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Spectroscopy of the dwarf nova CG Draconis

Albert Bruch[1], **Thomas Schimpke**[1,⋆], **and Alexander Kochsiek**[1]

Astronomisches Institut, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, D-48149 Münster, Germany

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Abstract. We present spectroscopic observations of the dwarf nova CG Dra which exhibits a two component spectrum. Absorption lines stand out clearly and can be classified as belonging to spectral type K5 $\pm$ 2. The wavelength dependent veiling fraction could be determined. The emission spectrum is not untypical for a dwarf nova but shows some peculiarities in the helium lines. Radial velocity measurements indicate a period of either 4^h32^m or 5^h37^m, too short for the absorption line spectrum if interpreted within the canonical CV model. Worse, the absorption line radial velocity amplitude is approximately a factor 30 less than that for the Balmer lines and *in phase* with them. This cannot easily be explained in the framework of standard CV models. However, it cannot be excluded that the RV variations of the absorption lines are accidential and that the corresponding star is not a component of the cataclysmic variable.

Key words: stars: binaries: close – stars: novae, cataclysmic variables – stars: individual: CG Dra

1. Introduction

CG Dra is a little known dwarf nova which was discovered by Hoffmeister (1965). In a later paper Hoffmeister (1967) classified it as U Gem-like and suspected it to belong to the CN Ori group, i.e. dwarf novae exhibiting a rapid sequence of outbursts without well-defined quiescent states between them. Bruch et al. (1987) report about further photographic photometry. The first and so far only spectrum of CG Dra was published by Bruch & Schimpke (1992). These observations showed that the system belongs to those relatively few cataclysmic variables which contain along with the usual emission lines a strong absorption line spectrum.

Systems with these properties have a high potential to teach us about the secondary stars in CVs which otherwise are not directly observable at visual wavelengths. An impressive recent example in this respect is the system DX And (Drew et al. 1993; Bruch et al. 1997) to which CG Dra resembles a lot at first glance. This motivated us to perform time-resolved spectroscopy of CG Dra in order to study its properties in more detail. However, as will be shown below, these observations reveiled that CG Dra is either a very unusual dwarf nova, or – more easily understood – that the absorption line star is not the secondary of the system.

2. Observations and reductions

CG Dra was observed during the three nights from 1993 June 29 – July 1 at the 3.5m-telescope of the DSAZ on Calar Alto, Spain. The Cassegrain Twin Spectrograph was used which consists of two complete spectrographs. A dichroic beam splitter separates the blue and the red light of the observed object into two channels which are fed into the two spectrographs. Two Tektronix CCD chips with a pixel size of 24 μm^2 served as detectors. The useful spectral ranges were approximately 4000 Å – 5500 Å in the blue and 5400 Å – 6850 Å in the red, at a dispersion of $\approx$1.8 Å/pixel in both channels. A slit width of either $0\farcs8$ or $1\farcs1$ was used. With the seeing having been of the order of $2''$, substantial (unquantified) light losses at the slit edges will have occured. Therefore, a flux calibration of the spectra was not attempted. We use only spectra normalized to the continuum in this study.

A total of 16 spectra of CG Dra were recorded with integration times of 2400 sec (with the exception of two spectra which were exposed for only 1800 sec). Each stellar spectrum was bracketed by two exposures of a He-Ar calibration lamp. In addition to CG Dra some main sequence standard stars of late spectral types were observed with the same instrumental setup in order to permit a detailed comparison with the absorption line component of the CG Dra spectrum. A journal of the observations of CG Dra and these comparison stars is given in Tables 1 and 2, respectively.

The basic reductions including debiasing, flatfielding, extraction of the stellar spectrum, using the optimized algorithm of Horne (1986), and wavelength calibration were done in the standard way within IRAF. The subsequent analysis was performed using the MIRA software package (Bruch 1993).

Send offprint requests to: Albert Bruch

⋆ Visiting Astronomer, German-Spanish Astronomical Centre, Calar Alto, operated by the Max-Planck-Institut für Astronomie Heidelberg jointly with the Spanish National Commission for Astronomy

Table 1. Journal of observations and heliocentric radial velocities of CG Dra

HJD (mid-exp.) 2449100+	R.V. (Hα) (km/sec)	R.V. (Hβ) (km/sec)	R.V. (abs.) (km/sec)
68.4277	95	152	−8
68.4640	156	73	−21
68.5017	−7	−45	−20
68.5393	−63	−193	−17
68.5774	−136	−128	−18
69.4154	175	187	−6
69.4495	36	−114	−21
69.4857	−120	−159	−28
69.5209	−117	−98	−22
69.5576	−2	111	−19
69.5938	124	177	−13
70.4166	−126	−245	−22
70.4572	−93	−239	−23
70.4937	4	−55	−14
70.5285	137	112	−15
70.5641	123	19	−16

Table 2. Observations of late type standard stars

Name	Spectral type	No. of exp.
ξ Boo	G8	2
HD 124752	K0	2
107 Psc	K1	1
HR 6806	K2	1
HD 128165	K3	2
61 Cyg A	K5	4
61 Cyg B	K7	1
HD 147379	M0	3
BD+14°774	M2	1

3. The spectral components

3.1. The absorption line spectrum

As was pointed out in the introduction, the spectrum of CG Dra consists of an absorption and an emission line component. Attributing the former to the secondary star and the latter to the accretion disk, this enables to determine the motion of both binary components and thus to measure the mass ratio (keeping in mind, however, the numerous well-known uncertainties of such measurements in CVs). To obtain radial velocities from the emission lines, overlying absorptions, disturbing the line profiles, should be removed first. This requires the determination of the veiling fraction, i.e. the fractional contribution of the primary to the total light, and the spectral type of the cool star. Of course, knowledge of these items is also of interest by itself.

3.1.1. The veiling fraction

Since the veiling fraction is expected to be wavelength dependent, three spectral ranges free from strong emission lines were selected: $\lambda\lambda$ 4365 Å – 4820 Å (blue), $\lambda\lambda$ 4900 Å – 5445 Å (green), $\lambda\lambda$ 5460 Å – 6530 Å (red). The particularly strong absorptions of Mg I b at $\lambda\lambda$ 5167 Å – 5184 Å and Na D at $\lambda\lambda$ 5890 Å – 5896 Å were masked since slight peculiarities in these lines might otherwise dominate the results and render them unrepresentative for the entire spectrum. The spectra were then rebinned to a logarithmic wavelength scale, cross-correlated against each other, shifted to a common rest frame, and finally co-added to yield a mean absorption line spectrum.

The spectra of the late type comparison stars, treated in the same way, were then cross-correlated with the mean CG Dra spectrum, shifted to the rest frame of the latter, and subjected to a simulated veiling, assuming a veiling fraction v. In the ideal case of identical absorption line spectra and the correct value of v the difference between these two spectra should vanish in the absence of noise. In the real world, finite differences remain, and we take their mean squared values (after subtraction of a spline fit to the differences in order to remove large scale structures due to slight differences in the normalization of the CG Dra and the comparison star spectra) as a quality indicator: The smaller they are, the better is the assumed value of v.

This procedure was repeated for all available comparison stars, yielding a value for the veiling fraction of CG Dra as a function of the assumed type of the absorption line spectrum and for the three spectral ranges.

In order to test the effect of masking the Mg I b and Na D lines, the calculations were also performed without masking. This results in a slight increase of v in the green band ($\approx$ 5% for a K5 spectrum) and a decrease in the red ($\approx$ 18%). The wavelength dependence of v then deviates significantly from what would be expected if it is caused by a steady state accretion disk (see Bruch et al. 1997), while otherwise it is compatible with the expectations. This justifies the masking of Mg I b and Na D.

3.1.2. The type of the absorption line spectrum

The spectral type of the cool star was determined using three criteria: (1) the mean squared values of the difference between CG Dra and the comparison stars as measured in the previous section to find the veiling fraction, (2) the maximum value of the cross-correlation function between CG Dra and the comparison stars for the three spectral ranges defined above (again masking the Mg I b and Na D lines), and (3) a visual comparison of CG Dra and the comparison spectra.

All criteria yielded a spectral type between K3 and K7 for all spectral bands, with a clear preference for K5. Therefore, we conclude that the type of the absorption line spectrum of CG Dra is K5 with an uncertainty of at most 2 subtypes to either side.

In Table 3 the measured veiling fraction for this spectral type is listed for the blue, green and red range. The mean of all spectra of CG Dra, shifted to a common rest frame for the

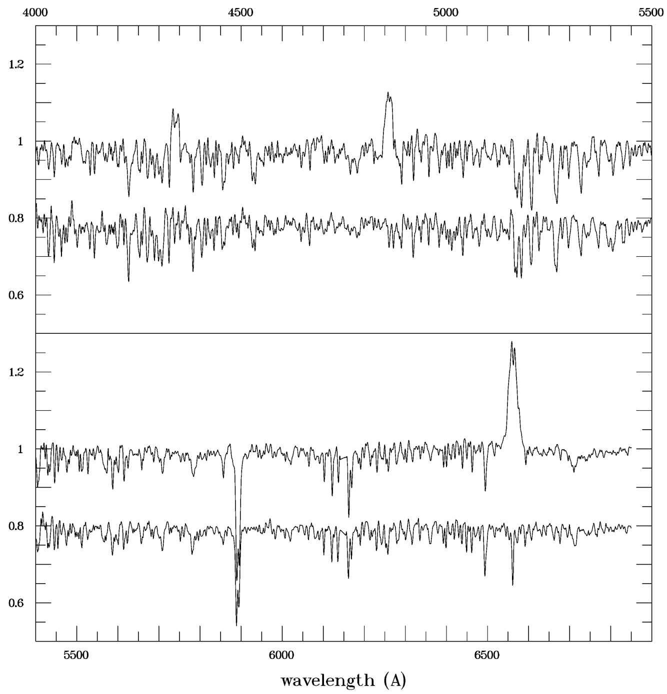

Fig. 1. Mean spectrum of CG Dra shifted to a common rest frame for the absorption lines, compared to the K5 V standard star 61 Cyg A in the blue-green (top) and yellow-red (bottom) range.

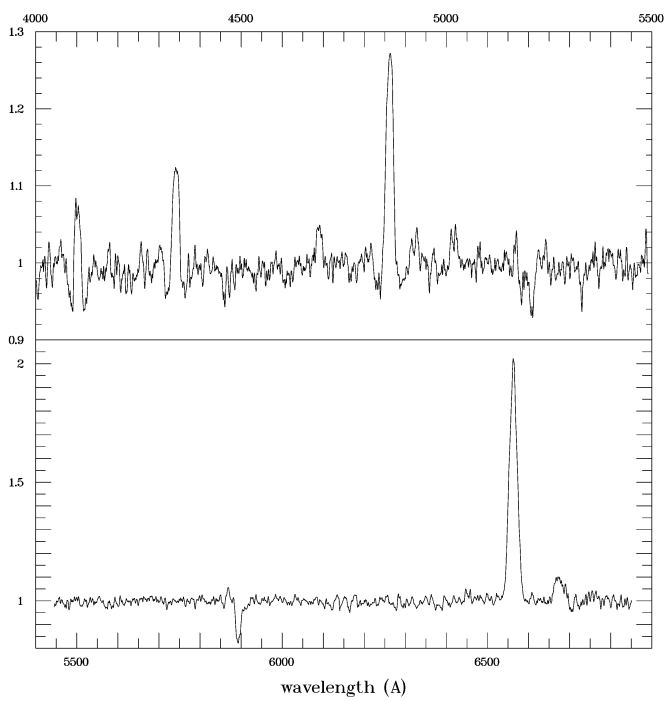

Fig. 2. Mean emission line spectrum of CG Dra in the blue-green (top) and yellow-red (bottom) range.

Table 3. Veiling fraction of CG Dra

central wavelength Å	veiling fraction
4593	0.72
5173	0.63
5995	0.50

absorptions, is shown in Fig. 1 together with the spectrum of the K5 standard star 61 Cyg A, scaled according to the veiling fraction (and shifted downwards for clarity).

3.2. The emission line spectrum

In order to free the emission line spectrum from the contamination by the absorption lines, the spectrum of 61 Cyg A, suitably scaled to account for the wavelength dependent veiling fraction, was subtracted from each CG Dra spectrum after having been shifted into the rest frame of the CG Dra absorption lines. After renormalization the resulting spectra were shifted to a common emission line rest frame, determined by the radial velocity measurements of Hα and Hβ (which will be described in Sect. 4), and then co-added. Fig. 2 shows the resulting blue-green (top) and yellow-red (bottom) spectra (note the different scales of the normalized flux in the two frames). The strongest absorption lines (Mg I b and Na D) were obviously not sufficiently well subtracted and remain as spurious features in the emission line spectrum.

As usual for CVs, the emissions are dominated by the Balmer series. Most dwarf novae in quiescence tend to have a rather flat or even inverted Balmer decrement. In the present case the normalization to the continuum inhibits a direct measurement of the Balmer line intensities and thus the decrement. However, knowledge of the veiling fraction and the wavelength dependence of the fluxes of a K5 V star (Straižys & Sviderskienė 1972) permit a rough determination of the shape of the continuum of the primary and then of the ratio of the Balmer line intensities. It is found that $j_{\rm H\alpha}/j_{\rm H\beta} \approx 2$ and $j_{\rm H\gamma}/j_{\rm H\beta} \approx 0.8$. Thus, the decrement is definitely shallower than in Case B recombination (Osterbrock 1989) but still considerably steeper (at least concerning the first ratio) than in most dwarf novae (see e.g. the compilation of Williams 1983). Beginning with Hβ, the Balmer emission lines appear to be superposed by broad absorption troughs. Such features are often seen in the early and late stages of dwarf novae outbursts. In the present case the exact photometric state of CG Dra during the epoch of our observations is not known. However, it cannot have been much brighter than the minimum state since otherwise the absorption line spectrum would have been outshone.

The next most obvious features in the emission spectra of dwarf novae are the lines of neutral helium. In this respect, CG Dra is unusual. Normally, the strongest optical He I line is the one at 5876 Å, closely followed by He I 4471 Å (Williams 1983). While the former is faintly seen in CG Dra, the latter is

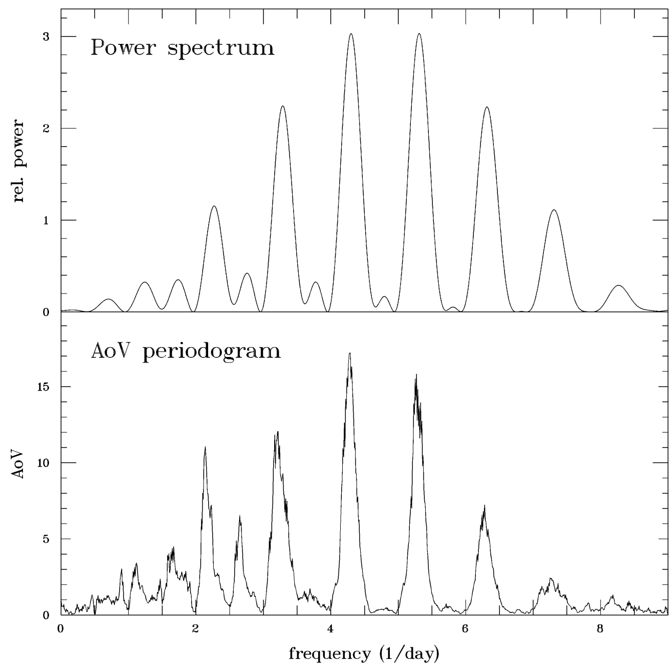

Fig. 3. Power spectrum (top) and AoV periodogram (bottom) of the radial velocities of Hα measured at a separation a = 18 Å of the Gaussians.

not detected at all. In contrast, if the line redward of Hα is identified as He I 6678 Å, it would be much stronger than usual. The two emission lines redward of Hβ are normally identified with He I 4922 Å and 5016 Å. However, there appears to be another emission at λ 5170 Å (somewhat corrupted by the partly overlying Mg I b absorption). This line is not uncommon in dwarf novae (see Williams 1983, Bruch 1989, Bruch & Schimpke 1992). It is due to Fe II and part of a triplet whose other members are located at 4924 Å and 5018 Å. In view of the weakness of other He I lines it is therefore tempting to attribute the emissions redward of Hβ to Fe II instead of He I.

Another unusual albeit not unprecedented feature in the spectrum of CG Dra is the presence of He II 4686 Å. This line is more commonly seen in the spectra of classical novae and is particularly strong in magnetic systems. If it is seen in dwarf novae, then normally during outburst maximum or decline (e.g. in SS Cyg; Martínez-Pais et al. 1996). It is normally accompanied by a complex of C III and N III lines at 4640-4650 Å which, however, may not be visible above the noise in the present case. The inspection of the individual spectra shows that the He II line is not always seen. However, its presence is neither restricted to particular observing nights nor orbital phase ranges (concerning the orbital period, see Sect. 4).

4. Radial velocity measurements

4.1. The emission line spectrum

To determine orbital elements we measured the radial velocities of Hα and Hβ, applying the double Gaussian convolution method of Schneider & Young (1980) in connection with the diagnostic diagrams introduced by Shafter (1983) (SYS-method thereafter). To this end, we used those spectra which were freed from the distortions introduced by the absorption lines (see Sect. 3.2).

Within an iterative scheme the radial velocities were measured as a function of the distance a between the Gaussians, and then the diagnostic diagrams were constructed using an initial guess for the orbital period, derived from a power spectrum of prelimiary radial velocities measured via Gaussian fits to the lines. It became obvious already at this stage that two periods were about equally likely. The subsequent iteration was therefore performed for both candidate periods. The optimal value of a was determined from the diagnostic diagrams, and the RV values measured for these Gaussian separations were again subjected to a power spectrum analysis in order to refine the period. This method quickly converged and after two iterations no further improvement was achieved.

The power spectrum and an AoV periodogram (Schwarzenberg-Czerny 1989) (slightly smoothed) are shown in the upper and lower frame, respectively, of Fig. 3 (for Hα; the corresponding diagram for Hβ is very similar). They are consistent with each other. The small misalignment of the peaks at low frequencies can probably be explained by problems of the AoV method with empty phase bins and a small number of data points. For the same reason the difference in height of the principle peaks of the AoV periodogram cannot be considered significant. The diagnostic diagrams for Hα and Hβ can be found in Fig. 4, and Fig. 5 shows their radial velocity curves. The elements of the RV curves are summarized in Table 4.

In the diagnostic diagram of Hβ the parameter σ_K/K starts to increase rapidly for a Gaussian separation $a > 13$ Å. At about the same separation the amplitude K of the RV curve starts to drop off from a broad maximum, γ reaches a minimum after a steady decline, and the phase ϕ begins to increase steeply after an extended plateau. Therefore a = 13 Å appears to be the optimal choice for the Gaussian separation.

The diagnostics are not as clear in the corresponding diagrams for Hα. The primary indicator for the optimal value of a, σ_K/K, increases slowly but steadily between a = 13 Å and a = 23 Å, making it difficult to choose an optimal value. a = 18 Å is therefore adopted, corresponding to the same Gaussian separation in velocity space as chosen for Hβ. The individual radial velocities measured at the quoted separations of a = 18 Å and a = 13 Å for Hα and Hβ, respectively, are listed in Table 1.

The power spectrum calculated from the RV values of Hα at a = 18 Å exhibits an alias pattern (Fig. 3) which makes it impossible to be sure about the true period. Folding the data on the periods corresponding to the two principal power spectrum peaks does also not lead to a solution: For the longer (shorter) period the scatter around the best least squares sine fit is slightly larger (smaller) for Hβ than for Hα. Therefore, we perform all subsequent calculations for two periods, namely $P_1 = 0.1893 \pm 0.0006$ days ($\equiv 4^h 32^m \pm 1^m$) and $P_2 = 0.2343 \pm 0.0021$ days ($\equiv 5^h 37^m \pm 3^m$). These are the mean values from independent

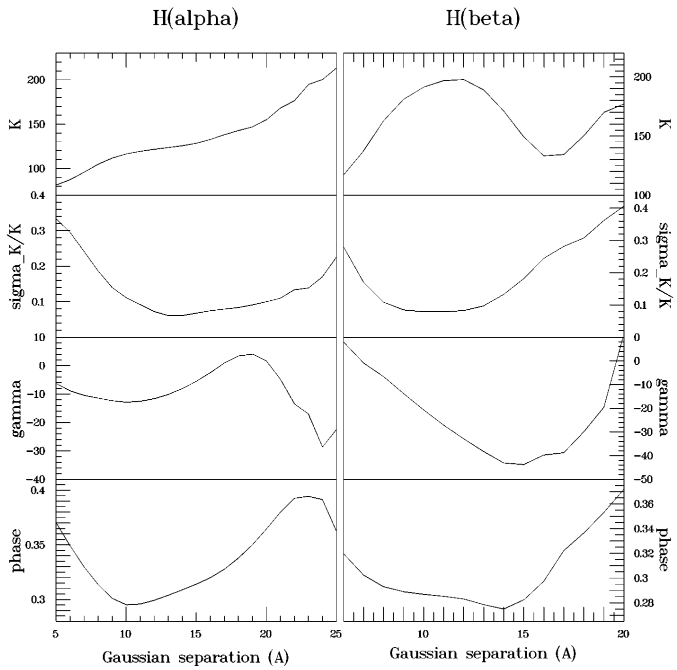

Fig. 4. Diagnostic diagrams for the radial velocity curve of CG Dra for Hα and Hβ, obtained for a period of 0.1893 days.

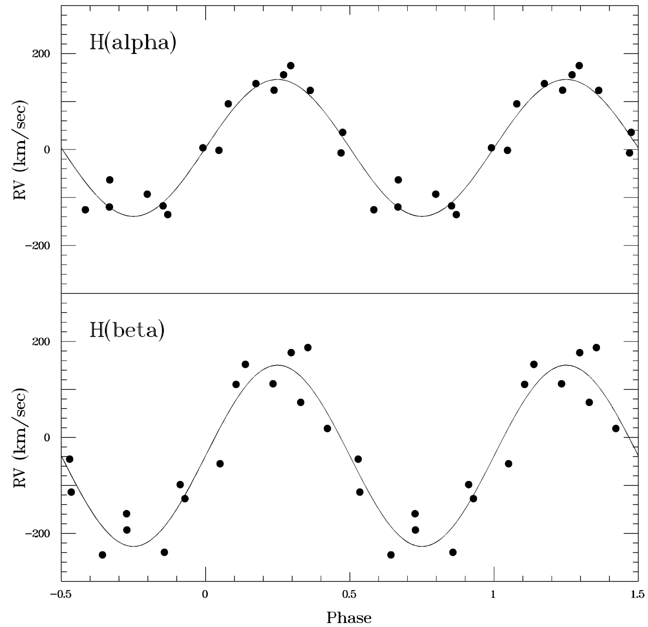

Fig. 5. Radial velocity curves (dots) of Hα (top) and Hβ (bottom) folded on P_1 = 0.1893 days together with the best fit sine curves (solid line).

Table 4. Elements of the radial velocity curve of CG Dra

	Period (days)	K (km/sec)	γ (km/sec)	$\Delta\phi$
Hα	0.1893±0.0006	143±12	8±8	0
	0.2343±0.0021	143±10	13±8	0
Hβ	0.1893±0.0006	188±18	−42±8	−0.06±0.02
	0.2343±0.0021	176±24	−26±17	−0.06±0.02
abs.	0.1893±0.0006	5±2	−18±1	−0.08±0.05
	0.2343±0.0021	5±2	−18±1	−0.06±0.06

measurements of Hα and Hβ, derived from a sine fit to the final radial velocities. The indicated errors are the formal standard deviations and should be regarded as lower limits rather than reliable error estimates.

The radial velocity curves of Hα and Hβ shown in Fig. 5 (see also the elements summarized in Table 4) have a significantly different amplitude. The same has been observed in many other CVs (for an extreme case see the amplitude difference of Hβ and He II 4686 Å measured by Bruch 1982 in HR Del). The same holds true for the systemic velocity γ. This reflects the uncertainty about what is exactly measured in the emission lines. In spite of using the SYS-method, which is meant to measure the motion of the accretion disk as close to the primary as possible, we cannot be sure that the radial velocity curves reflect the motion of the white dwarf. This is underlined by a phase difference between the RV curves of Hα and Hβ. While in Fig. 5 the phases of both curves have been adjusted independently such that zero-crossing occurs at phase zero, there is in reality a phase shift between Hα and Hβ, the latter lagging 0.06 in phase behind the former (for both solutions, P_1 and P_2; see also the diagnostic diagrams in Fig. 4). Because of these uncertainties we refrain from drawing conclusions concerning the dynamics of CG Dra from the RV curves.

A problem concerning the measurements of radial velocities in the emission line wings with the SYS method could be the underlying absorption component, seen in Hβ (and the higher members of the Balmer series) but not in Hα (see Fig. 2). Since this absorption can only be detected in the mean spectrum it cannot reliably be removed from the individual spectra before the radial velocity measurements are made. In order to investigate nevertheless the question whether it can have an appreciable effect on the RV curve some simulations were performed. In each spectrum Hβ was overlayed by an artifical absorption line with Gaussian shape and a depth similar to that actually observed in the mean spectrum (0.05 below the continuum) and a corresponding width (Gaussian parameter σ = 20 Å). Three cases were regarded: (1) a stationary absorption line centred on the wavelength corresponding to the γ-velocity of the Hβ emission, (2) the absorption moving in phase with the emission line and with the same amplitude, and (3) the absorption moving with a phase shift of 180°. In all cases the SYS method showed the optimal separation a to be the same as found for the original data. A least squares sine fit to the corresponding radial velocity curve yielded differences compared to the unmodified data of up to 16 km/sec in K and 9 km/sec in γ. The phase changes by no more than 0.013.

These numbers show that the absorption line below Hβ can have an effect on K, γ and the phase of the order of their sta-

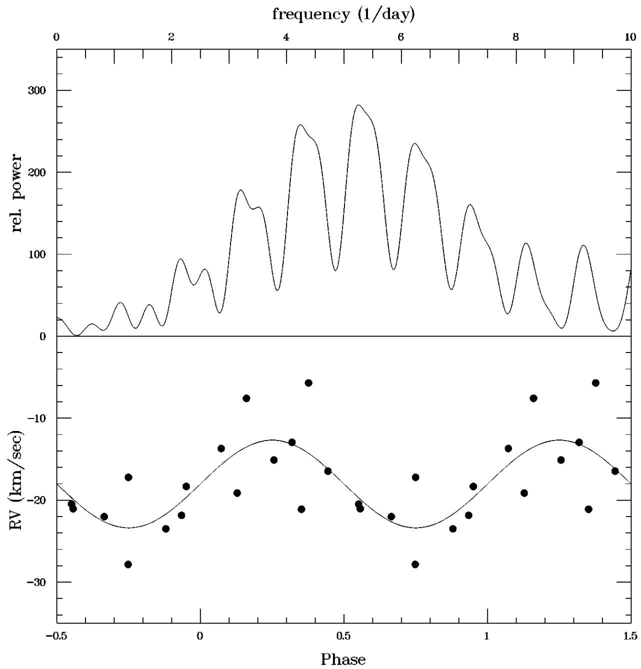

Fig. 6. Top: Power spectrum of the absorption line radial velocities; bottom: corresponding radial velocity curve (dots) folded on P_1 = 0.1893 days together with the best fit sine curve (solid line).

tistical errors. This is, however, not sufficient to explain the difference between between their values in Hβ and Hα.

4.2. The absorption line spectrum

CVs have in general a mass ratio $q \equiv M_2/M_1 < 1$. Then, the amplitude of the RV curve of the secondary is larger than that of the primary. Considering the results of the previous section and the well defined absorption lines in the combined spectrum, it should therefore be easy to measure the motion of the cool star in CG Dra. However, the results of RV measurements of the late type spectrum by means of a cross-correlation with the spectrum of 61 Cyg A are surprising.

The RV variations of the absorption lines are not only very small, but they are even almost *in phase* with those of the emission lines. The invididual heliocentric RV values, calculated using a radial velocity of 64 km/sec for 61 Cyg A (Hoffleit 1964), are listed in Table 1. They are mean values derived from cross-correlations in four spectral ranges which are free from strong emission lines (4365 Å – 4830 Å, 4898 Å – 5508 Å, 5534 Å – 5861 Å, 5927 Å – 6516 Å). The second of these contains the Mg I b lines which were again masked (see Sect. 3.1.1). However, the difference between the radial velocities with the lines masked and not masked, respectively, amounts to only -2.8 ± 4.3 km/sec and is thus insignificant. In Fig. 6 (top) the corresponding power spectrum is shown. The highest peak corresponds to a period very close to P_1. In view of the small velocity variations and the scatter of the data it is not justified to independently derive a period from the absorption lines (a formal sine fit yields a period less than $4^{\rm m}$ longer than P_1). Therefore, the absorption line RV curve folded on P_1 is shown in Fig. 6 (bottom). Its K- and γ-values as well as the phase shift relative to Hα are listed in Table 4.

5. Discussion

Obviously, the properties of the absorption line spectrum form severe obstacles for the interpretation of the observations of CG Dra within the canonical model for CVs.

Attributing it to the secondary star and assuming it to be on the main sequence, the spectral type of K5 $\pm$ 2 would imply an orbital period of $6^{\rm h}22^{\rm m} \pm 26^{\rm m}$, using the spectral type – mass relation of Schmidt-Kaler (1982) and the $M_2 - P$ - relation of Patterson (1984) with $\alpha = \beta = 1$. This is inconsistent with the two possible values of the period determined in Sect. 4.1. Thus, the mean density of the secondary would be *higher* than that of a main sequence star, a feature which has not been observed in any other CV (whereas the opposite case – the secondary being undermassive for its radius – is not uncommon and can be understood as either due to evolution off the main sequence or a deviation from thermal equilibrium caused by the mass transfer).

Within the canonical model an absorption line RV amplitude of the order of 30 times smaller than the emission line amplitude, implying a secondary 30 times more massive than the white dwarf, is – irrespective of the uncertainties concerning the dynamical interpretation of emission line motions and the possibly limited accuracy of the measured values which are not expected to be wrong by orders of magnitude – wholly out of the question. No stable mass transfer would be possible in such a system (Politano & Webbink 1990). In a magnetic system seen almost face on (to explain the small RV amplitude of the absorptions) a scenario might be imagined where a line emitting gas stream can attain the emission line RV nevertheless. However, the troubling fact of emissions and absorptions moving *in phase* stands against such a scenario.

In a binary system where the emission and absorption line systems are stationary in a co-rotating frame – which appears to be the case here since both systems have the same period but must arise at different locations because of the different amplitudes – the line systems must necessarily be formed at the same side of the centre of mass if they are in phase. In CVs emission lines can be in phase with the absorptions if they are due to illumination of the secondary by the hot primary. However, in this case the amplitude of the absorptions should be larger than that of the emissions because the illuminated face of the secondary is closer to the centre of mass than its unilluminated part where the bulk of the absorptions is expected to be formed. Moreover, the emission lines should then be narrower than observed.

Let us nevertheless assume for the moment a scenario of an illuminated secondary. Then, the emission lines should have maximum strength at the upper conjunction of the secondary. Phase 0 being defined as the epoch of positive zero-crossing of the emission lines, this should happen at phase 0.5. At the same time the equivalent width (EW) of the absorptions should have a minimum. In Fig. 7 the EWs of Na D, Hα and Hβ are

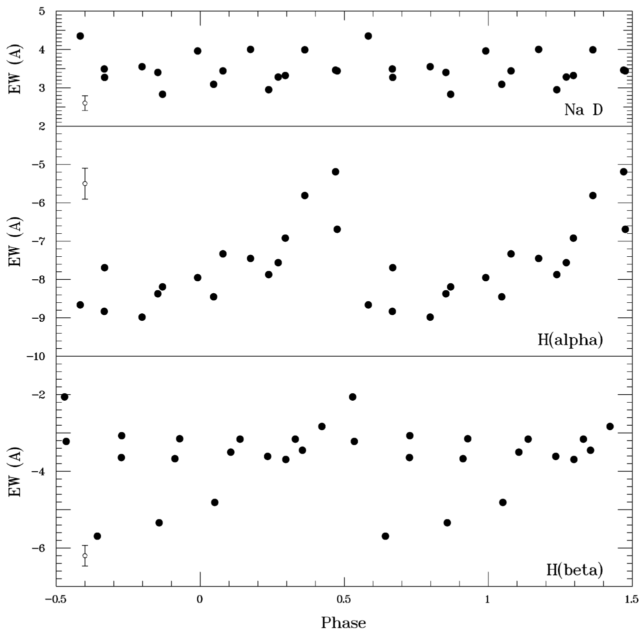

Fig. 7. Equivalent width of Na D (top), Hα (centre) and Hβ (bottom) as a function of phase.

shown as a function of orbital phase. An idea of the errors – notoriously difficult to be determined objectively for EWs – has been obtained by calculating standard deviations from several independent measurements of the same lines. Representative error bars are shown in the figure. There may be a slight but hardly significant maximum of the EW of Na D at phase 0.5. This contrasts with the expectations just as the definite maximum (emission line EWs are taken to be negative here) for the Balmer lines at this phase. Note that the three deviating points for Hβ correspond to three subsequent spectra in one night and are therefore likely to be due to other than orbital variations. The phase shift between the maxima in Hα and Hβ is similar to the phase shift in their RV curves.

Thus, while the spectrum of CG Dra at first glance appears to be quite compatible with that of a dwarf nova – albeit with an unusually but not unprecedentedly strong contribution of absorption lines – and the photometric behaviour also appears to be consistent with this interpretation (Hoffmeister 1967), details of the spectroscopic behaviour cannot be reconciled with the standard model for CVs (or with any obvious modification of it). Is there a totally different interpretation of the observations? We have thought of other models (including a mass accreting main sequence star in a binary and a pulsating single star with an extended line emitting envelope above a photosphere), but for obvious reasons they all run immediately into difficulties.

Finally, as a last possible solution of the problem, we consider the question whether the apparently clear absorption line RV variations can be an artifact of the measurements or purely accidential.

Concerning the first point, faint emission lines in the region for the cross-correlations, moving together with the Balmer lines, might distort the absorption line profiles as a function of phase, imprinting upon their RVs an apparent movement in phase with the emissions. Simulations with moving Gaussian profiles added to the absorption line spectrum showed no measureable effect.

The absorption line RV curve shown in Fig. 6 is constructed from the mean of the RV values measured in four wavelength regions. The periodic variations cannot be detected in the data of any one of the individual regions. Therefore, considering the relatively low number of available spectra the question should be addressed whether the apparent periodicity might be purely accidential. For this purpose 10 000 RV curves were simulated, sampled at the same times as the real data. The RV values were taken at random, equally distributed between the largest and the smallest of the actually measured values. For each simulated RV curve a power spectrum was calculated. In 1.5% of all cases its maximum values was higher than in the power spectrum of the real data and at a frequency corresponding to within $\pm 4^{\rm m}$ of P_1 (i.e. the formal difference observed between P_1 and the absorption line period; see Sect. 4.2).

Thus, it cannot be excluded that the observed absorption line period is artificial, caused by an accidential distribution of measurement errors of data in a source with constant RV. If this is true it must be concluded that the absorption lines originate in a star not being part of the catalcysmic variable, i.e. either forming an unresolved optical double star with CG Dra or – more probably – being the third component of a hierarcical triple system. In this case the problem of the spectral type being too early for the orbital period also dissolves.

6. Conclusions

The observations presented here have shown that although CG Dra appears to be a normal dwarf nova – albeit with an unusually strong absorption line component – the detailed analysis reveals some properties which (if they are real and not due to accidential errors of measurements) are not easily explained in the framework of standard CV models.

The absorption line spectrum can be classified as K5. It contributes about half of the total flux at 6000 Å and less at shorter wavelengths as is to be expected in a dwarf nova system containing a hot accretion disk. The emission lines of the latter are a bit unusual concerning the He I lines. The Balmer lines are as expected. They permit to determine radial velocities with sophisticated methods. Aliasing problems prevent to measure an unambiguous period. Two values, $4^{\rm h}32^{\rm m}$ and $5^{\rm h}37^{\rm m}$ are equally likely. The amplitudes of Hα and Hβ are significantly different, underlining again the long known fact that care has to be exercised in the dynamical intepretation of the line movements.

The problems concerning the CG Dra data start with the incompatibility of the absorption spectrum with the emission line period: It is too early, i.e. a main sequence star of corresponding mass and size would not fit into the Roche-Lobe of the secondary if DG Dra were a normal dwarf nova.

The problems become worse considering the radial velocities of the absorption lines which were measured with cross-correlation techniques, using the spectrum of the K5 V standard star 61 Cyg A, observed with the same equipment as CG Dra, as a template. Although radial velocity variations are apparently present at a period compatible with that found for the emission lines, the amplitude is of the order of 30 times smaller in contrast to the prediction that it should be larger (or at least of the same order of magnitude).

While the latter feature might still be explainable in a special geometrical and dynamical situation, the fact that emission and absorption lines move in phase renders such an explanation impossible. It implies that both line systems must arise on the same side of the centre of mass if the RV variations are due to movements in a binary system.

Simulations revealed a non-negligible probability for the absorption line RV period to be an artifact caused by an accidential distribution of errors of the measurements. This opens the possibility of the late type spectrum being associated to a star which is not a component of the dwarf nova. The final answer to this question can only be found by independent observations.

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