COMMISSION 27 OF THE I. A. U.
INFORMATION BULLETIN ON VARIABLE STARS
Number 2711

Konkoly Observatory
Budapest
24 April 1985

HU ISSN 0374 - 0676

STARSPOTS AND THE Mg II EMISSION OF VW CEPHEI

The idea that dark starspots make the more massive components of cool W UMa binaries appear cooler is an attractive explanation of light curves (Mullan 1975; Eaton, Wu, and Ruciński 1980; Eaton 1985). Observed light curves require the spots to be spread quite uniformly over one component of the system, a distribution that may show up in chromospheric heating. The chromospheric emission observed in the ultraviolet, however, seems to be practically independent of phase in several systems (Vilhu and Ruciński 1985; Ruciński, Vilhu, and Whelan 1985; Eaton 1985), and this might be taken to indicate that the active regions associated with spots are spread evenly over both components.

If evenly distributed spots are the cause of W-type light curves, we can predict their effects on chromospheric emission through analogy with RS CVn binaries. In the RS CVn system II Peg, Marstad et al. (1982) observed a particularly luminous active region that enhanced Mg II λ2800 emission by ~30% and transition-region emission by an order of magnitude. This region was visible when the star was faintest, as might be expected from the sunspot analogy, but Poe and Eaton (1985) find spots were visible at all phases, not just when the active region was in view. Further, the active region producing the enhanced emission was found by Marstad to cover only ~6% of the stellar surface, much less than the coverage by spots (Linsky 1984). This suggests that changes in the spot distribution act to excite strong active regions, probably by tearing closed magnetic flux tubes as spots move past one another. Further evidence for changing spot distributions producing the enhanced chromospheric and transition-region emission of active stars comes from a flare observed on UX Ari (Simon, Linsky, and Schiffer 1980). In this case the flare seemed to be associated with interaction of active regions on different components of the binary. Simon, Linsky, and Schiffer proposed that it is this sort of interaction that gives the episodic giant flares observed in RS CVn systems.

The importance of this result is that it predicts W UMa systems, which would have many relatively small spots being dragged about by differential rotation, should be literally covered with material producing strong chromospheric as well as transition-region lines. The bulk of the line emission should be confined to the spotted component. On the other hand, if most of the chromospheric emission does not come from such active regions (perhaps it comes from an enhanced chromospheric network), the surface flux in Mg II would not be especially elevated over the quiet phases of RS CVn binaries. We have already seen in SW Lac, which has the most extensive observations of any system studied to date, that Mg II surface flux is not highly correlated with phase (Eaton 1985). VW Cep, with a later spectral type and stronger Mg II emission, is an even better star to compare with II Peg.

We have used 30 IUE spectra of VW Cep, obtained at three different epochs as part of observing programs CBDJE and CBEJE, to investigate the Mg II emission. Emission strength is measured by an index formed by taking the ratio of average flux in a 22 Å band at 2799 Å to average flux between 2585 and 3200 Å (Mg II omitted), expressed as a magnitude difference. The ultraviolet continuum flux is roughly proportional to surface area, so the Mg II index is a measure of surface flux. Figure 1 shows the phase dependence of Mg II emission, which is very slight indeed. Not only is there little phase dependence, but the average level seems to be roughly constant from year to year. If we compare flux in the 22 Å Mg II band to flux at V, we get (MgII-V) ≈ 2.5. The

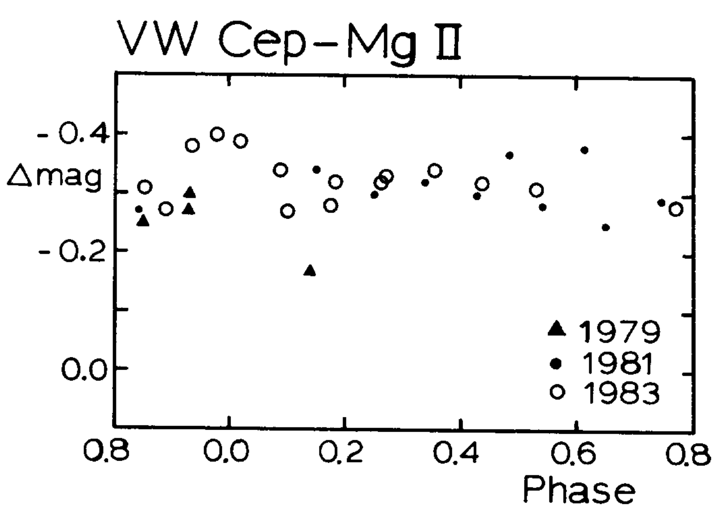

Figure 1. VW Cep: Strength of Mg II emission relative to average brightness of continuum between 2580 and 3200 Å. This is roughly a measurement of surface flux in the emission lines. Observations were obtained with the IUE satellite.

observations of II Peg by Marstad et al. yield (MgII-V) = 2.2 for epochs of weak emission. The cooler II Peg [(B-V) = 1.0, vs. 0.87 for VW Cep] has a larger bolometric correction by -0.4 mag, and (MgII-M_{bol}) for the two stars must therefore be equal. Differences in calibration noted, this equality of F(MgII)/F(bol) means that VW Cep is not covered with the very many strong active regions predicted for extensive numbers of starspots. Note also that Vilhu and Ruciński (1983) and Ruciński (1985) find that W UMa binaries are no stronger emitters of Mg II on the average than other late-type rapidly rotating stars.

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