Spectropolarimetry of WR66*

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Abstract: We have carried out spectropolarimetric observations of the Wolf-Rayet star WR66 (WN8) with EFOSC1 mounted on the ESO 3.6m telescope of La Silla. The results indicate a polarization level of about 5 to 6 % in the continuum which is most probably due to interstellar polarization.

1 Introduction

The spectra of Wolf-Rayet stars exhibit the signature of strong stellar winds that render an accurate determination of the stellar parameters extremely difficult. The structure of these extended atmospheres has been a matter of debate for many years. One of the most relevant questions concerns the geometry of the winds. Most of the current NLTE-models assume spherically symmetric, homogeneous, steady-state winds (see e.g. Hillier 1995 and references therein). Recently, some progress in the modeling was made by adopting a preferred axis (Cassinelli et al. 1995) in order to take into account the effects of stellar rotation and/or a magnetic field. From the observational point of view, there exists some evidence that the winds of some WR stars are not spherically symmetric. Possible origins of asymmetries include binarity, magnetic fields, rotation and moving inhomogeneities. In this context, the techniques of polarimetry and spectropolarimetry provide very promising tools to disentangle the question of asymmetries in WR atmospheres (Schulte-Ladbeck 1995).

WR 66 (≡ HD 134877) is a Wolf-Rayet star of spectral type WN8 exhibiting a small amount of residual hydrogen in its atmosphere (Hamann et al. 1995). Recently, photometric variations on a short period of ~ 4 hours were reported independently by Antokhin et al. (1995) and Rauw et al. (1996). An investigation of the spectrum of WR 66 (Rauw et al. 1996) revealed the existence of a non-steady mass loss along the line-of-sight towards the star. The N IV λ4058 emission line was found to have an anomalous shape compared to other late WN stars. This could either indicate that a high degree of ionization is maintained at a much higher distance from the star than in typical late WN stars, or that the wind of WR 66 is not spherically symmetric. In order to in-

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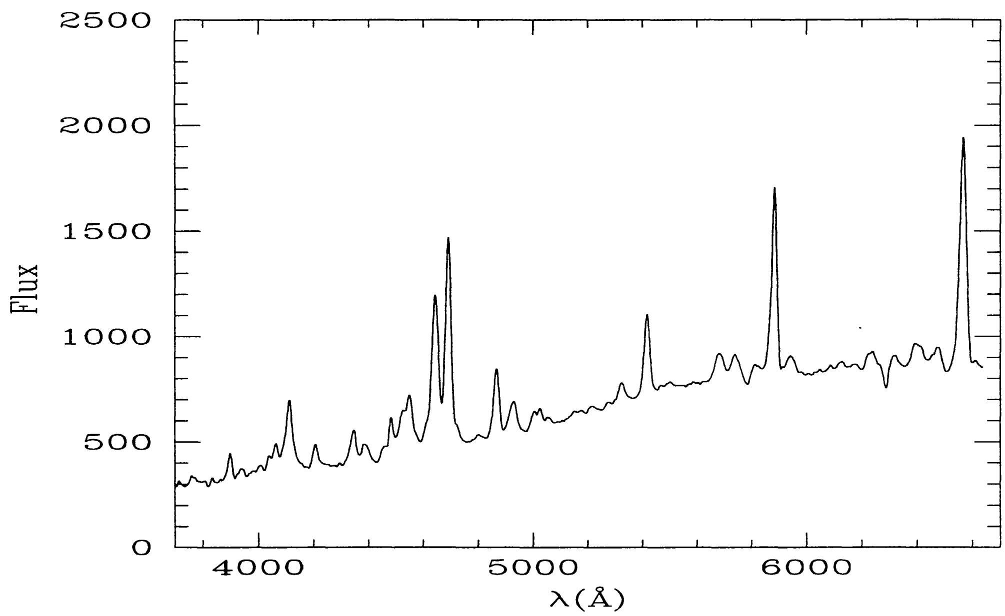

Figure 1: The spectrum of WR 66 between 3700 and 6600 Å as obtained in April 1995. The flux is in arbitrary units.

vestigate the latter possibility, we decided to study the wind of WR 66 with spectropolarimetry.

Previous polarimetric observations of late WN stars were conducted by Drissen et al. (1987). Using a broad-band filter (FWHM = 1800 Å) centered on λ 4700, they found a mean linear polarization of 1.78% for WR 16 and of 1.18% for WR 40, both being WN8 Wolf-Rayet stars. Their data indicate a significant variability of the polarization, especially for WR 40. Drissen et al. attribute this variability to inhomogeneities in the stellar wind.

2 Observations and reduction of the data

The data were obtained in April 1995 with the ESO 3.6m telescope at La Silla equipped with EFOSC1 (ESO Faint Object Spectrograph and Camera, Dekker & D'Odorico 1986). Spectropolarimetry is achieved with EFOSC1 by inserting a Wollaston prism in the filter wheel, a slit in the aperture wheel and a grism in the grism wheel (di Serego Alighieri 1996). For each object in the slit, this produces two orthogonally polarized spectra separated by 10" in the direction of the slit, perpendicular to the dispersion. We made use of a mask (put in the focal plane of the telescope) to prevent overlap from spectra and to reduce the sky contribution. One of the free sections is used for the object and the rest is for the sky and/or field stars. The intensity difference of the two orthogonally polarized spectra provides a measure of one of the normalized Stokes parameters describing the linear polarization. To determine the two necessary Stokes parameters or equivalently the degree of linear polarization P(λ) and the position angle $\theta(\lambda)$ of the plane of vibration of the E vector, we took spectra positionning the Wollaston

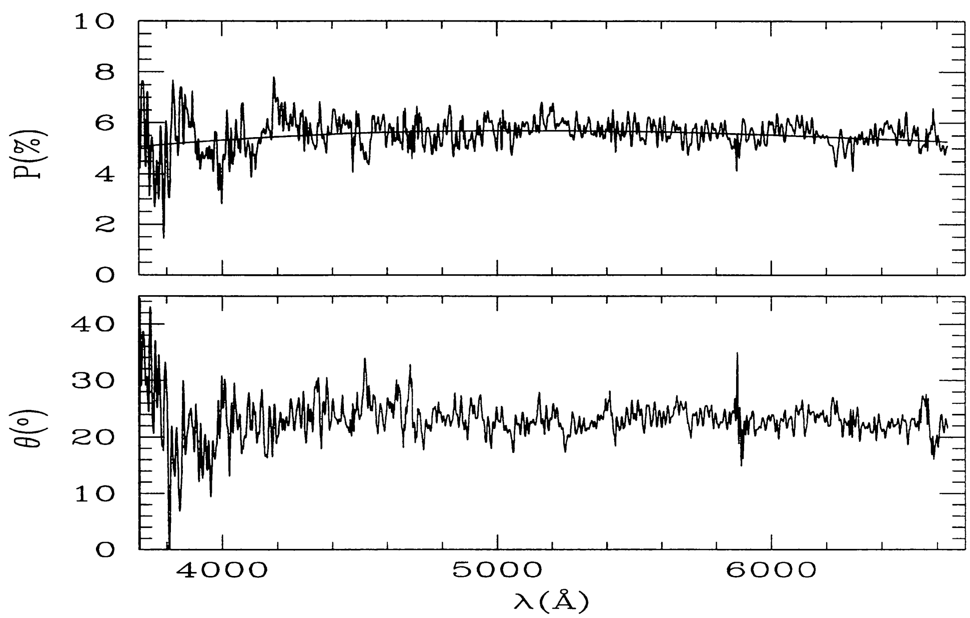

Figure 2: The results of our spectropolarimetric observations of WR 66. The upper panel shows the degree of polarization as a function of wavelength. The overplotted line is a Serkowski type interstellar polarization curve with $P_{max} = 5.7\%$ and $\lambda_{max} = 5100$ Å(see text). The lower panel gives the wavelength dependence of the angle of polarization.

prism at two different angles separated by 45°.
WR 66 was observed with the B300 grism, giving a wavelength coverage from 3640 Å to 6860 Å. The detector was a Tektronix 512 × 512 CCD with a pixel size of $27 \mu m^2$. The slit was 2" wide, giving us a linear dispersion of about 6 Å/pixel. The spectrophotometric standard stars EG 274 and LTT 3218 were observed with the same set-up to allow the flux calibration. We also observed the polarimetric standard star HD 161291 (Serkowski et al. 1975) and the non-polarimetric standard star HD 176425 (Turnshek et al. 1990) to check our measurements, to estimate the instrumental polarization and to fix the zero-point angle. Reduction of the spectra were performed with the MIDAS software. Every strip in the image has been calibrated in an independent way, both in wavelength and flux, and as accurately as possible since the Stokes parameters mainly result from the subtraction of two orthogonally polarized spectra.

3 Results

We first compare our spectropolarimetric observations of the standard star HD161291 to that published by Serkowski et al. and find an excellent agreement, both in the degree of polarization and in the wavelength dependence.
The results of the spectropolarimetry of WR66 are shown in Figs. 1 and 2 : we give the spectrum of the star, the degree of linear polarization and the position angle of the polarization as a function of wavelength, between 3700 and 6600 Å.
We notice on Fig. 2 that the emission lines have quite the same degree of polarization (about

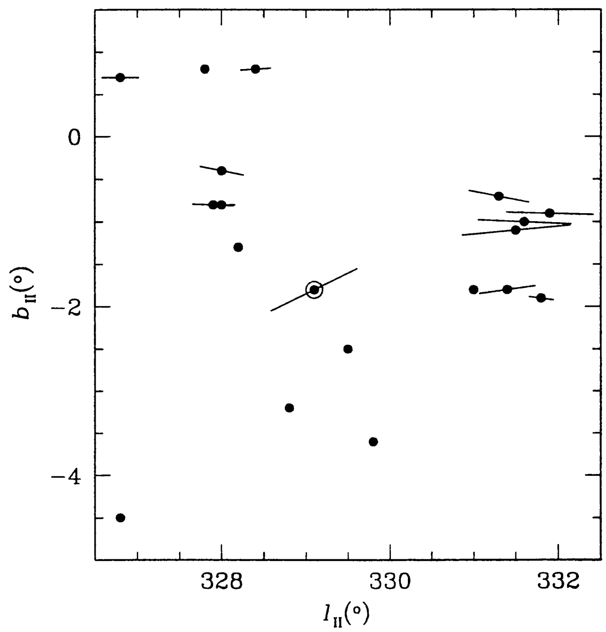

Figure 3: Distribution of the polarization pseudo-vectors in galactic coordinates for stars around WR66, taken from the catalogue of Axon & Ellis (1976). The length of each vector is proportional to the amount of polarization. WR66 is the encircled point.

5 to 6%) as the continuum. Also, the angle of polarization appears essentially constant with the wavelength. These two results suggest that the observed polarization is essentially due to the interstellar dichroïc absorption. We thus tried to fit our data with a typical interstellar polarization curve ($P/P_{max} = e^{-K.\ln^2\left(\frac{\lambda}{\lambda_{max}}\right)}$ where K = 1.15, Serkowski et al. 1975). As can be seen, a curve with the parameters λ_{max} = 5100 Å and P_{max} = 5.7%, fits reasonably well our data, supporting the interstellar polarization hypothesis. Such a high degree of polarization is compatible with the empirical Serkowski et al. relation $P_{max}/E(B-V) \leq 9\%$, and the value E(b-v) = 0.9 derived by Schmutz & Vacca (1991) if we assume E(b-v) $\simeq$ E(B-V). As illustrated by Fig. 3, the degree of polarization and the angle of polarization of WR66 in galactic coordinates ($\theta_g = 64°$) are compatible with those of surrounding stars taken from the catalogue of Axon & Ellis (1974), further supporting this interpretation.

We therefore conclude that the high degree of polarization observed in the Wolf-Rayet star WR66 ($P_V \simeq$ 5 to 6%) is mainly due to interstellar polarization. However, a smaller intrinsic polarization component ($P \simeq 1\%$) cannot be excluded.

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