SPECTROSCOPY OF CN ORIONIS*

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Abstract. Two outbursts and a minimum phase of the dwarf nova CN Orionis have been observed spectroscopically. One outburst was covered almost completely. The outburst spectra show periodic variations of the absorption lines which are interpreted with the formation of an elliptic disc during outburst stage. During decline from outburst a narrow emission line appears in the core of the broad Hα absorption line. The balmer decrement in the outburst phase is much steeper than in the minimum phase. This implies that during the outburst the emission line region is located more outward in the disk. The semi amplitude of the radial velocity curve was determined to K1 = 152 km/s ± 10 km/s. Using the photometric orbital period and an assumption about the inclination angle the approximate system parameters could be derived.

1. INTRODUCTION

In the last years two different models for dwarf nova outbursts - the masstransfer model (Bath 1973) and the disk instabillity model (Osaki 1974) - have been discussed extensively. In order to find arguments in favour of one of these models, an extensive 24 hour observation of CN Orionis was organised in 1982 (Schoembs 1982). CN Orionis was chosen because of its short outburst period of about 14 days. During this observing period 72 spectra from two outbursts have been collected, One outburst could be covered almost completely. To analyse the relation between the orbital phase and the radial velocity and to determinate the two photometric periods (Schoembs 1982), minimum spectra were obtained in 1985.

The first outburst was observed by H. Barwig at the 1.9m reflector with the cassegrain spectrograph and a photon counting array at Mount Stromlo, Australia. The second outburst and the minimum phase was observed by W. Seitter, R. Schoembs and R. Haefner at the ESO 1.52m telescope with the Boller & Chivens spectrograph and the image dissector scanner in Chile. The reduction was performed with the IHAP-system at the ESO headquarters at Garching.

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* Based on observations colleted at the European Southern Observatory, La Silla, Chile and at Mount Stromlo Observatory, Canberra, Australia.

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2. THE ABSORPTION SPECTRA

2.1 FIRST OUTBURST

Figure 1 shows the summed spectra from the three observed nights covered. In the lower part of the picture a spectrum of the sky with two strong Hg-emission lines is visible. The influence of these lines could not be eliminated completely because of saturation effects in the detector. All hydrogen lines show broad absorption, HeI 4472 is a relatively weak absorption feature, HeII lines are not detectable. In the course of the outburst the hydrogen lines are filled up, most clearly to be seen at Hβ.

2.2 SECOND OUTBURST

The different spectra of the second outburst have been averaged for each night and are shown in figure 2a (rise to maximum) and 2b (decline from maximum). The intensity of the spectra has been corrected according the photometric observations at La Silla. For comparison a minimum spectrum (19/20.12.) is shown at the bottom of each figure.

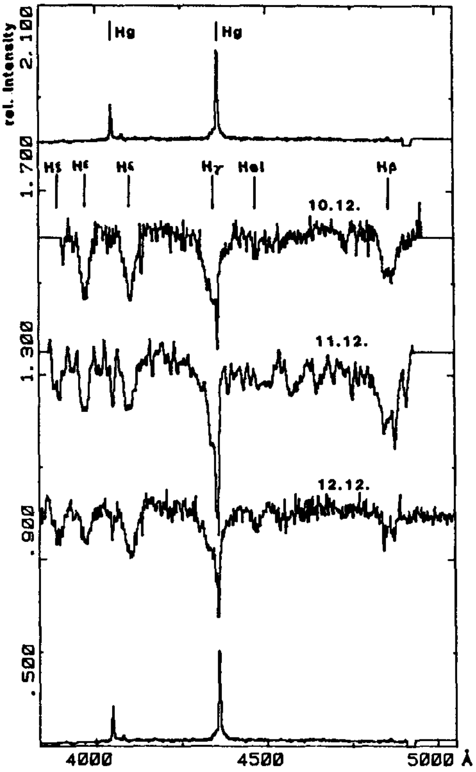

Figure 1: Summed spectra of the first outburst.

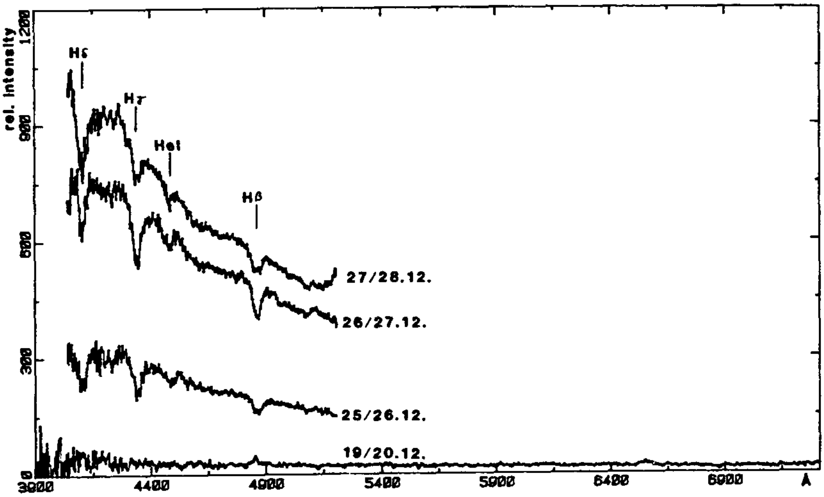

Figure 2a: Summed spectra of the second outburst. Rise to maximum.

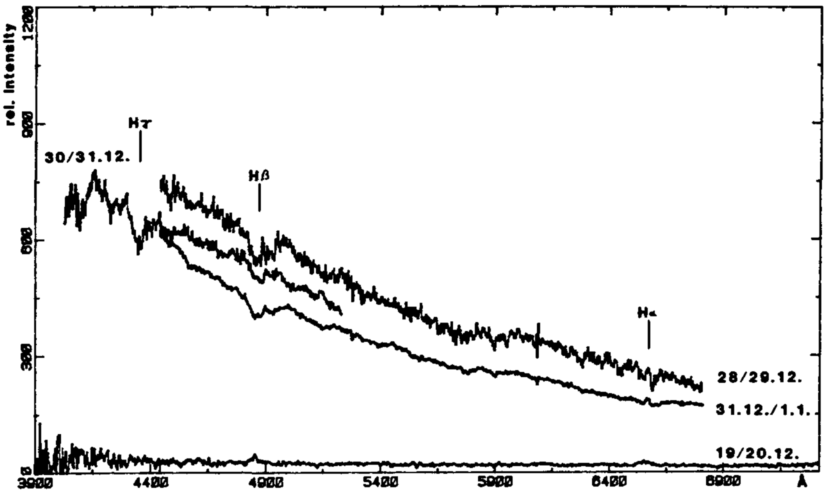

Figure 2b: Summed spectra of the second outburst. Decline from maximum.

The spectra are showing the same behaviour as those obtained at Mount Stromlo: broad absorption lines of hydrogen, absence of HeII lines, weak absorption of HeI 4472. During rise the absorption lines are getting stronger, reaching maximum of absorption just before the photometric maximum and diminishing rapidly in the course of decline from outburst, although the visual brightness at this stage is still about two third of the maximum value. In the last nights a narrow emission line is visible in the broad absorption core of Hα, its line width is about one half of the line width during quiescence. Further more a considerably steeper balmer decrement is found. This phenomenon has been observed for KT Per and RX And (Clarke and Bowyer 1984) and for SS Cyg (Clarke et al. 1984) as well.

2.3 DISCUSSION

The smaller width of the emission lines during outburst indicates their enhancement in outer regions of the disc where smaller keplerian velocities exist. In favour of this interpretation is also the balmer decrement: a steeper decrement is caused by smaller photoionisation rates, smaller average electron densities and/or smaller temperatures (Drake and Ulrich 1980). In a stationary disc, areas with low temperatures and densities are found further out. Therefore a steeper balmer decrement is an indication of a more peripherical location of the emission line region.

For the analysis of periodic variations in the spectra phase diagramms were computed. The phase of each spectrum of the two outbursts was calculated using the photometrical period (photometric phase $\phi_0=0$ at hump maximum). The spectra were binned into similar phaseintervals of 0.1P. Figure 3 shows the result for Hβ. On the blue side of Hβ a sharp absorption is visible in the Mount Stromlo spectra which is caused by a pixel error in the spectra. In spite of this disturbance the assymetric shape is obvious. At Φ=0.9 there is a steep edge on the red wing, at Φ=0.4 this feature is found at the blue wing and at Φ=0.0 it is again visible at the red side of the line. This phenomenon can be observed for all hydrogen lines during all stages of the outburst. For radial velocity determination the line profile has been smoothed. The resultant radial velocities for the minimum of the absorption lines vary between +600 km/s and -600 km/s. They are twice as large as the radial velocities of the minimum spectra. An elliptic disc may account for this effect. A keplerian velocity of 4000 km/s at the inner part of the disc, an inclination angle between 50 and 70 degrees and a numerical excentricity of 0.15 would be sufficient to produce the required additional radial velocity component of 300 km/s.

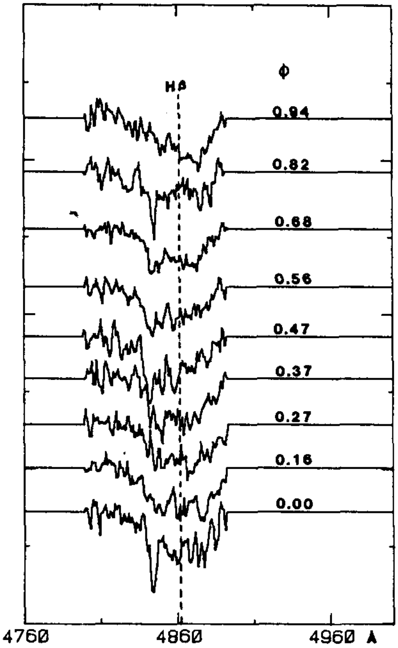

Figure 3: Phase diagramm of Hβ.

3. THE MINIMUM SPECTRA

11 spectra covering one photometric period have been collected during quiescence. Figure 4 shows the mean spectrum. Strong hydrogen emission lines and HeI 5876 are visible, no HeII lines were detected. The emission line features on the red side of Hβ may be due either to HeI 4922, 5016 or to the multiplett FeII 4924, 5018, 5169.

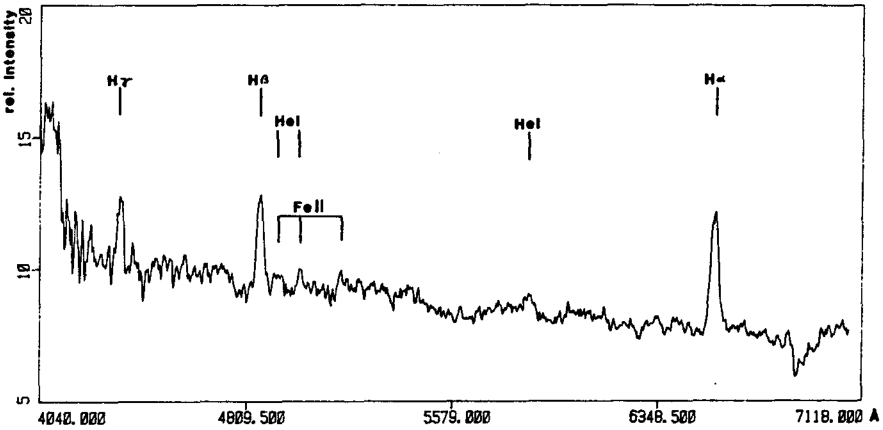

Figure 4: Mean spectrum of CN Orionis in quiescence.

Radial velocities have been computed by fitting a gaussprofile to the hydrogen emission lines. A least square fit yields K1 = 152 ± 10 km/s. Using the photometric period of 0.1639 d and the approximate angle of inclination between 60 and 70 degrees (Marschhaeuser 1986), the following system parameters were obtained:

P : $0.1639\ \mathrm{d} \pm 0.0002\ \mathrm{d}$
K1: $152\ \mathrm{km/s} \pm 10\ \mathrm{km/s}$
i : $64.5° < i < 70.0°$
q : $0.49 < q < 0.78$
M1: $0.69\ M_\odot < M1 < 1.19\ M_\odot$
R1: $0.003\ R_\odot < R1 < 0.013\ R_\odot$
M2: $0.54\ M_\odot < M2 < 0.58\ M_\odot$
R2: $0.54\ R_\odot < R2 < 0.58\ R_\odot$
a : $1.51\ R_\odot < a < 1.83\ R_\odot$

Table 1: System parameters.

4. Acknowledgement

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5. Literature

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