HOT WIND IN THE DOUBLE DEGENERATE SYSTEM AM CVn

J.-E. SOLHEIM
Institute of Mathematical and Physical Sciences
University of Tromsø, Norway

and

O. KJELDSETH-MOE
Institute of Theoretical Astrophysics
University of Oslo, Norway

ABSTRACT

The close binary system Am CVn consists of two helium white dwarf stars in close orbit. Strong flickering in the optical light curve and the observed spin-up in the rotation period indicate that mass transfer takes place (Solheim et al., 1984). The optical spectrum shows broad helium absorption lines (Robinson and Faulkner, 1975) sometimes partly filled in by emission (Voikhanskaya, 1982). The optical spectrum shows no sign of hydrogen, and the line profiles are interpreted as due to an accretion disk of intermediate angle of inclination with a temperature of the order of 20.000 K (Robinson and Faulkner, 1975). Another possibility is direct accretion onto a magnetized BD white dwarf (Voikhanskaya, 1982). In the latter case a magnetic field $B \approx 10^6$ to 10^9 gauss is needed. Voikhanskaya also reports significant changes in the absorption line profiles from 1978 to 1980.

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Data and Reduction

In this communication we report some results from an analysis of IUE data taken at low resolution with the short wavelength camera in 1978, 1979 and in 1983. The system has been observed 4 times, and data for the exposures are given in Table 1.

Table 1. IUE SHORT WAVELENGTH CAMERA OBSERVATIONS OF AM CVn

Obs	Date	Exp. no.	Exp. time minutes	Observer
I	16.03.1978	SWP 1673	60	Greenstein
II	05.01.1979	SWP 3807	50	Greenstein
III	30.12.1979	SWP 7503	60	Greenstein
IVa	23.03.1983	SWP 19545	120	Solheim
IVb	23.03.1983	SWP 19546	60	Solheim

The IUE images have been reduced using the Starlink reduction programs. New spectra have been extracted for all four observing occations. The Ly-alpha line of hydrogen, being geocoronal, has been removed from the data. Other "gaps" are caused by the presence of reseau marks. Gaussian profiles have been fitted to the observed spectral lines. In the case of resonance multiplets we have assumed that the optically thin ratios apply to the relative intensities of the components. The fitted profiles have been used to estimate line shifts, widths and intensities.

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Obviously the results obtained may depend to some degree on the model assumption for the reduction. For the simple multiplets of N V and C IV and for the He II line this dependence is not strong and the measured line parameters are fairly reliable. Difficulties in determining the local continuum accurately may, in extreme cases, lead to a 25 % uncertainty in the measured equivalent widths. Results for the Si IV and Si III lines are even more uncertain and it is sometimes difficult to make good fits. This may be caused by possible blends from multiplets of O IV ans S IV which have a number of lines between 1397 Å and 1417 Å. The presence in the spectra of the Si III line at 1417 Å is also uncertain.

Observations

The full spectra are reproduced in Figure 1. The two earlist spectra (I and II) show a flat continuum flux, $f_\lambda \propto \lambda^{-2.3}$, with a hot source, perhaps the boundary layer, seen below 1200 A. The two last spectra (III and IV) are consistent with $f_\lambda \propto \lambda^{-2}$, which is typical for steady state disks, and with no steepening in the far UV. Apparently a change in the continuum took place sometime in 1979. Considerable changes in the spectrum of AM CVn are not unknown from other observations. Thus Voikhanskaya (1982) observed completely different line profiles in visual spectra taken in March and June 1980.

Several absorption features are present in the spectra in Figure 1. Only the resonance lines of N V, Si IV and C IV and the 1640 Å line of He II are identified with certainty. We have not been able to find any of the

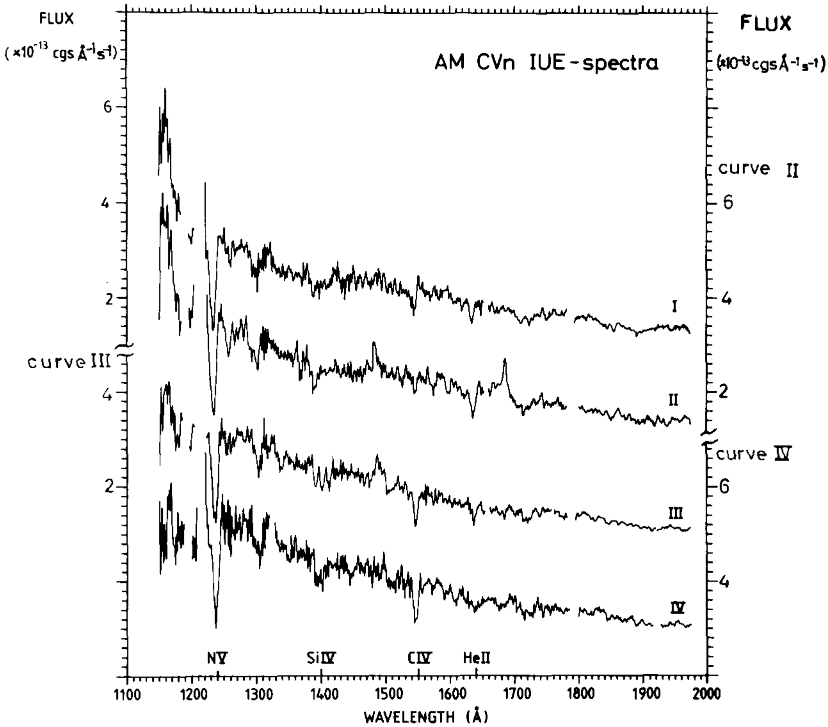

Figure 1. IUE low resolution short wavelength spectra taken on four occations between March 1978 and March 1983. Roman numerals refer to the observing dates in Table 1. The geo-coronal Ly-alpha line and data point falling on reseau marks have been removed.

other lines suggested by Greenstein and Oke (1982). Furthermore, a clear absorption feature around 1720 Å cannot be identified. The nearest line given by Greenstein and Oke, the N IV line at 1712 Å, is not a reasonable identification.

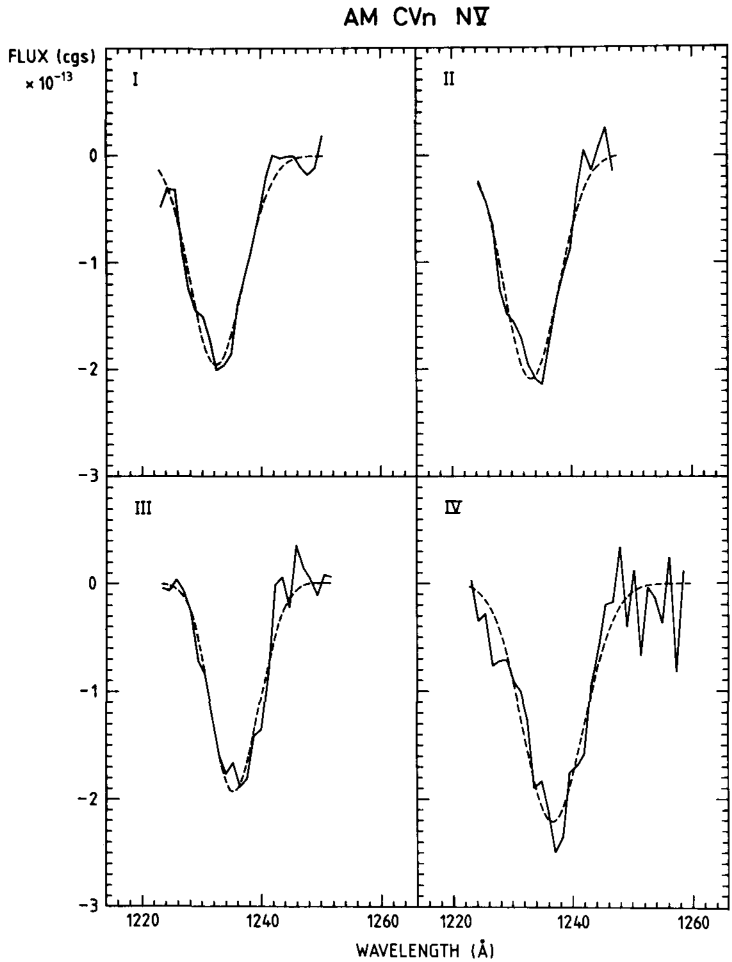

Figure 2. Data and Gaussian fits for the N V resonance doublet at 1240 Å. The Ly-alpha geocorona line makes the profile uncertain on the short wavelength side.

The detailed observed line profiles are shown in Figures 2-5, together with the best fits to the profiles. The fluxes on the ordinate axes are in units of 10^{-13} erg cm^{-2} s^{-1} $Å^{-1}$ with the zero value referring to the local continuum flux.

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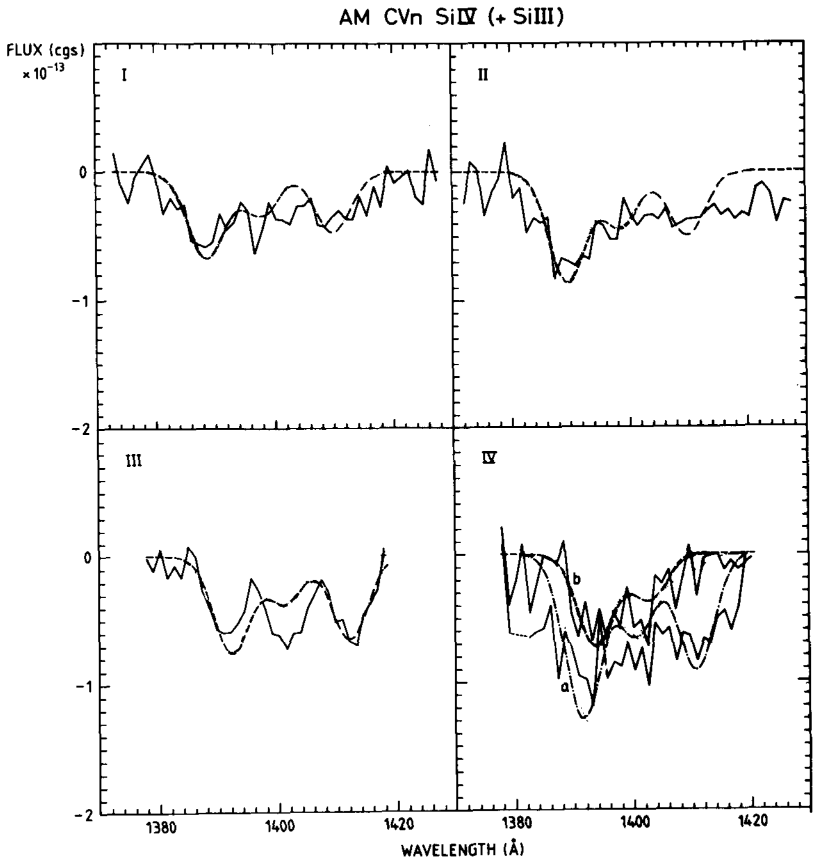

Figure 3. Data and Gaussian fits for the Si IV resonance doublet at 1400 Å and the Si III line at 1417 Å (multiplet UV 9). It is uncertain whether the Si III should be included in the fit.

All the lines have blue shifted cores with equivalent velocities ranging from 200–400 km s^{-1} to 1800 km s^{-1}. The shifts varies strongly from line to line and between the various observations, but the N V lines give consistently the highest velocities. The C IV, Si IV and He II lines have smaller and more similar velocities. Observed edge velocities varies from 2000 to 4000 km s^{-1}, which is well below the escape velocity for a solar

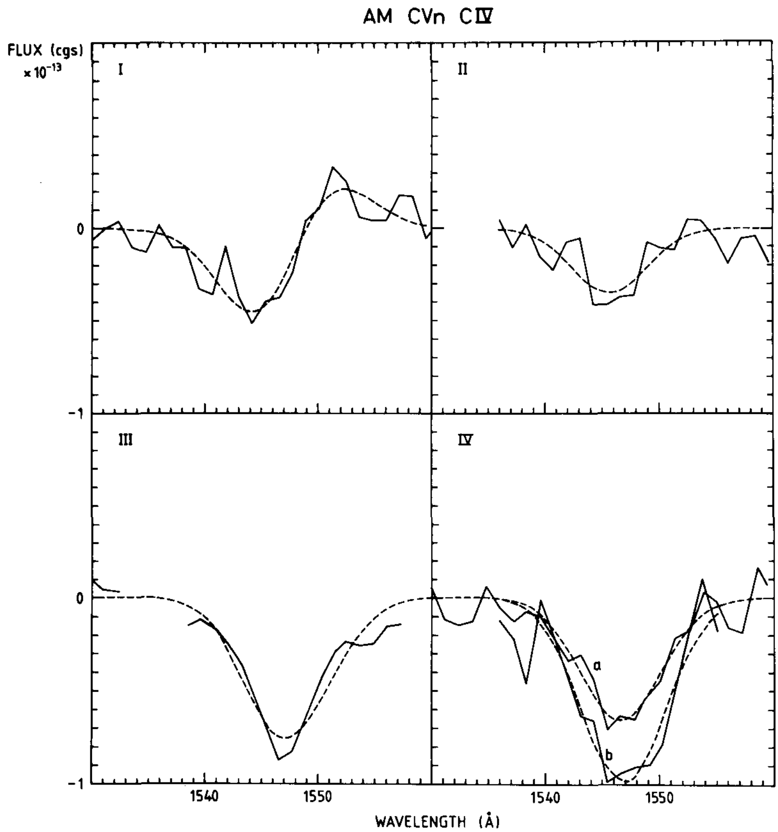

Figure 4. Data and Gaussian fits for the C IV resonance doublet at 1550 Å.

mass white dwarf. However, the estimates of the edge velocities may be uncertain because of the limited spectral resolution of the IUE.

The low spectral resolution also limits our determination of the line widths. The fitted lines have widths in the range 6 Å to 9 Å which cannot be distinguished from the instrumental width. However, the measured values clearly places an important limit on the velocity variation inside the emitting region. The transition zone lines in the UV are clearly not from

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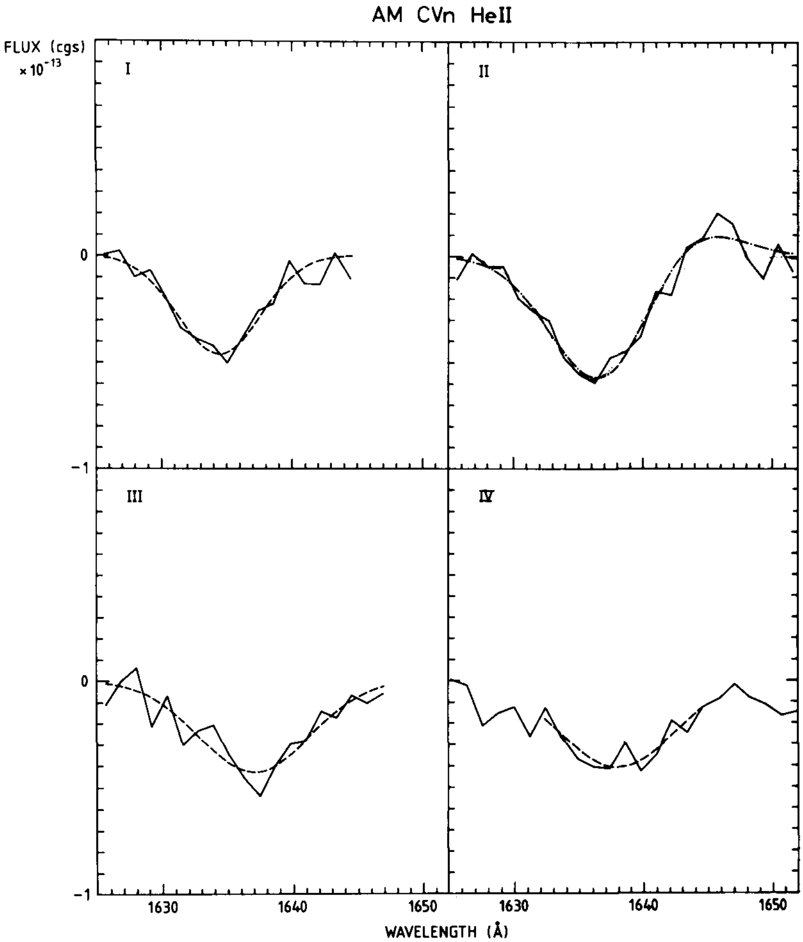

Figure 5. Data and Gaussian fits for the He II Ba-alpha line at 1640 Å .

the same source as the helium lines in the visible which according to Robinson and Faulkner (1975) have widths approaching 100 Å. This indicates that the UV lines do not come from a rapidly rotating accretion disk.

The strengths of the lines show variations. The N V lines are the stron-

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gest with central blue shifted absorption depths down to 0.4 - 0.6. The other lines are considerably shallower with central absorption depths in the range 0.15 - 0.4. This agrees with the computational results of Drew (1986) who finds that the depth of the blue shifted absorption should not exceed 0.5. The equivalent widths for N V have a small variation between 6 Å and 8 Å. The equivalent widths for the other lines vary considerably with factors of 2 to 4 between the various observations. Thus, the C IV lines have equivalent widths ranging from 1.2 Å to 4.3 Å. The variations for the C IV and N V lines appears correlated, while He II is anti-correlated with N V and C IV.

We find evidence of a P Cyg emission feature to the red of the absorption only on two occasions, in C IV in spectrum I (Figure 4) and He II in spectrum II (Figure 5). The emission is very weak and may be considered marginal. This disagrees with Greenstein (1979) who finds strong P Cyg emission in a number of lines in the same spectra.

Perhaps the most interesting result of the observations are the strong variability of the UV spectrum of AM CVn. This has already been pointed out for the continuum where the slope of the flux is changing in 1979 between observations II and III. As noted above the lines also show variations. Particularly interesting are the variations between the two last observations, IVa and b, which took place only 3 hours apart. The strong change in the spectrum around the Si IV lines and the C IV lines are likely to be real. Future investigations of short term variability are therefore of great interest and a start will be made with our next observations of AM CVn with IUE scheduled for 1987, where we plan phase resolved observations.

Discussion

We conclude that the far UV lines are formed in an optically thick wind seen against a bright disk. From comparison with theoretical line profiles (Mauche and Raymond, 1986; Drew, 1986) we suggest that a model with a hot wind originating from the polar region of the accreting star and observed in front of the bright disk, may explain the observations. The inclination of the system may be 30 degrees or less in order to explain the shape of the absorption lines. This conclusion is reached from comparing the marginal P Cyg emission feature with the calculations of Mauche and Raymond. The variation in line depths and in the blue shifts may be explained by a gusty wind and changing geometry of the wind flow pattern. The wind pattern may change on time scales as short as a few hours.

Acknowledgements

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