THE UV SPECTRUM OF VV CEP.[x]

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Abstract

IUE spectra of VV Cep have been obtained in 1978 and 1979 during the chromospheric phase of the eclipse. The profiles of the Mg II resonance lines differ from one another and this peculiarity, common to other M type supergiants, is examined. The value of M_V derived from the extension of the Wilson and Bappu relation to Mg II lines is compared with other determinations. The variation of the absolute flux in the 1200-2000 Å range is presented.

Introduction

The last eclipse of the peculiar binary system VV Cep (P = 20.34 yrs) occurred in 1976-78. The long chromospheric eclipse phase has been covered spectroscopically both for ingress and for egress at the two main telescopes of the Haute Provence Observatory. The phenomena observed on these ground spectra down to 3300 Å are complex; some of the physical parameters of VV Cep determined up to now (e.g. the radii of the stars, the temperature of the secondary star) are still uncertain. No spectroscopic features that can be confidently related to the hot companion have been observed in the region 3300-7000 Å and in order to obtain more information on the chromospheric layers of the primary star and on the spectrum of the secondary VV Cep has been observed by IUE in 1978 and 1979. Two high resolution spectra covering the long wavelength region were obtained on July 31, 1978 and on March 13, 1979 respectively. The low resolution spectra obtained

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with the large aperture and covering the short wavelength range (1175-2000 Å) have been used mainly to determine the absolute flux of the star.

The high resolution spectra.

Due to the crowding of the lines only these two spectra could be used for line identifications. The spectrum in this region is complex, since both absorption and emission lines are present and a reliable continuum cannot be drawn. Most of the sharp absorption lines are chromospheric lines due to once-ionized metals and the general behaviour is very similar to that of the ground spectra in the region 3300-3600 Å at the same phase. The most interesting ions are Fe II, for which no UV lines can be observed from the ground and the two Mg II resonance lines.

The strongest Fe II lines are present as emission lines with a central absorption core, indicating that they, as the Mg II lines, are formed in the extended chromosphere.

The h and k lines of Mg II show the typical self-reversed profiles expected for chromospheric resonance lines. The two profiles are different from each other. The R/V ratio of the emission components in higher for λ 2795 than for λ 2802; the absorption core of λ 2795 is symmetrical and violet-displaced by about 0.25 Å with respect to the centre of the emission line, while the absorption core of λ 2802 is asymmetrical, having a red wing steeper than the violet wing, and at the bottom is centred on the emission component.

These peculiarities are not characteristics of only VV Cep; at least some of them are shared by other late-type supergiants. In α Ori (M2Iab) (Kondo et al., 1972), α Sco (M1Ib) (Bernat and Lambert, 1978) only λ 2795 shows asymmetric emission components, while λ 2802 is symmetric; the same is true for Boss 1985, another VV Cep system (Cassatella et al., 1979). On the other hand, in giant stars such as α Boo (K2III) Moos et al., 1974) and CH Cyg (M6III) (Hack, 1979) the two line profiles do not differ from each other.

The fluorescence mechanism in Fe I and Mn I lines through coincidences with Mg II resonance lines has been investigated by Bernat and Lambert (1976) and seems to offer the key to interpret the different profiles of Mg II lines in M supergiants. In fact the Fe I 4307 is weaker than expected from its f value compared to λλ 4271 and 4325 of the same multiplet 42 in the stars with different Mg II profiles investigated by Bernat and Lambert; from our ground spectra we can add that λ 4307 is weaker than expected also in VV Cep and Boss 1985 and it is of the expected intensity in CH Cyg where the two Mg II lines have the same profile.

The asymmetry of the absorption core of the h line present on both spectra of VV Cep at our disposal seems not to have been observed in other stars; we cannot say whether the fact that the profile is more complex than those of other supergiants observed by Copernicus is due to an unidentified peculiarity of VV Cep or to the higher resolution of IUE or on the other hand to an instrumental effect since the h line is at the edge of two echelle orders of IUE.

It is well known that a relation between the line widths and the absolute visual magnitude can be derived from Mg II lines in analogy to the Wilson and Bappu relation derived from the Ca II lines. The calibration of this relation for Mg II is still improvable; some discrepancy exists between the calibration by different authors mainly as regards the most luminous stars. Moreover we can surmise that in VV Cep these lines are variable with phase as is the Ca II K line; in fact no M value could be derived from K line by Wilson (1976) for VV Cep. Finally we have at our disposal only two UV spectra taken during the chromospheric phase of the eclipse, and owing to all the above-mentioned uncertainties not much weight can be assigned to the M_V derived from the Mg II emission widths. Neverthless, using the M_V versus log W relation by McClintock et al. (1975), a value of $M_V = -4.3$ is derived from the mean value of the lines on both spectra; using the most recent relation of Weiler and Oegerle (1979) a value of $M_V = -4.9$ is derived from the K line. A value of $M_V \simeq -4$ is derived from the Ca II K line measured on a spectrum taken during the totality. We can compare these values with the most recent determination of the absolute magnitude of VV Cep, $M_V = -4.0$, obtained by van de Kamp (1977) from a long series of astrometric measures.

The low resolution spectra.

The flux distribution derived from the three low resolution spectra of the short wavelength region is not the same on the three spectra and the increase of the mean flux for $\lambda > 1450$ Å between the June and July 1978 spectra had been interpreted as due to the progress of the eclipse (Faraggiana and Selvelli, 1979). However the next spectrum, obtained on March 1979, shows unexpectedly that in the same region the mean flux decreased to the value of June 1978 except in the range 1450-1620 Å where it is slightly higher on the more recent spectrum. In the region below $\lambda = 1420$ Å the mean flux is about the same on the three spectra; the only remarkable difference is a steadily incresing absorption feature at $\lambda = 1300$ Å; OI 1302.174 or, more probably, the blend of Si III Mult. UV 4 is responsible for it.

In the region around 1800 Å the strong emission lines visible on the first spectrum are filled up by the increased continuous emission on the next spectrum and are dominant again on the last spectrum, where unfortunately crosses on the tracing indicate the poor quality of the data.

The mean flatness of the spectrum on the whole range does not have a counterpart in theoretical models or on the observed S2/68-spectra of any normal star. The VV Cep spectrum is probably highly distorted by the presence of variable emissions not directly related with the phases of the eclipse.

At this stage we are not able to choose between the various ways of explainig the observed flux distribution; for example it might be due to the contribution of the secondary star distorted by an envelope surrounding it as well as by the envelope surrounding the whole system and responsible for the forbidden emission lines on the ground spectra, or to high and not homogeneous layers of the chromosphere of the primary and to the large envelope.

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COMMENTS FOLLOWING FARAGGIANA

Milone: The difference in asymmetry between the Mg II H and K lines is also seen in the NRL echelle (solar) atlas data. (We also worried about whether this was real. These features were reduced to ∿0.030Å but the spectrum was "holey" and had much scattered light.)-- This wasn't said but probably should have been!

Faraggiana: I am glad to know that different stars observed with different instruments still show the same "error"--It makes us confident that the "error" is in the stars.

Stencel: You found M_V = -4.2 which is somewhat underluminous for an M supergiant--what causes this?

New M_V correlations should be checked: Weiler & Oegerle (Astrophys. J. Suppl. 39, 1979) have re-evaluated M_V-log W_o(Mg II) with seventy Copernicus spectra and improved on all earlier estimates; Stencel (Astrophys. J., 215, 1977) has provided an additional M_V-log W_o relation for the H-K wing emission lines among cool evolved stars. Also, I have checked Weiler-Oegerle against Wilson-Bappu with IUE for 50 cool stars and find agreement to $\pm 0^m.7$ which is close to the $\pm 0^m.5$ error of each separate correlation.

Faraggiana: The value I quoted has been derived using Weiler and Oegerle relation following the suggestion you gave me two days ago. Even in this case the most luminous stars deviate from the mean relation. I can say that: 1) The value derived for VV Cep is a lower value of the luminosity owing, as I said, to the presence of the underlying continuum of the hot companion; 2) A large difference between h and k profiles is observed in M supergiants and is absent in M giants. VV Cep which shows a small difference between the two profiles may have an intermediate luminosity.