PHOTOSPHERIC AND CIRCUMSTELLAR VARIABILITY OF THE RAPIDLY ROTATING O STAR HD 93521

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1. HD 93521: Pulsation, Rotation, and Mass Loss

HD 93521 is an O9.5 V star with several well-documented peculiarities, including: an extremely large projected rotational velocity (400 km/s according to Conti & Ebbets 1977); absorption line profile variations (Fullerton 1990); weak emission at Hα (Irvine 1989); evidence for a rotationally-modified stellar wind in its UV resonance lines (Massa 1992; Howarth & Reid 1993); and stellar wind variability in the form of discrete absorption components (Prinja & Howarth 1986). Thus, HD 93521 provides an ideal laboratory for studying the interaction between rapid rotation and variability in both photospheric layers and the circumstellar environment.

2. Photospheric Variability

We obtained a time series of 36 high S/N (350), moderate resolution (7000) spectra of the He II λ4686 and He I λ4713 lines of HD 93521 with the coudé spectrograph of the 2.1m telescope at the McDonald Observatory on 2 nights in 1987 March. These observations show recurrent, regularly spaced "bumps" with semi-amplitude $\sim$1% of the continuum that traverse the He I line profile from blue to red every 4.8 hours. Analysis of these variations by means of the periodogram technique developed by Gies & Kullavanijaya (1988) indicates that a single sinusoidal frequency of 13.65 ± 0.04 d^{-1} (i.e., period 1.76 ± 0.01 hours) extends across the He I λ4713 profile. In contrast, similar variations are barely visible in the He II line, and we could not detect the 1.76-hour period in our observations of it. Simultaneous photometry did not indicate statistically significant light variations with amplitude greater than 0.002 magnitudes in the Strömgren y filter.

The simplest interpretation of the variability in He I λ4713 is in terms of a single mode of nonradial pulsation (NRP), with period in the observer's

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frame of 1.76 hours. The variation of pulsation phase with position in the line profile indicates that a high-degree, prograde mode is excited ($m = -9 \pm 1$), while the large amplitude suggests that the mode is sectorial ($\ell = |m|$). Photometric variations are not expected from such a mode because of the nearly perfect cancellation of temperature variations and surface-area distortions between adjacent sectors of the visible disk of the star. Since the NRP amplitude is greatly reduced in He II λ4686, we infer that this line must be formed either farther from the photosphere than He I λ4713, or closer to the hot, polar caps of the rotationally distorted stellar surface.

3. Circumstellar Variability

At various epochs we have also obtained less intensive time series observations of the He I λ5876 and Hα lines of HD 93521, both of which are diagnostics of the circumstellar environment. The cores of these lines are blue shifted by $\sim$50 km/s, and both exhibit small blue- and red-emission peaks that are displaced by $\sim$500 km/s from line center. Although the temporal sampling of our data is fragmentary, changes in the shape, strength, and emission V/R ratio are evident from night to night. We cannot determine if the circumstellar variations are cyclical from the present data.

The morphology of these profiles confirms that a weak disk persists around HD 93521, as had been deduced previously from the peculiar UV resonance line profiles of this star (Massa 1992; Howarth & Reid 1993). The blue shift of the line centers and the most common V/R asymmetries suggest that material is flowing slowly outward through disk, perhaps in the manner described by the "Wind-Compressed Disk" model of Bjorkman & Cassinelli (1993). We are planning further optical and UV observations of HD 93521 to investigate whether the circumstellar variability is related to the underlying NRP.

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