SPECTRAL VARIATIONS IN CH CYGNI DURING THE ACTIVITY PHASE IN 1982

A. SKOPAL
Astronomical Institute, Slovak Academy of Sciences,
Tatranská Lomnica, Czechoslovakia
M. MIKOLASJEWSKI
Institute of Astronomy, N. Copernicus University, Torun,
Poland
and
T. TOMOV
Bulgarian Academy of Sciences, Rozhen, Bulgaria.

ABSTRACT. Rapid variations of the radial velocities of absorption components of Ti II lines in CH Cyg are presented. The periods of these variations are determined to 1.89 and 41.07 days in 1982. The variations are interpreted through oscilliations in the mass transfer from the M component onto the accretion disk of the companion during periastron passage.

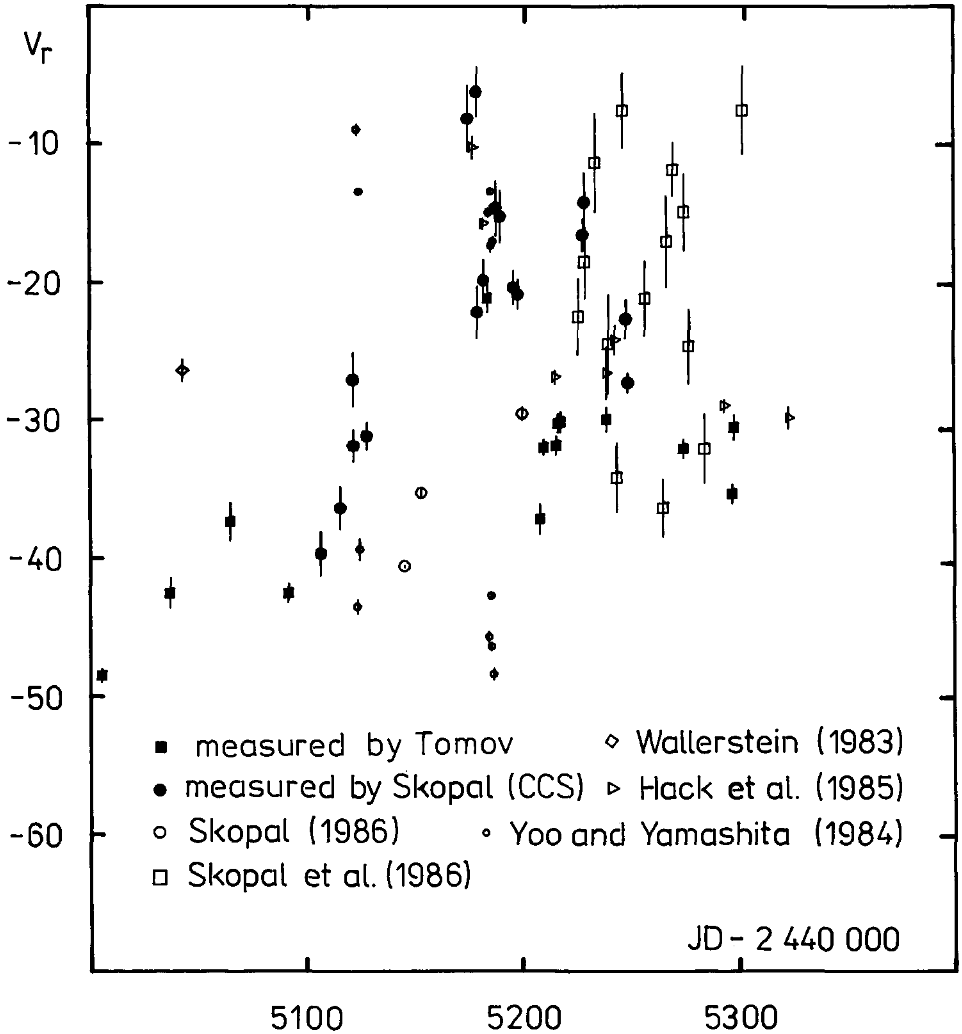
1. INTRODUCTION

The symbiotic star CH Cygni reached the maximum of its acitivity in 1982. The main features at this time are: the maximum of brightness is reached the intensity of the emission lines and the blue continuum is in creased, and a strong absorption shell spectrum with very sharp Ti II and Sc II lines and broad H I, He I, Mg II and Ca II lines has developed Wallerstein, 1983; Spiesman, 1984; Chochol et al., 1984; Chocol et al., 1984; Skopal, 1986). A remarkable feature is the splitting of the absorption components of ionized metals into two components (Wallerstein, 1983; Spiesman, 1984; already observed in 1981 (Chochol and Hric, 1982). A complicated structure of these lines of ionized metals, which consist of many components and show a large scatter of radial velocities was found by Luud and Tomov (1984). Hack et al. (1986) mention that during a recent outburst the radial velocities of the absorption components of Ti II increased from -35 km/s to about 0 km/s during about 300 days and then decreased from 0 km/s to -60 km/s in about 900 days. In the autumn of 1982, rapid changes of the radial velocities of

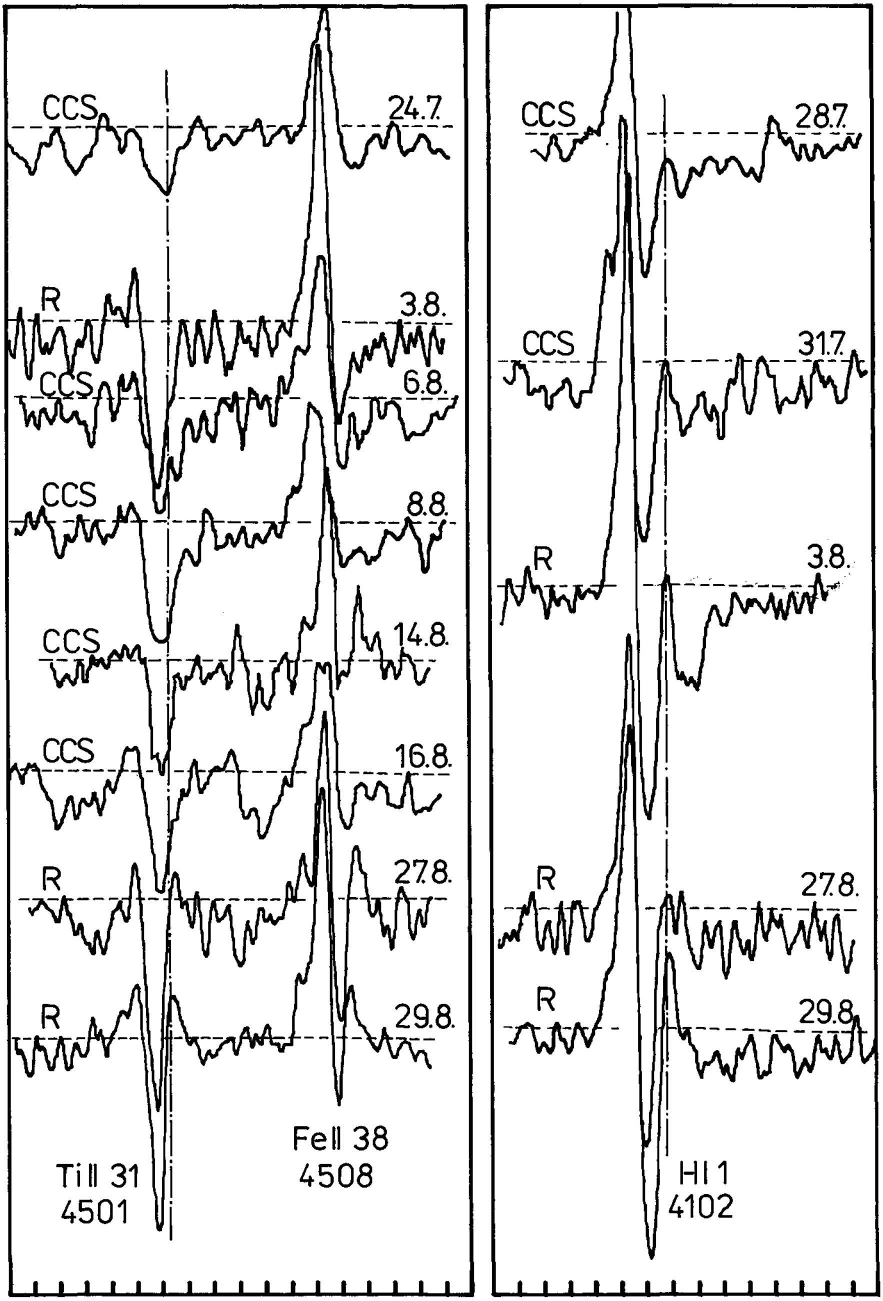
Paper presented at the IAU Colloquium No. 93 on 'Cataclysmic Variables. Recent Multi-Frequency Observations and Theoretical Developments', held at Dr. Remeis-Sternwarte Bamberg, F.R.G., 16–19 June, 1986.

Astrophysics and Space Science **131** (1987) 747–754.

Fig. 1. The radial velocities of the main absorption components of the spectral lines Ti II in CH Cyg in 1982. Yoo and Yamashita give the radial velocities of both components.



V_r
-10
-20
-30
-40
-50
-60
■ measured by Tomov
● measured by Skopal (CCS)
○ Skopal (1986)
□ Skopal et al. (1986)
◇ Wallerstein (1983)
▷ Hack et al. (1985)
∘ Yoo and Yamashita (1984)
JD - 2 440 000
5100
5200
5300



https://doi.org/10.1017/S0252921100105627 Published online by Cambridge University Press

Fig. 2. Intensity records of the time development of the profiles of ionized metals and hydrogen in CH Cyg. The dashed lines represent the radial velocity $RV_{hel} = 0$.

the Ti II lines were observed on a time scale of about 20 days (Skopal et al., 1986).

To explain these changes of radial velocities and absorption component profiles of ionized metals, CH Cyg is assumed to be a binary. The interpretations are mostly based on the assumption that gaseous streams between the components exist. Very large turbulence and high inhomogenity of the streams (Luud and Tomov, 1984; Too and Yamashita, 1984) or a different projection of these streams onto the accretion disk and its variations (Skopal, 1986) reflect the rapid changes mentioned above. Wallerstein (1983) interpreted the splitting of the absorption lines of ionized metals as indications for the existence of a shell star with two absorbing envelopes.

The aim of this paper is to show that these changes of the radial velocities and of the profiles of absorption lines can be interpreted as variations of the mass transfer rate from the cool M component onto the accretion disk of the companion when the system passes the periastron.

2. OBSERVATIONAL DATA AND RESULTS

In 1982, 17 moderately high dispersion (18 Å/mm) spectra of CH Cyg were obtained with the Canadian Copernicus Spectrograph (CCS) in the blue spectral region. The spectrograph was attached at the f/15 focus of the 90 cm Schmidt-Cassegrain telescope in Toruń Observatory. 14 spectroggrams (9 Å/mm) were obtained in the coudé focus of the 2-m telescope in the National Astronomical Observatory in Rozhen (see Luud and Tomov, 1984).

The values of the radial velocities of the absorption components of the Ti II spectral lines measured by us as well as published data are shown in Figure 1. Analysis of these data was performed (Yoo and Yamashita's values of the radial velocities of both components were omitted) through Fourier analysis and phase dispersion minimization. Both methods showed with good agreement two most significant periods of 1.89 and 41.07 days. The earlier analysis of the radial velocities showed very large orbital periods (about, 16 y). The short periods of the radial velocities of ionized metals found by us cannot reflect an orbital motion. Therefore to find the orbital period the data had to be selected. All the values of the radial velocities of ionized metals in the years 1983-83 higher than about -30 km/s were omitted. For the cool component all published values of radial velocities were used. The new preliminary orbital elements were computed using the code SPEL (Horn, 1986). The epoch of the periastron passage T_0 = 2 439 440±53 JD), the orientation of the orbit ($\omega = 183^{\circ}.7 \pm 3.8$) and its eccentricity ($e = 0.548 \pm 0.017$) are important in our considerations. The estimation of the Roche lobe for this eccentricity, the ratio of masses 3.5, the sum of masses 3.0 and the period 5888±42 days $R_{\odot}$ (Paczynski, 1971).

According to Luud and Tomov (1984), the radius of the M component in CH Cyg is 340±35 $R_\odot$. Since we do not exactly know the masses of the components of CH Cyg, we cannot exclude the possibility that the M giant fills its Roche lobe in periastron, and therefore mass transfer can take place.

Figure 2 shows the profiles of Ti II 34, λ4501 Å, Fe II 38, λ4508 Å and H I, λ4102 Å in the period from July 24, 1982 to August 29, 1982. The main feature of the changes in the line profiles is increasing depth of the red absorption wings of ionized metals (mainly Ti II, Sc II, Ca II) and H I. This behavior is dominant at the begining of August 1982. At the end of August the red emission components of these elements begin to increase.

3. INTERPRETATION

The observed changes of the radial velocities and line profiles can be interpreted as an oscillation of the mass transfer from the cool M component to the accretion disk around the hot component. The system CH Cyg passed the periastron at the end 1982 (T_0=2 439 440±53 JD) when the radial velocities reached their minimum. The transferred cooler matter infalling to the accretion disk increases at first the optically thick layer of the matter which lies in the projection onto the central part of the disk - the red absorption wings of the spectral lines will become deeper and therefore the radial velocities will be shifted to positive values. Then the matter reaches the optically thin outer parts of the accretion disk which are irradiated by the central star. The red emission components of the ionized metals increase and therefore the main absorption components become narrow and their radial velocities will be shifted to negative values. These changes have a period of about 40 days in 1982 (see Figure 2) to 20 days at the end 1982 (Skopal et al., 1986).

The frequency of the oscillations in the mass transfer can be caused by dynamical instabilities of the cool component filling its Roche lobe (Bath, 1984). Decreading Roche lobe before passage trough periastron increase the frequency of oscillations of mass transfer.

Short period (1.89 days) variations can be caused by an orbital motion of inhomogenities in the accretion disk as proposed by Bath (1977), but this behavior must be confirmed by photometric observations.

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