Stellar Rotation
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The Erupting Star in HD5980: A Rapid Rotator ?

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Abstract. We present evidence suggesting that the star that erupted in 1994 in the SMC multiple system HD 5980 has $v \sin i \sim$230 km s^{-1}, which is close to the breakup velocity for this star.

The Wolf-Rayet (WR) system HD 5980 is located in the Small Magellanic Cloud, and consists of an eclipsing binary pair (stars A and B) in an eccentric (e=0.27) and relatively short period (19.265 days) orbit. The UV spectrum betrays the presence of a third O3-5 type star C, which may only be a coincidence line-of-sight object, since its photospheric absorption lines remain nearly stationary on the orbital timescale. Small amplitude RV variations ($\sim$50 km s^{-1}) have been reported (Moffat et al. 1998), but this amplitude is too small for the inferred masses of stars A and B, $\sim$50 and 28 $M_\odot$, respectively (Niemela et al. 1997). In this paper we show that a stationary photospheric absorption line (assumed to arise in star C) can display such small amplitude RV variations if the spectrum of star A has very broad ($v \sin i > 200$ km s^{-1}) absorption lines that follow a large-amplitude RV curve. The broad photospheric absorption would be very difficult to detect because it is superposed on the Wolf-Rayet emission lines.

To test this scenario we use the UV spectra constructed from Kurucz LTE line-blanketed model atmospheres calculations (see Koenigsberger, Kurucz, & Georgiev 2003 for details), rotationally broadened, and shifted in velocity space according to star A's expected RV curve. These are superposed on a stationary set of narrower absorption lines, assumed to arise in star C. In Figure 1 we plot the amplitude of the radial velocity variations that are measured on the combined line profile, for different values of star A's $v_{\rm rot}$. As larger values of $v_{\rm rot}$ are superposed on the stationary lines of star C, the RV variations become smaller.

Moffat et al. (1998) and Koenigsberger, Kurucz, & Georgiev (2003) report amplitudes of 56km/s and 30km/s respectively, for the observed RV variations in the photospheric lines. The corresponding rotational velocities from Fig. 1 are 215 km s^{-1} and 245 km s^{-1}, respectively. These values are close to the critical rotational velocity of star A, assuming it has $R_A \sim 35\ R_\odot$.

Thus, we suggest that star A is a rapidly rotating star that has left the Main Sequence and that, due to its rapid rotation and increasing radius, is at the limit of stability, becoming unstable at times and producing eruptions.

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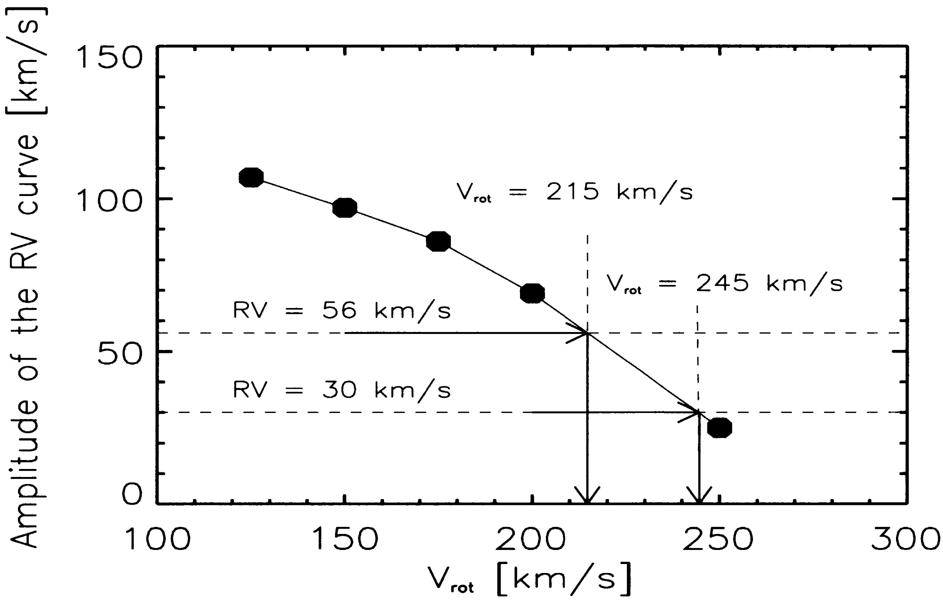

Figure 1. Dependence of the amplitude of the radial velocity on the rotational velocity

Finally, it is tempting to speculate that the relatively large mass of star A, its Wolf-Rayet characteristics, and its rapid rotation may make it a candidate for a future gamma-ray burst source, within the framework of some of the current scenarios (see Woosely, this Symposium for a review of the scenarios).

References

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