RevMexAA (Serie de Conferencias), **5**, 120–122 (1996)

HD 5980 IN THE INFRARED

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RESUMEN

Espectros infrarrojos de alta resolución de la binaria HD 5980 fueron obtenidos en Mayo y Noviembre 1995, después del reciente evento de tipo LBV. Se observaron cambios espectrales importantes entre Mayo y Noviembre. La comparación con espectros infrarrojos de otras estrellas tempranas revela una similitud notable con la estrella de tipo Ofpe/WN9 HDE 269445 y con la estrella LBV He 3-519.

ABSTRACT

High-resolution infrared spectra of the binary HD 5980 were taken in 1995 May and November, after the recent LBV-like event. Significant spectral changes occurred between May and November. Comparison with infrared spectra of other early-type stars reveals a striking similarity with the Ofpe/WN9 star HDE 269445 and the LBV star He 3-519.

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

1. INTRODUCTION

The binary system HD 5980 in the SMC underwent spectacular spectral and photometric changes over the last few years (Barbá et al. 1995; Koenigsberger 1995), going from early WN type to late WN, then to LBV-like, while the visual magnitude increased by 2.3. We present here high-resolution (R = 1600) infrared spectra taken after the LBV-like outburst of November 1994. Our first K-band spectrum was taken on 1995 May 11 at the CTIO 1.5-meter telescope. Our H-band and second K-band spectra were taken on November 10 at the CTIO 4-meter.

2. THE 1995 MAY SPECTRUM

In our 1995 May Spectrum, the He I 2p-2s singlet at 2.058 μm is seen mostly in emission, without clear P Cygni absorption. This is totally unlike WN6 and WN7 stars, which show the feature in absorption only (Eenens & Williams 1994) but is more typical of late WN types and, in general, of dense winds in which He^{++} has already recombined relatively close to the star. Indeed, the 2p-2s transition would not be seen in emission, in the presence of a strong branching ratio in favor of the 2p-1s transition (584 Å), if a strong ultraviolet radiation near 584 Å would not overpopulate their common upper level. The profile of the 2.058 μm emission feature is asymmetric, but our data do not allow us to tell whether this is related with the the 19.3 day period.

The feature near 2.11 μm is a blend of He I 3p-4s singlet and triplet (2.113 μm). It also shows an asymmetric profile. The position of the feature rules out N III 8-7 (2.117 μm).

The He I 7-4 array certainly contributes to the broad feature near 2.166 μm. Indeed, satellite lines are observed: 7s-4p near 2.15 μm and 7d-4p near 2.18 μm. He II 14-8 must also contribute, as He II 10-7 is observed at 2.189 μm. Although Br γ 7-4 may contribute to the 2.166 μm emission, it cannot be the main contributor, since the spectrum resembles those of the hydrogen-poor WN8 star WR 123 and of the hydrogen-poor LBV star He 3–519, while hydrogen-rich late-WN stars exhibit relatively much stronger 2.165 μm.

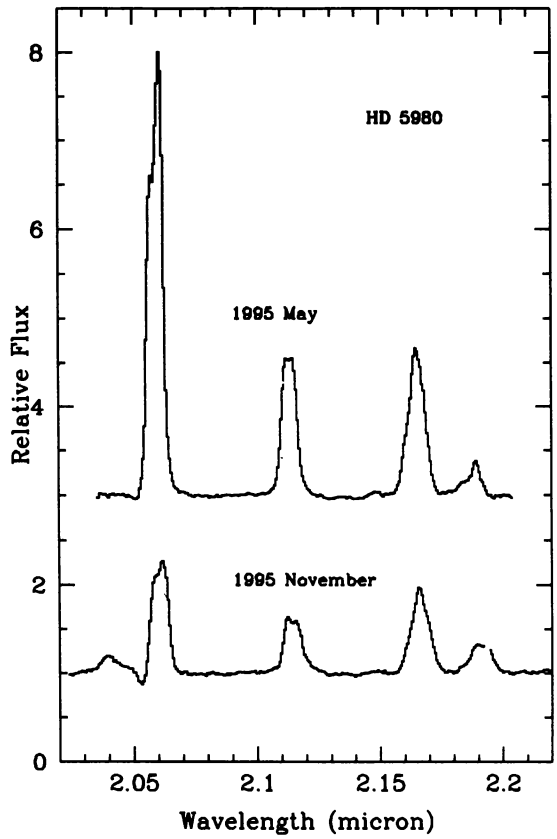

Fig. 1. Normalized 2 μm spectra of HD 5980. The May spectrum has been shifted vertically for clarity.

3. THE 1995 NOVEMBER SPECTRUM

In our 1995 November spectrum, the strength of the 2.058 μm emission and other He I lines has dramatically decreased while a P Cygni absorption has appeared in the 2p-2s profile. At the same time, the He II line at 2.189 μm line is becoming relatively stronger and a new He II line (15-8) is now seen at 2.038 μm. All this indicates an increase in the ionization of the wind.

Our H-band spectrum looks very different from, e.g., that of the hydrogen-rich star GG Car. The Brackett lines, if at all present, are much weaker in HD 5980. We believe that the observed transitions are mainly due to He I (10-4 to 16-4). We also observe He I 4p-3s at 1.509 μm and He II 9-6 near 1.476, as well as three members of the n-7 series (14-7, 13-7 and 12-7) near 1.489, 1.572 and 1.693 μm respectively.

4. COMPARISON WITH OTHER EARLY-TYPE STARS

Our forthcoming atlas of infrared spectra of massive stars in transition enables us to compare the infrared spectrum of HD 5980 with new infrared spectra of stars of types OIf, Ofpe/WN9, LBV, B[e] and WN (Morris et al. 1996).

The strong 2.058 μm emission without much P Cygni absorption observed in HD 5980 in 1995 May reminds mostly the spectra of the Ofpe/WN9 stars HDE 269445 and HDE 268840, i.e., of late-type WN stars. However, this line is very sensitive to wind density, so it is much more indicative of the stellar wind structure than of the wind composition or the star evolution.

For the relative strength of the various 2-μm lines, the May spectrum of HD 5980 was identical to the Ofpe/WN9 star HDE 269445. The general appearance of the K-band spectrum of HD 5980 makes this star also

similar to the LBV stars we observed, especially the LBV star He 3-519. However, the lines of Fe II near 2.08 μm and of Mg II near 2.14 μm, seen in some LBV spectra, are not observed in HD 5980.

These similarities are consistent with LBV stars showing an Ofpe/WN9-like spectrum at visual minimum, such as AG Car (Stahl 1986) and R 127 (Stahl et al. 1983).

5. CONCLUSIONS

We conclude, from its infrared spectrum, that the outbursting component of HD 5980 is probably an evolved WN star, showing Ofpe/WN9 spectral characteristics because of peculiar wind conditions after the LBV outburst. Between May and November, its ionization has increased, suggesting that the star is on its way to its previous WN4 spectral type.

PRJE is grateful to G. Coyne and the Vatican Observatory for their generous support.

REFERENCES

Barbá, R.H., Niemela, V.S., Baume, G. & Vazquez, R.A. 1995, ApJ, 446, L23
Eenens, P.R.J., & Williams, P.M. 1994, MNRAS, 269, 1082
Koenigsberger, G., Guinan, E., Auer, L., & Georgiev, L. 1995, ApJ, 452, L107
Morris, P., Eenens, P.R.J, Hanson, M.M., Conti, P.S., & Blum, R.D. 1996, ApJ, submitted
Stahl, O. 1986, A&A, 164, 321
Stahl, O., Wolf, B., Klare, G., Cassatella, A., Krautter, J., Persi, P., & Ferrari-Toniolo, M. 1983, A&A, 127, 49