UV AND OPTICAL SPECTROSCOPY OF CH CYGNI IN 1980-86

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CH Cyg is a binary (P~5750 days) consisting of a normal M6-7 giant and an unseen companion. During active phase its spectrum is similar to that of a symbiotic star - the strong B-A continuum and numerous low-excitation emission lines dominate the visual and UV spectrum. The last outburst, started in 1977, is conspicuous by the highest brightness level observed since monitoring begun in 1935. In mid 1984, a drop in brightness was accompanied by large continuum and emission line changes and correlated with a radio outburst and two expanding jets appearance (Taylor et al. 1985).

In the following, physical conditions in CH Cyg are analyzed on the basis of low (150 Å/mm) and high (18 Å/mm) resolution spectra obtained at Torun Observatory and low resolution IUE spectra.

Fig.1 presents several examples of energy distributions in the optical spectrum, normalized to continuum at λ4275 Å.

Table 1. Observational data and parameters for HII region.

Period	Hα/Hβ	Hγ/Hβ	Hδ/Hβ	H8/Hβ	n_e (cm^{-3})	R($R_\odot$)
1980	8.7*	.25	-	-	$10^{10}-10^{11}$	25-100
1982/4	-	.28↗.34	.12↗.19	.07↗.1	$3x10^{10}-10^{11}$	40- 85
1984/5	-	.36	.25	-	$5x10^{9}-10^{10}$	57- 90
1985	2.7	.47	.20	-	$< 10^{8}$	$4x10^{3}$
1985/6	-	.39	.20	-	$\lesssim 10^{10}$	$\gtrsim 60$

* according to Blair et al. 1983, Ap.J. Suppl., 53, 573.

The electron density range was estimated by comparison of observed Balmer decrement with the teoretical decrements given by Drake and Ulrich (1980), assuming T_e =10000 K and E(B-V)=0. Then, the radii of the HII region were derived using emission measures for the Balmer continuum, assuming a distance d=330 pc (Mikołajewska et al. 1986). The values are given for five periods: 1980 - before maximum of activity;

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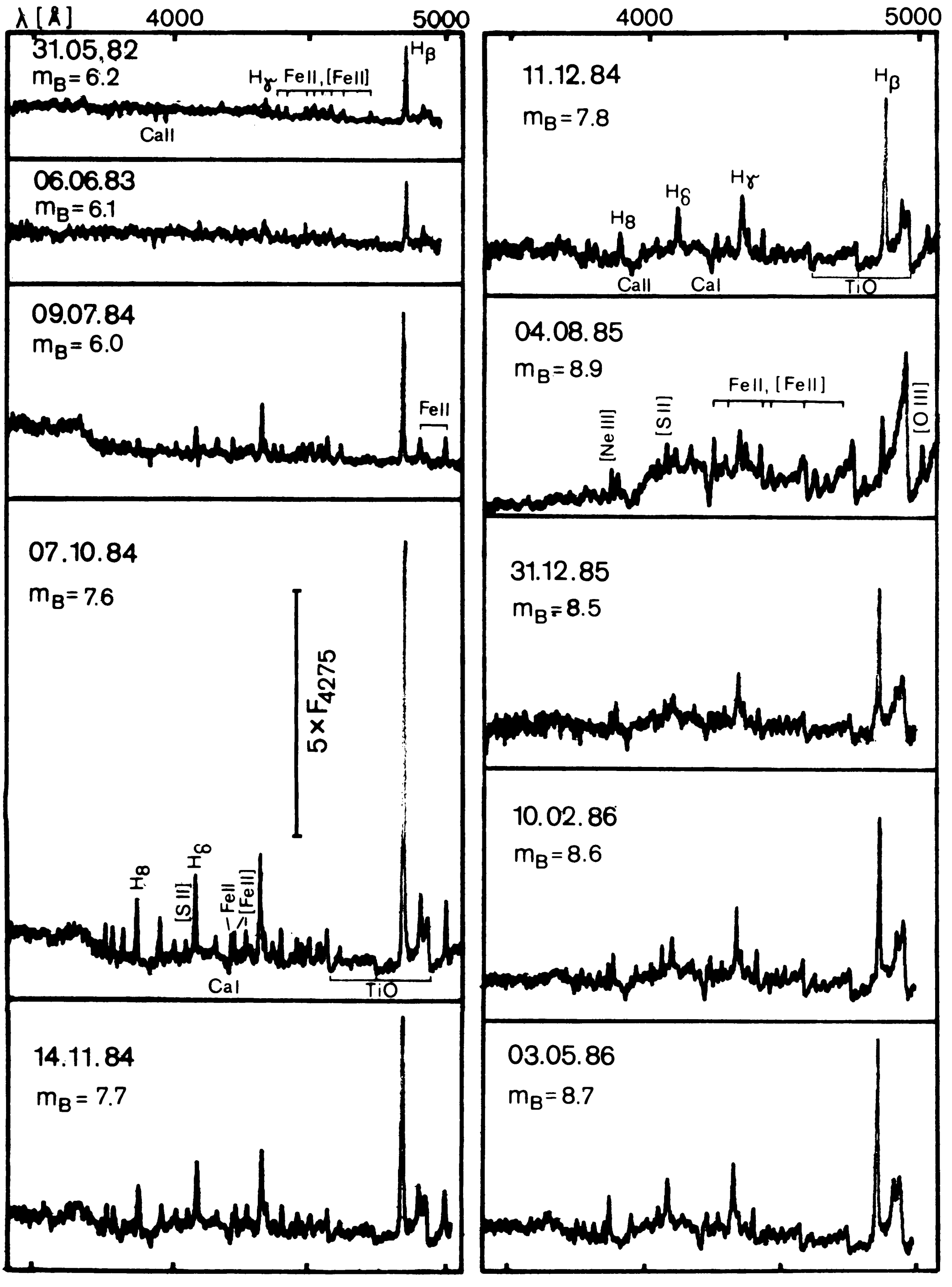

Figure 1. Low resolution optical spectra of CH Cyg: energy distribution F_λ / F_{4275} .

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1982/mid 1984 - maximum; mid 1984/Feb 1985 - after drop in brightness; Mar-Oct 1985 - minimum (see also Mikołajewski et al. 1986); 1985/6 - after minimum.

In Sept 1980 Balmer lines were visible up to H38 (Farragiana and Hack 1980), while in 1982-83 they were observed up to H30. This corresponds to $n_e = 4 \times 10^{10}$ cm^{-3} and R(HII)=42 $R_\odot$ in 1980, and $n_e \lesssim 10^{11}$ cm^{-3}, R(HII)$\gtrsim$40 $R_\odot$ in 1982-83

After the drop in brightness in mid 1984, the "nebular phase" with strong forbidden lines in optical and very rich and high-excitation emission line spectrum in UV range was observed. The ratio of CIII] lines implies $n_e = 5 \times 10^6$ cm^{-3} (Selvelli and Hack 1985), much lower than the values suggested by the observed Balmer decrement.

In Mar-Oct 1985, a deep minimum in U band and IUE integrated flux was observed and interpreted as an eclipse of a hot component (Mikołajewski et al. 1986). Weak single profile Balmer lines were observed instead of the double peaked lines present in the spectrum before and after the minimum, while forbidden lines remained strong. The average ratio of [OIII] 5007/4363=3.6 implies $T_e > 8000$ K and $n_e > 10^6$ cm^{-3}. Assuming the cosmic abundance of O/Ne and considering [OIII] 5007/[NeIII] 3869=1.4 we have $T_e = 10000$ K and $n_e = 8 \times 10^6 cm^{-3}$. All these n_e values are close to the derived from the CIII] lines and in agreement with the observed Balmer decrement. The value of $n_e = 10^7$ cm^{-3} was adopted for the R(HII) estimation.

The Balmer jump measured on our spectra was always in very good agreement with the values predicted by the fits for IUE spectra (Mikołajewska et al. 1986).

If the 1985 minimum is indeed due to an eclipse, than:

- The double peaked Balmer lines are formed close to the hot component possibly in a disk or a rotating envelope.
- Variations of Balmer decrement suggest a presence of two different regions: relatively small (R ~ 50-100 $R_\odot$) and dense ($n_e \sim 10^{10}$-10^{11} cm^{-3}) disk or envelope occulted during the minimum and extended (R~4000 $R_\odot$) low density ($n_e \sim 10^6$-10^7) region, possibly coinciding with jets, in which single profile HI lines and most of forbidden lines are emitted.
- X-ray detection in May 1985 (Leahy and Taylor 1986) suggests that X-ray emission arises from a region which is not close to the hot component (e.g. from jets).

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