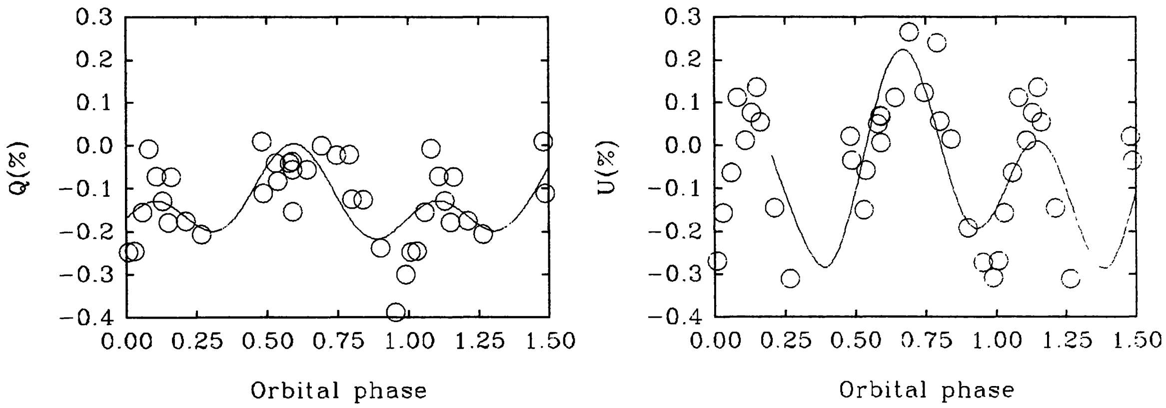

Fig. 2. Stokes parameters Q and U versus the orbital phase of HD 5980. The solid line is the plot of the wave, and double wave Fourier fit to the pre-outburst (1987-1991) polarimetric observations.

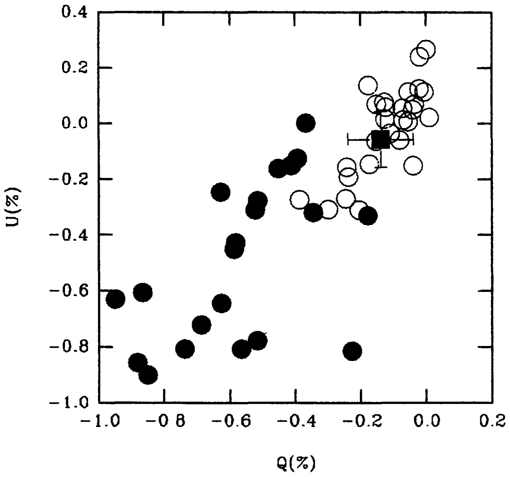

Fig. 3. All polarimetric observations of HD 5980 in the Q, U plane. Pre-outburst values (1987–1991) are shown as open circles, and the polarization toward to Sk 80 as a filled square with error bars. Post-outburst 1995 observations are denoted by filled circles.

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