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# NARROW- AND INTERMEDIATE-BAND Hα PHOTOELECTRIC PHOTOMETRY OF VW CEPHEI

The W Ursae Majoris-type eclipsing binary VW Cep (BD+75°752) was observed through a complete orbit on 30 October 1979 U.T. The observations were made with a photoelectric photometer mounted on the 38-cm reflector of Villanova University Observatory. The detector is a thermoelectrically cooled (to -10°C) EMI 9558 photomultiplier tube and a microprocessor-controlled integrating system was used to record the signal. A pair of intermediate- and narrow-band interference filters centered near the rest wavelength of the Balmer Hα line (λ6563) was used. The Hα filter pair is similar to that used by Baliunas et al. (1975) in the definition of the Villanova α-system. The Hα narrow-band filter is centered at 6568Å and has a bandwidth of FWHM = 35Å. The intermediate bandpass filter is broad enough to be little affected by the presence of the Hα feature within the bandpass. The α index is defined as follows:

$$\alpha = -2.5 \log F_N/F_I + \text{constant}$$

where $F_N$ and $F_I$ are the fluxes measured through the narrow- and intermediate-bandpass, respectively, and yields a measure of the net Hα line strength.

The comparison star was BD +76°809 (SAO 9836; $m_V$=7.1; F2) and was the same star used in a previous study of VW Cep by Guinan et al. (1980). The observing sequence was the usual pattern of sky-comparison-variable-comparison-sky, with each observation lasting 20 seconds. The effects of differential atmospheric extinction were removed by using an extinction coefficient of k(λ6585)=0.185, found from the observations of the comparison star. The differential extinction corrections were, however, small because of the angular proximity of the comparison star to the variable star.

The differential magnitudes in the λ6585 intermediate bandpass are plotted against orbital phase in Figure 1. The standardized α indices are also shown in the figure where a numerical de-

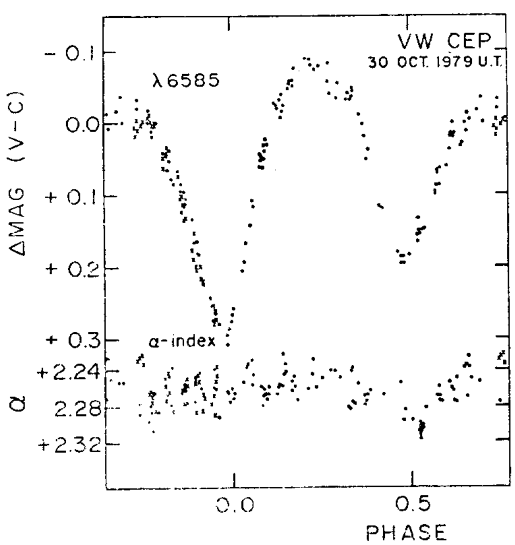


Figure 1. The λ6585 intermediate-band light curve and α index for VW Cep, as a function of orbital phase where a numerical decrease in the α index corresponds to an increase in net Hα emission. The filled circles represent observations obtained during the coverage of the first orbit while the "χ" symbols represent data obtained during the second orbit. The phases were computed using the ephemeris of Cristescu (eq.1).

crease in the α-index indicates an increase in the total energy flux through the narrow-band filter relative to the intermediate-band filter. This can be due either to increasing emission or decreasing absorption in the Hα line relative to the continuum. The phases were computed according to the ephemeris of Cristescu (1978):

$$MIN = JD\ Hel\ 2443448.2663 + 0.2783176 \cdot E \qquad (1)$$

where 0.0 phase corresponds to the time of mid-primary eclipse.

Using the method of Szafraniec (1948), the times of primary and secondary minimum were determined as Min I = HJD 2444176.6161 ± $0^{d}.0006$ and Min II = HJD 2444176.7584 ±0.0011, respectively. Only data within $\pm 0.10$ phase of mid-eclipse were used in obtaining each timing. The O-C for the above timing of primary minimum using the light elements of Cristescu is $-0^{d}.0074$ while the O-C for the secondary minimum is $-0^{d}.0039$ when secondary eclipse is assumed to occur at the half period point.

As shown in Figure 1 the present light curve is very asymmetrical, the maximum near 0.25 phase being about 0.060 mag brighter than the corresponding one near 0.75 phase. The depths of primary and secondary minimum, relative to maximum light near 0.25 phase, are 0.377 mag and 0.275 mag, respectively. Intermediate band $\lambda$6585 light curves of VW Cep obtained in July 1977 by Guinan et al. (1980) and in November 1978 by Guinan and McCook (unpublished) also display outside eclipse asymmetries, but not to the extent seen in the 1979 data. The differences in the mean height of the maximum at 0.25 phase relative to the maximum at 0.75 phase in the sense Max I- Max II are -0.015 mag and -0.030mag for the 1977 and 1978 data. Investigations of the outside eclipse changes in the light curve of VW Cep have been made by Kwee (1966), Leung and Jurkevich (1969) and by Pustylnik and Sorgsepp (1976). Leung and Jurkevich interpret the light curve variations as arising from a circumstellar cloud of absorbing material which revolves with a period about 9.3 seconds longer than the orbital period of the stellar components, resulting in a 780 day beat period. Pustylnik and Sorgsepp, however, interpret the light curve asymmetries as arising from the effect of a hot spot produced by a gas stream impacting on a circumstellar shell (or disk) around the hotter star. More recently, W UMa systems have been linked with RS CVn-type stars (Hall 1976) in which the photometric disturbances often present are attributed to the presence of large subluminous regions (starspots) over their surfaces. The recent identification of VW Cep as an X-ray source (Carroll et al. 1980) and the detection of strong emission lines of CIV, HeII, NV and SiIV in the far UV spectrum of VW Cep by the I.U.E. satellite (Dupree et al. 1980), further appear to relate W UMa-systems to RS CVn binaries.

Despite the relatively large scatter in the $\alpha$-indices (introduced chiefly by the observational noise in the narrow-band data), a phase dependent variation in $\alpha$ is clearly present. As shown in Figure 1, the α-index has its largest numerical value of α=2.30 during mid-secondary eclipse. No significant variation in the α-index appears to be present during primary minimum or during the outside eclipse phases. Outside secondary minimum, the mean value of α lies between 2.24 and 2.27. A value of $\alpha \simeq 2.29 \pm 0.01$ is expected from the G5 $\pm$ K1(3) spectral types assigned to the components of VW Cep (e.g. Koch et al. 1970). Thus, at mid-secondary minimum the observed α-index appears appropriate for the assumed spectral types of the component stars, while outside the eclipse the α-index is too small. The smaller than expected value of α outside secondary eclipse can be explained by weak residual Hα emission observed at these phases. At secondary minimum (when the K component is partially eclipsed) the Hα emission appears to be absent, thus suggesting that the Hα emitting region is on, or closely associated with, the eclipsed star. Hα emission has also been observed in several RS CVn systems where it may arise from active regions on the stellar surfaces. A similar origin may be possible for VW Cep in which the asymmetries in the light curve as well as the behaviour of the α-index may be explained in terms of active regions on the surface of the cooler star.

Further Hα narrow- and intermediate-band photometry of VW Cep is planned. An extensive analysis of the observations is underway and will be published in the near future.

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