*Massive Stars Near and Far*
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# Observations south of HD 5980

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**Abstract.** We study the He II $\lambda 4686$ emission south of multiple-star system HD 5980, which hosts two WN-type stars. We use optical VLT FORS1 long-slit spectra. The observations are close to the eclipse phase. Broad He II emission with a SNR $> 5$ is observed as far as 7.6 pc from HD 5980. The He II emission that is closest to HD 5980 is 1.2 pc directly south and has a redshifted component with FWHM 1450 km s-1 originating in the eclipsing WN5-6 star, and a blueshifted component with FWHM 600 km s-1. The second component cannot be explained by either the nearly- eclipsed WN star or the nearby supernova remnant, SNR B0057-724. We suggest that the additional He II emission comes from the colliding winds of the two WN stars.

**Keywords.** binaries: eclipsing – stars: individual (HD 5980) – stars: Wolf–Rayet – HII regions – Magellanic Clouds

## 1. Introduction

NGC 346 (the brightest H II region of the Small Magellanic Cloud) hosts a multiple massive-star system, HD5980, that is of great interest for understanding massive-star evolution and binary-black hole formation.

HD 5980 is composed of least three massive stars. Its first component, star A, is a $60 \pm 10$ $M_\odot$ (Koenigsberger et al. 2014) that went through the eruptive luminous blue variable (LBV) phase during 1993-1994, and that now has a spectrum corresponding to that of a WN5-6 nitrogen-sequence Wolf-Rayet (WR) star. Its second component, star B, is a close eclipsing WN4 companion of similar mass ($66 \pm 10$ $M_\odot$; Koenigsberger et al. 2014). The ultraviolet spectrum of HD 5980 has a third component, star C, which is believed to be itself a binary system containing a late O type supergiant (Hillier et al. 2019).

## 2. Observations

The VLT FORS1 observations that we use in this work were obtained on September 10, 2002. The observations include a direct V-band image that corresponds to a plate scale of 0.2" / pixel; and long slit (0.51" x 410") optical spectra of three different locations (slit A, slit B and slit C) of NGC 346 that are shown in Figure 2. Spectra were obtained at each location with three grism / filter combinations: low dispersion (3440-7600Å); blue (3560-5970 Å); and red (5330-7485 Å) spectra.

## 3. Properties of the broad He II emission lines

Tipically, the FWHM of WR stars is $\geqslant$ 1000 km/s, meanwhile the FWHM due to nebular emission is 100 km/s. We divided the slit into 5"-long windows. We find a He II emission maximum in window 22. Figure 1, left panel shows that the He II profile is composed of a redshifted-component with FWHM = 1439 km $s^{-1}$ and a blueshifted-component with FWHM = 603 km $s^{-1}$. The emission is observed as far as 7.6 pc away from HD 5980. We find that the orbital phase (0.32) of our observations is close to the

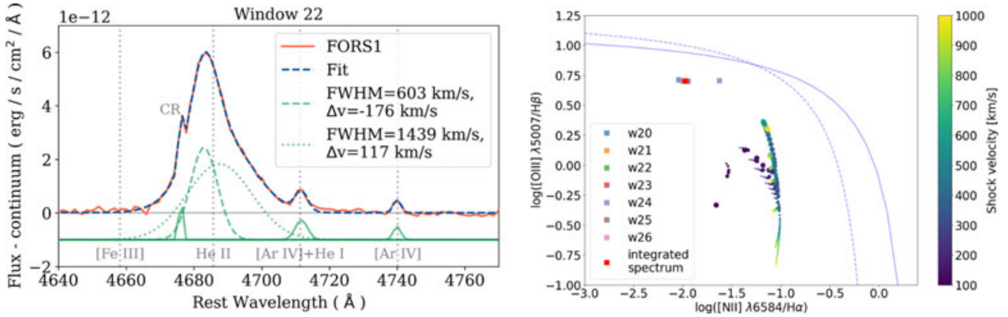


**Figure 1.** Left-. Continuum-subtracted spectrum corresponding to window 22. He II 4686 line (red curve). The blue curve is a multi-gaussian fit to the observations. The green curves show the individual Gaussian components (we use a dashed curve for He II). The legend gives the FWHM and velocity shift of the He II line components. Right-. [O III] 5007 / H$\beta$ versus [N II] 6584/H$\alpha$ diagnostic diagram. The dashed and solid lines represent the Kauffmann et al. (2003) and Kewley et al. (2001) curves. The squares represent values measured in windows of slit C with two gaussian components and the red-filled square is the value measured after integrating the spectra of the 7 windows. We also show the shock models of Alarie & Morisset (2019) with SMC metallicity, shock speeds between 200 and 1000 km s-1 (see colour bar) and magnetic field strengths between 0.0001 and 10 $\mu$G (given by the size of the filled circle, where the size increases with the strength).

eclipse of the system (0.36), so the second Gaussian component may not correspond to the second WN star of the binary system.

## 4. X-ray emission around HD 5980

There is X-ray emission around HD5980 due to the presence of the SNR B0057-724. This diffuse emission reaches the region covered by our slit C. Thus, we looked at the position of our observation in optical diagnostic diagrams relative to the radiative shock models of Alarie & Morisset (2019). It is unlikely that the nearby SNR significantly contributes to the He II emission because the observations are far from the location of the shock models.

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