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Whole Earth Telescope observations of the interacting binary white dwarf V803 Cen in its low state

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SUMMARY

Using a network of observatories in the southern hemisphere, high-speed photometry of the interacting binary white dwarf (IBWD) V803 Cen in its low state is presented. Because of the faintness of the system, the 1611-s oscillation, reported in previous studies when V803 Cen was near maximum, was difficult to distinguish from the noise in many of the individual high-speed photometric runs; it was, however, unambiguously detected in combinations of runs. No evidence for the presence of either its harmonics or the previously observed 175-s oscillation was found. Low-state optical spectroscopy of V803 Cen confirmed the presence of weak He emission lines which had been suspected in an earlier study. The line profiles showed evidence of doubling, typical of an accretion disc, and varied in strength, possibly correlated with system luminosity. The breadths of the emission lines were similar to those of the He absorption lines seen near maximum, suggesting that the same mechanism, Stark broadening, is responsible. The He emission-line strengths indicate that the lines are optically thick and their weakness at times suggests that the continuum is nearly optically thick; the construction of detailed hydrogen-deficient disc models to account for these properties is urged.

1 INTRODUCTION

The Whole Earth Telescope (Nather 1989) is a collaboration by astronomers at several institutions to obtain contemporaneous high-speed photometry of rapid variable stars from several observatories in both hemispheres. The aim is to obtain the maximum amount of information from time-series data by obtaining as near continuous coverage as possible on selected objects for many days or even weeks at a time. In this way, among other advantages, the aliasing ambiguities which confuse the analysis of data strings with gaps should be avoided or greatly reduced. In this paper the results of the first observing campaign in this project are reported for the interacting binary white dwarf V803 Cen.

Previous papers (O'Donoghue, Menzies & Hill 1987; Wood *et al.* 1987; O'Donoghue & Kilkenny 1989) have discussed the basic properties of the stars PG 1346+082 and V803 Cen: briefly, both systems show erratic luminosity variations of as much as 4 mag on a time-scale of days or less and much more rapid variations with a period between 1000 and 2000 s and an amplitude of a few per cent. The short-period variations possess a rich harmonic structure and there is evidence for other short periodicities as well (e.g. 175 s in V803 Cen). The spectra of these stars, when they are near maximum brightness, are characterized by broad, shallow He I absorption lines but these are replaced by a continuous spectrum (or perhaps weak He I emission lines) when the stars are near minimum brightness. These properties are similar in most respects to those of AM CVn (Solheim *et al.* 1984) except that the latter star does not exhibit large changes in luminosity. An interacting binary white dwarf (IBWD) model, in which an extremely low-mass white dwarf ($\sim 0.02\,M_{\odot}$) with a helium envelope fills its Roche lobe and transfers mass via an accretion disc on to another white dwarf, has been proposed to explain the properties of these three stars by Faulkner, Flannery & Warner (1972), Wood *et al.* (1987) and O'Donoghue & Kilkenny (1989).

If this model is correct, the orbital period of these systems could be as short as 1000 s. As a result, previous workers have proposed that the 1050-s period in AM CVn (Solheim *et al.* 1984), the 1490-s period in PG 1346+082 (Wood *et al.* 1987) and the 1611-s period in V803 Cen (O'Donoghue & Kilkenny 1989) (which we will call by the generic name '10^3-s oscillations') are equal or close to the orbital periods of the systems. However, no compelling evidence exists to show what the orbital periods of these systems are and the physical mechanism responsible for the 10^3-s oscillations has not been identified although a number of possibilities are discussed in the cited references. In order to investigate the nature of these (and other) periods in these systems, an extensive program of high-speed photometry of PG 1346+082 and V803 Cen was scheduled at several observatories in both hemispheres in 1988 March. Optical spectroscopy was also obtained as well as ultraviolet observations with the *IUE* satellite (which latter will be reported elsewhere). This paper reports the optical data obtained for V803 Cen. A preliminary report on the photometric data set acquired for PG 1346+082 has been published by Provencal *et al.* (1989).

2 OBSERVATIONS

2.1 Photometry

High-speed photometric observations were obtained in 1988 March with the 1.0-m reflector at the South African Astronomical Observatory (SAAO); with the 1.6-m reflector at the Laboratório Nacional de Astrofísica (LNA); with the 1.5-m reflector at Cerro Tololo Inter-American Observatory (CTIO) and with the 1.9-m and 1.0-m reflectors at Mount Stromlo and Siding Spring Observatories (MSSSO), all equipped with two-star photometers (Nather & Warner 1971) (the second channels at LNA and SAAO were inoperative). An observing log appears in Table 1. All observations were made in 'white light' with a variety of photomultiplier tubes listed in the note to Table 1. With the exception of the data obtained at LNA, where an S-20 cathode with an extended red response was used, these tubes were blue-sensitive yielding an effective wavelength close to that of a Johnson *B*-filter. V803 Cen was inaccessible to the northern hemisphere sites participating in the campaign: McDonald Observatory, Mauna Kea Observatory and Haute Provence Observatory.

The data were reduced by subtracting the sky background and correcting for extinction using a mean extinction coefficient. Residual low-frequency trends were removed from the light curve by normalizing by a linear or, if necessary, higher order polynomial fitted to it by least squares. The mean brightness of the object during the run was found by comparing the count rate with that obtained from observations of nearby standard stars; the results are listed in the final column of Table 1. Owing to low-frequency drifts in the

Table 1. Journal of high-speed photometry.

Run	Observatory	Date & Time (UT)	HJD start 2440000+	Sampling Time (s)	Length (hr)	Mean B mag ±0.1
S4224	SAAO	11 3 88 0 25 40	7231.52130	10.0	2.8	13.7
A9	MSSSO	12 3 88 12 7 52	7233.00903	10.0	.6	17.0
S4226	SAAO	12 3 88 21 19 31	7233.39215	10.0	.9	17.5
RA104I	LNA	13 3 88 3 55 20	7233.66703	10.0468	1.2	
RA104II	LNA	13 3 88 5 9 51	7233.71879	10.0468	.6	
RA104III	LNA	13 3 88 5 48 52	7233.74588	10.0446	.5	
RA104IV	LNA	13 3 88 6 29 2	7233.77378	10.0446	.5	
TOL-16	CTIO	14 3 88 2 23 0	7234.60297	10.0	1.6	17.0
RA106	LNA	14 3 88 2 57 18	7234.62679	10.0439	4.6	
TOL-18	CTIO	14 3 88 6 55 0	7234.79187	10.0	2.5	16.9
A13	MSSSO	14 3 88 11 54 0	7234.99952	10.0	1.4	16.9
S4229	SAAO	14 3 88 21 55 0	7235.41691	10.0	5.3	17.0
TOL-21	CTIO	15 3 88 1 12 0	7235.55372	10.0	1.8	17.0
RA107	LNA	15 3 88 1 59 23	7235.58663	10.0454	4.0	
TOL-23	CTIO	15 3 88 5 49 0	7235.74609	10.0	3.5	16.9
A18	MSSSO	15 3 88 11 38 0	7235.98847	10.0	2.8	17.0
S4232	SAAO	15 3 88 21 25 30	7236.39648	10.0	5.7	17.0-16.4
S4234	SAAO	16 3 88 21 33 10	7237.40186	10.0	1.2	17.3
A20	MSSSO	17 3 88 12 16 10	7238.01509	10.0	1.7	
S4237	SAAO	17 3 88 20 34 0	7238.36082	10.0	1.6	17.3
A22	MSSSO	18 3 88 12 9 0	7239.01016	10.0	.2	
S4242	SAAO	19 3 88 20 50 40	7240.37250	10.0	1.1	17.3
S4245	SAAO	20 3 88 20 46 30	7241.36966	10.0	1.1	17.2
S4249	SAAO	21 3 88 20 57 20	7242.37724	10.0	1.4	16.9
S4252	SAAO	22 3 88 20 48 20	7243.37104	10.0	1.4	13.6-13.7

Note: Runs A9, A13 and A18 were obtained with the 1.0-m at Siding Spring and Runs A20 and A22 were obtained with the 1.9-m at Mt. Stromlo. Photomultiplier tubes used were: an Amperex 56 DVP at SAAO, an RCA 8852 at CTIO, an EMI 9658ER at LNA and an EMI 9840A in Australia.

sensitivity of the photomultiplier tube, this procedure could not be applied to the data obtained at LNA which were therefore only used to search for high-frequency variability.

2.2 Spectroscopy

All the spectra were obtained with the Reticon detector (Glass 1982) attached to the image tube spectrograph on the 1.9-m reflector at SAAO. As V803 Cen was faint for much of the observing period, most of the spectra were obtained at low dispersion (210 Å mm^{-1}) with grating 1 which covers the range 3300–7300 Å with a resolution of about 8 Å (FWHM). Grating 6, which has dispersion, wavelength coverage and resolution values of 100 Å mm^{-1}, 3400–5400 Å and 4 Å respectively, was also used. A journal of the observations appears in Table 2. The object was detected using both arrays of the Reticon detector to average out sensitivity differences. A Cu–Ar arc calibration lamp was observed about every 20 min and flat-field calibration spectra were obtained at the beginning and end of each night. Although spectrophotometric standard stars were observed, it was found that the resulting instrumental sensitivity calibration contained spurious 'turnovers' in the ultraviolet, probably resulting from a wavelength-dependence in the light losses due to the use of a narrow slit; the final reduced spectra were therefore left in counts and not converted to fluxes.

The spectra were reduced using standard techniques: pixel to pixel variations in the Reticon arrays were removed by dividing by the flat-field spectrum. The wavelength calibration was defined by fitting a fifth-order polynomial to the comparison arc spectra; this calibration was used to resample the arrays at equal wavelength intervals. Finally, the array containing the sky spectrum was subtracted from that containing the object.

3 PHOTOMETRIC RESULTS

Observers participating in the global network were informed which star to observe at the beginning of each nightly observing session by controllers who coordinated the network from the University of Texas at Austin. This allowed observatories at the same longitude to observe different targets depending on local weather conditions. As PG1346 + 082 is accessible from both hemispheres, it was decided that this star would be the highest priority target. V803 Cen was therefore observed only when a southern site was not required to observe PG1346 + 082. As a result, a rather limited data set was acquired (Table 1) in which substantial coverage was obtained only during a two-day period (runs TOL-0016 to S4232). Most of the data are shown in Fig. 1; the last section of the data set was omitted from Fig. 1 because all these runs (S4234–S4252) were short – no longer than about 1.5 hr.

As can be seen from Table 1, there were substantial changes in mean brightness of the system among the different runs. In the first and last runs (S4224 and S4252), the system was near maximum. With the exception of these two runs, it was close to 17th mag every time it was observed. This behaviour is in contrast to that reported previously (Elvius 1975; O'Donoghue *et al.* 1987; O'Donoghue & Kilkenny 1989) in which the system appeared to be at or near maximum most of the time. No systematic long-term monitoring of the system is available.

Significant changes in luminosity were found in two runs: an increase in brightness of more than 50 per cent took place during the course of S4232 while a decline in brightness of about 20 per cent occurred in S4252 (note that linear trends were removed from each run before plotting it in Fig. 1).

The data in Fig. 1, excluding S4224 and S4252, are the first light curves of V803 Cen in the faint state to be published. The previous studies of the rapid variability of V803 Cen (O'Donoghue *et al.* 1987; O'Donoghue & Kilkenny 1989), when it was almost always at or near maximum, found it to be periodically variable with a low amplitude (~few per cent) and periods near 1611 s (and its harmonics) and 175 s. We searched for these and any other periods by calculating Fourier amplitude spectra of all the runs. All these spectra were flat from 5 to 50 mHz. At lower frequencies (< 5 mHz), the spectra showed an increase in power with peaks of a few per cent in semi-amplitude resulting from the variability apparent in Fig. 1. The 1611-s period was only clearly distinguishable from other low-frequency peaks in the amplitude spectra of runs S4229, TOL-0023 and the short runs S4237 and S4249. In other runs, there

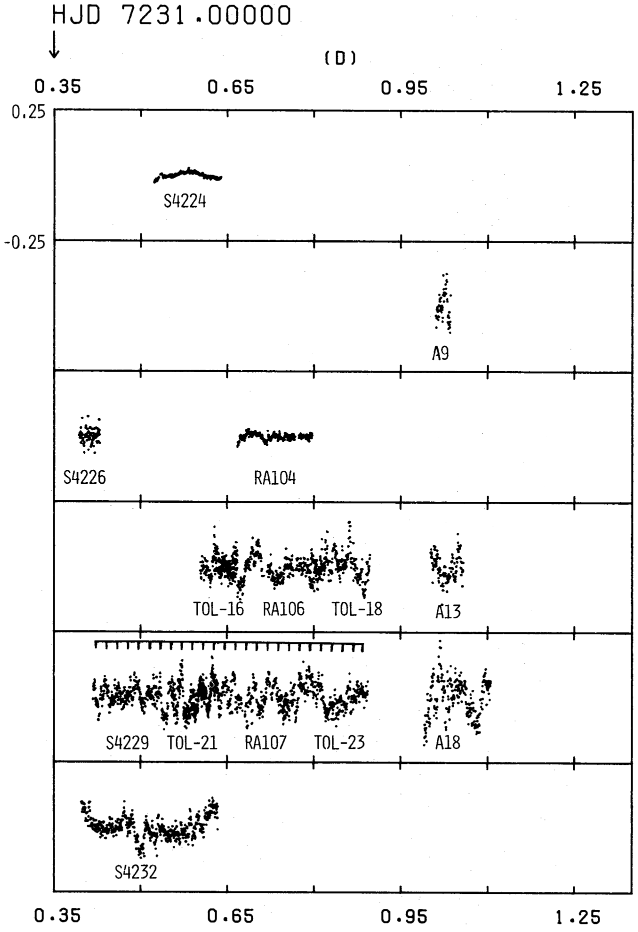

Figure 1. A plot of the first part of the data set listed in Table 1. Run numbers are indicated below the corresponding light curve. The abscissa is fractional Heliocentric Julian Date. The ordinate is in units of the mean brightness during the run, the corresponding *B* magnitude of which appears in Table 1. The ordinate in each frame spans half the mean brightness of the star during each run. The original data were summed into 40-s bins to yield the plotted points.

was a peak of semi-amplitude ~2 per cent near 1611 s in the amplitude spectrum (e.g. runs TOL-0021 and RA107) but there were also other peaks nearby of comparable or greater amplitude. In the amplitude spectra of runs S4226, RA104 and S4232, there was no peak near 1611 s exceeding 1 per cent. The 1611-s period was absent during the maximum light runs S4224 and S4252 with a much more stringent limit of 0.2 per cent. It is interesting to note that the semi-amplitude of the 1611-s oscillation in the data sets of O'Donoghue *et al.* (1987) and O'Donoghue & Kilkenny (1989) was less than 5 per cent. As the system was near maximum light in these data sets, we can say that the absolute semi-amplitude of the oscillation in the low-stage data presented here was much lower, although the relative amplitude could be comparable.

A Fourier amplitude spectrum, calculated for runs S4229, TOL-0021, RA107 and TOL-0023 combined, is shown in Fig. 2 and establishes the presence of the 1611-s period in these data. The resulting mean period for these runs, 1609 ± 8 s, was fitted to the data by least squares and the resulting times of maxima are indicated by the scale in the fifth panel of Fig. 1. The irregular character of the oscillation in the section of the data set can be appreciated by noting the 'missing' maxima and stretches of data when the oscillation is not readily visible at all.

No harmonic of the 1611-s oscillation or the 175-s oscillation nor any other coherent period was detected in the data listed in Table 1.

The cause of the variations in the data plotted in Fig. 1, which cannot be attributed to the 1611-s period, is of some interest. These variations are most easily seen in S4232 (during which the 1611-s period was not positively detected) and are of large amplitude (exceeding 20 per cent peak-to-peak) and low-frequency (note that the carets in Fig. 1 are spaced at intervals of 3.6 hr). We suspect that these variations are intrinsic to V803 Cen, analogous to the 'flickering' seen in the hydrogen-rich cataclysmic variables, but unfortunately we cannot be sure. The reason for this is that the faintness of V803 Cen in its low state resulted in an equal or greater contribution from the sky background to the total counts detected by the photomultiplier tube with the various combinations of diaphragm and telescope aperture used to acquire the data. As the sky background was not sampled continuously, it was not possible to exclude the sky as the cause of the variations in Fig. 1, so the detection of flickering in V803 Cen in its low state must be regarded as tentative. Note that if this non-periodic variability in V803 Cen in the low state is confirmed, it occurs on a longer time-scale (~20 min) than is typical in many hydrogen-rich cataclysmic variables.

3 SPECTROSCOPIC RESULTS

As can be seen from Table 2, two, or occasionally three (where an exposure in each Reticon array is counted 'one' spectrum), spectra of V803 Cen were obtained each clear night during the observing campaign. No significant differences were found among the spectra obtained on the same night so they were summed together to produce a mean spectrum for each night. With the exception of the data obtained on 1988 March 10/11, when the system was brighter than 14th mag and the spectrum showed broad, shallow He I absorption lines very similar to those seen by O'Donoghue & Kilkenny (1989), all the spectra were obtained when V803 Cen was near 17th mag; these spectra will be called 'low-state' spectra. The signal-to-noise ratios of the summed low-state spectra for each night were much better than that of the noisy low-state spectrum illustrated in fig. 1 of O'Donoghue & Kilkenny (1989) and emission lines could be seen in each of them. The sum of all the low-state spectra is plotted in Fig. 3 and shows a blue continuum on which moderately broad, weak emission lines are superposed. In addition to the easily identified lines of He I: $\lambda\lambda$ 3867/3888, 4023/4026, 4121/4143, 4387, 4471, 4921, 5015, 5047, 5875 Å and He II λ 4686 Å, we believe that He I $\lambda\lambda$ 6678 and 3819 Å are present as well as λ 4713 Å in the red wing of He II λ 4686 Å. These lines are attributable to a single element, helium, but we suspect the presence of an emission complex just longward of λ 4471 Å and find that the wavelengths of the two most prominent features here are 4550 ± 4 and

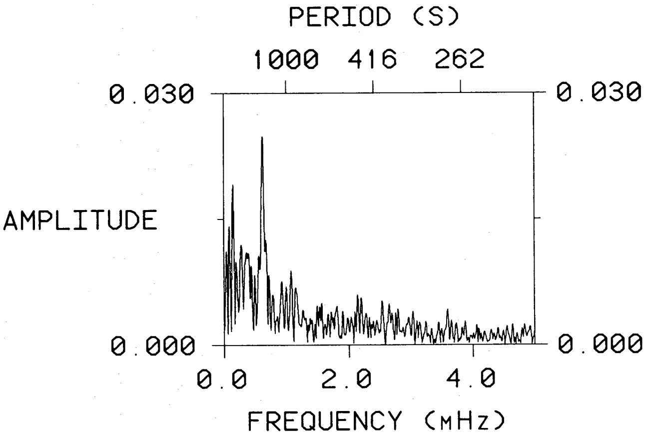

Figure 2. Fourier amplitude spectrum of runs S4229, TOL-21, RA107 and TOL-23 combined. The ordinate is in the same units as Fig. 1.

Table 2. Spectroscopic observing log.

Date 1988 March	Start Time (UT)	Exposure Time (s)	Grating
10/11	23:53	1250	1
	2:18	2400	6
12/13	22:16	2400	1
	23:04	2400	1
	2:36	2000	1
15/16	2:17	1800	1
	2:54	1800	1
16/17	22:08	2400	1
	22:55	2400	1
17/18	22:22	2400	1
	23:08	2400	1
19/20	21:20	2400	1
	22:07	2400	1
21/22	19:58	2400	1

4518 ± 4 Å. There also appears to be a narrow absorption feature between λλ 4921 and 5015 Å near 4957 ± 4 Å. In view of the weakness of these features, we are reluctant to suggest any identifications for them. In confirmation of previous studies (Elvius 1975; Westin 1980; O'Donoghue *et al.* 1987; O'Donoghue & Kilkenny 1989), no hydrogen is detectable in any of the spectra.

We suspect that some of the emission-line profiles are on occasion doubled. The λ 5875 Å profile in Fig. 3 is clearly 'flat-topped', as though consisting of two emission peaks with a weak absorption trough in between. Although noisier, there is evidence for the same effect, especially in the λ 4471 Å profile, on some of the individual nights.

There were significant differences in the strengths of the emission lines from night to night. In particular, the emission lines were only marginally visible on the nights of March 15/16 and 21/22. Inspection of Table 1 shows that V803 Cen was slightly brighter on these nights than on the other nights when low-state spectra were obtained. In order to obtain a quantitative estimate of the differences from night to night, full widths at half maximum (FWHM) (uncorrected for instrumental broadening) and equivalent widths (EW) were measured by fitting Gaussian profiles to all the unblended, or partially blended lines with sufficient signal-to-noise. The same procedure was carried out using the sum of all the low-state spectra shown in Fig. 3; the results appear in Table 3. Missing values in Table 3 arise from lines which are either too weak to measure (e.g. all lines in the spectra from 1988 March 15/16 and 21/22) or are hopelessly blended (e.g. λλ 4121/4143 or 4023/4026 Å). It is interesting to note that the FWHM and EW of the reliably measured lines such as λλ 4921, 4471 and 4387 Å are very similar to the values for the corresponding absorption lines discussed in the study of O'Donoghue & Kilkenny (1989). The other lines measured were either not included in the wavelength coverage of O'Donoghue & Kilkenny (1989) (e.g. λ 5875 Å) or are too badly blended or too weak to permit a comparison.

Finally, each of the low-state spectra for the individual nights was cross-correlated with the spectrum in Fig. 3 to search for radial velocity variations (details of this procedure are given in O'Donoghue & Kilkenny 1989). No significant variations were found exceeding about 40 km s^{-1}.

4 DISCUSSION

The photometric and spectroscopic results described in the previous two sections, which define the properties of V803 Cen in the lowest luminosity state of which we are aware, support the interacting binary nature of the system. This is not a trivial point as the unambiguous signatures of binarity (periodic radial velocity variations or eclipses in the light curve) have not so far been detected in V803 Cen (O'Donoghue & Kilkenny 1989). The tentative detection of short time-scale, aperiodic variability in the light curve (Fig. 1), if confirmed, is a signature of mass transfer in a close binary and the spectral changes in the system, from emission lines at minimum to absorption lines near maximum, are a

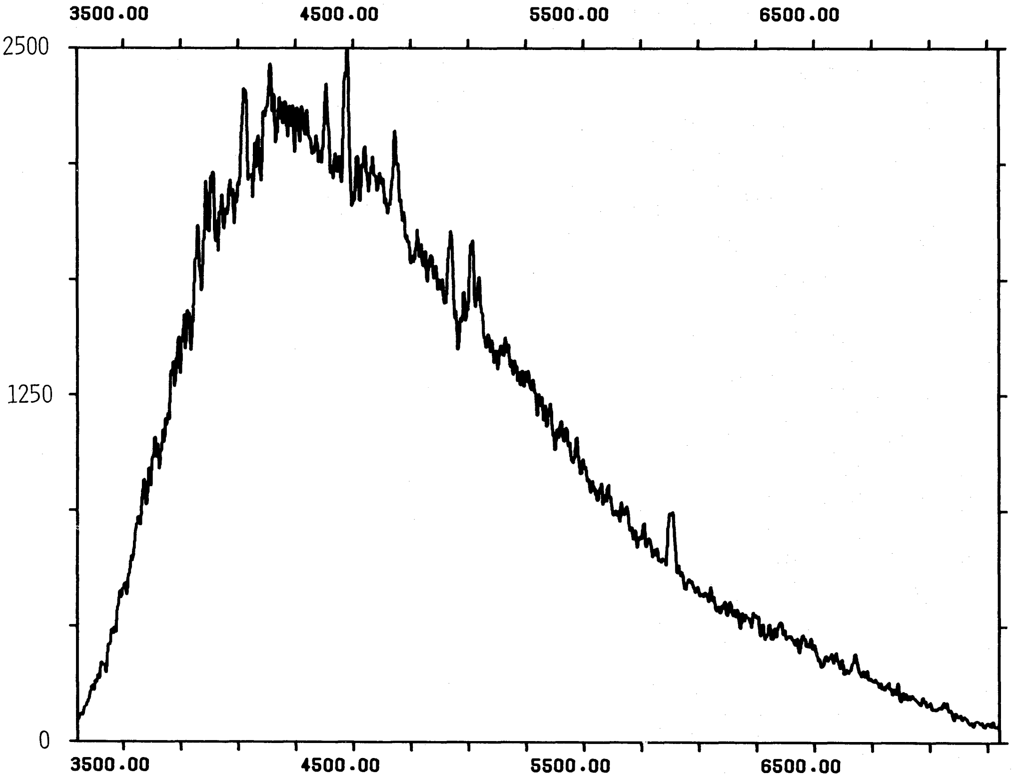

Figure 3. Sum of all the low-state spectra of V803 Cen during 1988 March 12–21. The ordinate is counts corrected for atmospheric extinction and the abscissa is wavelength in Å.

Table 3. FWHM (Å) and equivalent widths (EW) (Å) of helium lines.

Series Member	Rest λ (Å)	Date (1988 March)									
		12/13		16/17		17/18		19/20		Σ Low State	
		FWHM	EW	FWHM	EW	FWHM	EW	FWHM	EW	FWHM	EW
		±2	±1.5	±3	±1.5	±3	±1.5	±3	±1.5	±1	±0.5
2^3S-3^3P	3888.7									18	4.2 :
2^1S-3^1P	5015.7	29	8.8	11	5.9	17	10.5	18	6.7	20	6.3 :
2^1S-4^1P	3964.7										<1.0
2^3P-6^3S	3867.5									14	3.3 :
2^3P-3^3D	5876.0	30	12.9	21	18.1	27	22.2	25	24.0	30	14.8
2^3P-4^3D	4471.5	23	8.2	23	9.5	16	6.9	19	9.1	20	6.5
2^3P-6^3D	3819.7									16	3.3
2^1P-4^1S	5047.7	9	3.0			17	4.3	19	5.5	24	4.7 :
2^1P-5^1S	4437.6										<1.0
2^1P-4^1D	4921.9	24	7.8	16	5.3	16	6.9	12	4.2	21	5.4
2^1P-5^1D	4387.9	18	2.8	11	4.7			15	5.4	18	3.5
HeII λ4686										35	5.8 :

Note: The units of all numbers are Å. : denotes uncertainty due to a weak or partially blended line.

characteristic of the subclass of hydrogen-rich cataclysmic variables, the dwarf novae.

The poor signal-to-noise ratio associated with the 1611-s period in most of the data set precludes us from shedding new light on the mechanism for this or any other previously reported period. However, the Fourier amplitude spectrum shown in Fig. 2 establishes the presence of the 1611-s period in the low-state light curve. An inspection of the data from the parallel and much more extended study of PG1346+082 showed that the 1490-s period was obvious in all except a very few runs of that data set (Provencal *et al.* 1989) but that it occasionally exhibited the irregular behaviour characterizing the longest data segments shown in Fig. 1.

The sum of the low state spectra (Fig. 3), which constitutes a 7.6-hr exposure, confirms the presence of emission lines in the system in the faint state, as suspected by O'Donoghue & Kilkenny (1989). This result contrasts with the low-state spectrum of V803 Cen obtained by Kepler, Steiner & Jablonski (1989) which shows no sign of emission or absorption lines. Spectroscopy with comparable signal-to-noise of PG1346+082 in its low state, also obtained at SAAO during the 1988 March campaign, contained marginal evidence for He I emission lines (also suspected by Wood *et al.* 1987). It is interesting that, in the context of the IBWD model, there is still no sign of the Stark-broadened helium absorption lines of the mass-accepting DB white dwarf in the low-state spectrum of either star. This indicates that the accretion disc is responsible for most of the optical light emitted by the system at this apparent magnitude. This conclusion is supported by the tentative detection of doubling in the line profiles, a typical signature of an accretion disc, noted above.

The Balmer emission lines in the hydrogen-rich cataclysmic variables show a very flat decrement which has been interpreted as evidence that they are optically thick (Williams 1980). It is possible to make the same claim about the He I lines in Fig. 3 as the following discussion will show. As mentioned above, an accurate relative flux calibration of the spectrum in Fig. 3 was not possible but an approximate calibration (with an estimated error in the relative flux ratio of about 20 per cent) showed that the instrumental response was roughly constant between 4000 and 5000 Å and that around 5875 Å it had declined by a factor of 2. The resulting corrected relative line strengths are unlike those seen in the recombination spectra of low-density diffuse nebulae such as planetary nebulae. Instead, the flat decrement shows that the lines are optically thick which is demonstrated by the fact that $I_{5015}/I_{4922} \sim 1$ (Robbins & Bernat 1974). [Nather, Robinson & Stover (1981) used the same argument to show that the He I lines in the closely related system, GP Com, are also optically thick.] Further support for this picture is added by remembering that the lines faded to near invisibility on two nights (see above) indicating that the continuum had probably become optically thick.

Two possible sites have been proposed for the production of emission lines in the hydrogen-rich cataclysmic variables: either in the cool, mostly neutral, outer regions of the disc where the continuous opacity is low, or in a chromosphere above and below the optically thick parts of the disc responsible for the continuous emission (Schwarzenberg-Czerny 1981). The earliest models based on the former scenario are those of Williams (1980). These models assumed that the lines were formed in LTE in a standard steady-state accretion disc model and were successful in explaining the flat Balmer decrements as the peak intensity of the Balmer lines at a given point in the disc, given by the Planck function at the local temperature. As radiative transfer effects have been ignored, this treatment is necessarily approximate. More sophisticated modelling has been performed by Horne & Marsh (1986), who included the important effects of broadening by the velocity shear in a Keplerian disc, and Williams & Shipman (1988), who treated the radiative transfer process with an escape probability formalism and allowed for departures from LTE in the atomic level populations.

A sophisticated procedure to explain the line strengths in the data reported here is not warranted because of the difficulties extracting accurate line fluxes from the spectrum in Fig. 3. It is clear, however, that the flat He I line decrements can be explained in the same fashion as the flat Balmer decrements in the hydrogen-rich cataclysmic variables outlined above. The only helium-rich disc models of which we are aware are those of Williams & Ferguson (1982) in which, even when He/H is 1000, the Balmer emission lines are stronger than the He I lines. We caution against using this to set an upper limit on the hydrogen abundance in V803 Cen as, in contrast to the spectrum in Fig. 3, He II λ 4686 Å is of negligible strength in the Williams & Ferguson models; the excitation temperature in the latter is therefore likely to be higher which will favour weakening of the hydrogen lines. Nevertheless, it is clear that the luminous material in V803 Cen is extremely hydrogen-deficient.

O'Donoghue & Kilkenny (1989) argued that the widths of the absorption lines in V803 Cen were inconsistent with rotational Doppler broadening in an accretion disc but instead could be explained by Stark broadening in a region where $\log g \sim 6$, typical of the effective gravity in an accretion disc. They inferred a low inclination for the system because of the absence of rotational Doppler broadening. If this view is correct, the widths of the emission lines in Fig. 3, which are too wide to be explained by thermal Doppler broadening and are similar to the absorption line widths discussed by O'Donoghue & Kilkenny (1989), could be explained in the same way. We note that this would require electron densities in the line-emitting region $\sim 10^{16-17}\ \mathrm{cm}^{-3}$. The Stark-broadened emission line models of Lin, Williams & Stover (1988) show that such high densities are not incompatible with the presence of emission lines.

We urge the construction of models of extremely hydrogen-deficient discs in order to explore the parameter range required to account for the spectral properties of the IBWDs. It is remarkable that, although under conditions appropriate to disc and stellar photospheres the continuous opacity of helium is more than an order of magnitude smaller than that of hydrogen (e.g. Bues 1970), emission lines in the low states of helium discs are either absent or much weaker than in their counterparts in the hydrogen-rich cataclysmic variables.

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