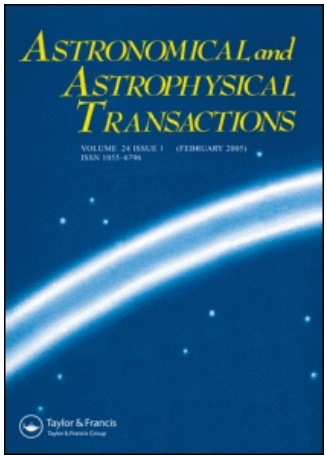

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CH CYGNI: A SYMBIOTIC STAR IN ITS TRANSITION PHASE TO QUIESCENCE

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In order to establish features of the transition period of the symbiotic star CH Cygni from activity to the quiescent phase, a behaviour of its cool component over the two years period (1987–1989) after its longest outburst has been investigated in the optical spectral region. Absorption and emission spectral lines have been measured and analysed. Physical parameters such as an excitation temperature and microturbulent velocity have been determined by the use of absorption lines and compared to the corresponding parameters belonging to normal stars of the same spectral type. The behaviour of the excitation temperature with time for some neutral metals suggests that quiescence has been reached gradually and that CH Cygni was very close to the condition of optical quiescency at the end of the investigated period. There was no evidence of a dependence of the microturbulent velocity on the temperature and of stratification with respect to the excitation potential. The emission line profiles, especially those of the first members of the Balmer series, proved to be a more reliable indicator of the transition to and from quiescence than the physical parameters.

KEY WORDS Symbiotic stars, individual stars, CH Cyg stars, M-type quiescence

1 INTRODUCTION

A behaviour of the symbiotic star CH Cyg over the two year period after its longest 1977–1986 outburst has been studied in the optical spectral region.

At the minimum brightness of its hot source CH Cyg is a semiregular variable star, a late type giant of spectral type of about M6 and luminosity class III (Mikolajewski *et al.*, 1990; Mikolajewski *et al.*, 1992). In active phases the radiation of the hot source is superimposed on that of the cool component, particularly in the short wave part of the optical region, and spectral features of a symbiotic star are observed (Deutsch, 1964; Faraggiana and Hack, 1971; Hack *et al.*, 1988). Signs of the radiation of a hot source are possibly present in the quiet phase and might be regarded either as remnants of a previous outburst or as possible indication of a new one (Jurdana and Kotnik-Karuza, 1994).

In order to establish the character of the quiescent period, we have investigated the behaviour of the excitation temperature and microturbulent velocity as well as the profiles of some emission lines, and compared them with the related phenomena in stars of the same spectral type and luminosity class: β And MOIII and 30 Her M6III. The former is interesting as a "normal" star (Hanni and Kipper, 1975) and the latter as a semiregular variable like the cool component of CH Cygni (Luttermoser *et al.*, 1994).

2 OBSERVATIONS AND METHODS

The spectrograms covering the 3800–6800Å spectral wavelength range at the dispersion of 12Å/mm and 10Å/mm were obtained respectively with the 152 cm and 193 cm telescope of the Haute Provence Observatory.

The time variation of the excitation temperature and microturbulent velocity of the neutral metals Fe I, Ti I, VI and Cr I during the quiescent period of CH Cyg have been measured. β And and 30 Her were taken for reference. The curve of growth method with refined fitting procedure has been used (Jurdana and Kotnik-Karuza, 1994). Difficulties in analysis of the line spectra of late type stars arise from an interference with strong molecular bands and heavy blendings of crowded absorption lines themselves. Under the assumption of reliable gf values, uncertainties of measurements of the spectra of given quality and errors in the derived physical parameters arise from difficulties of measuring weak lines, a possible departure from LTE and difficulties of locating continuum, although its truncation scarcely affects the values of the stellar atmosphere parameters being determined. For determination of the fiducial level of the continuum a smooth curve was fitted to the highest points of the peaks.

A larger source of error lies in the fact that the line wings are generally not well-defined in the spectra of cool stars.

3 RESULTS AND DISCUSSION

Absorption Lines

Absorption lines are formed in the photosphere of the cool component. They belong mainly to neutral metals and are, together with molecular bands, a dominant feature of the symbiotic spectrum in the quiescent phase. It looks like the spectra of M-type stars.

A regular decrease in the excitation temperature with time during the period 1987–1989 in CH Cygni for the investigated neutral metals Fe I, Ti I, V I and Cr I is evident, suggesting that quiescence with respect to this parameter is being reached gradually. Its value at the end of this period and only a few months before the first signs of the new activity is at the minimum and less than $T_{\rm exc}$ for 30 Her and β And

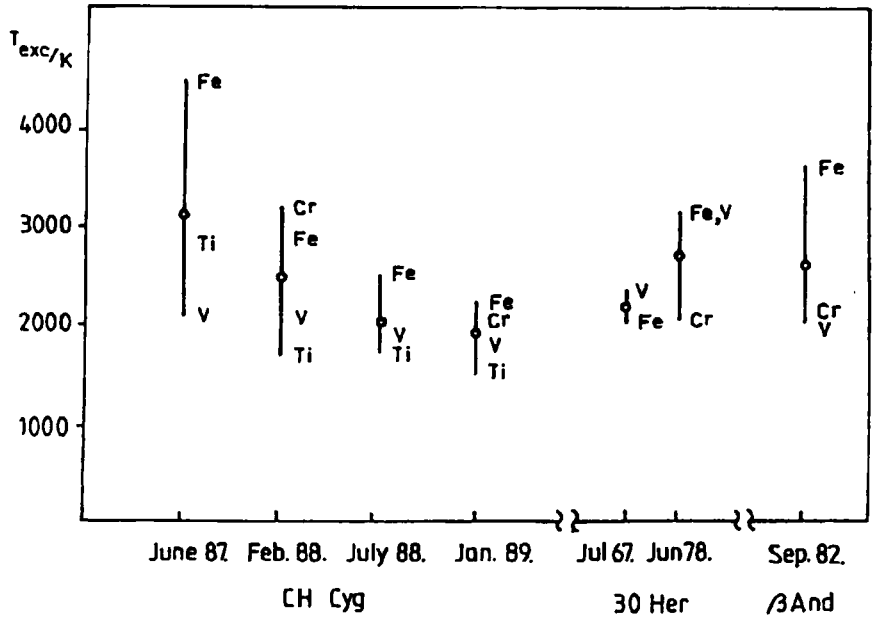

Figure 1 Excitation temperature of the neutral metals for CH Cyg, 30 Her and β And.

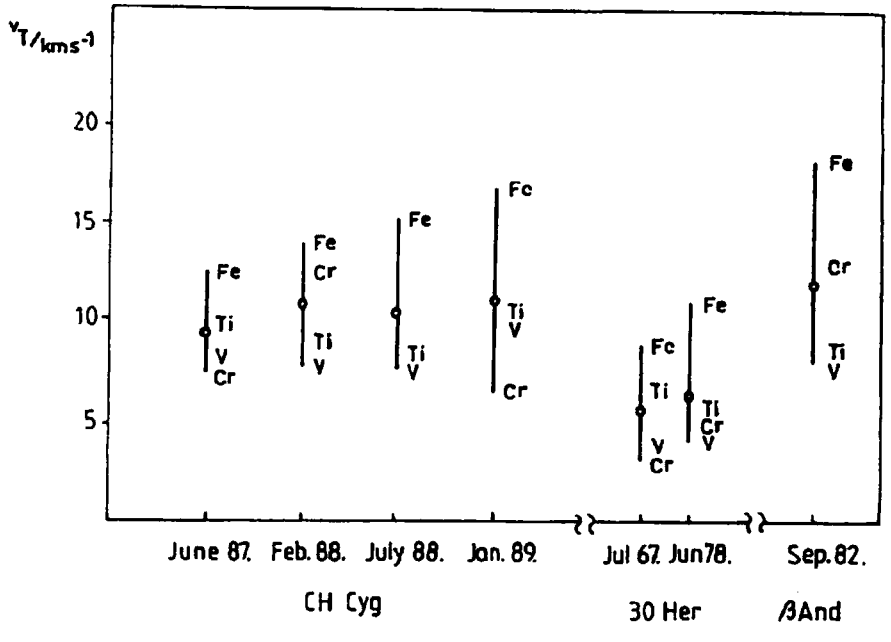

Figure 2 Microturbulent velocity of the neutral metals for CH Cyg, 30 Her and β And.

(Figure 1). This could be due to the variability of CH Cygni beetwen M6 and M7III spectral types. Compared to the variability of 30 Her in the interval 1967–1978, the changes in the excitation temperature during quigseence of CH Cygni are more pronounced. A decrease in the excitation temperature, for each of our investigated phases, with decreasing the atomic mass is evident in CH Cygni.

A pronounced maximum of the microturbulent velocity for Fe I with respect to the other elements in each phase of the quiescent period of CHCyg could be due to a remarkably larger ionization potential of Fe with respect to the other neutral metals studied (Figure 2).

There is no evidence of a dependence of the microturbulent velocity on the temperature. No substantial stratification has been found with respect to different excitation potential.

Emission Lines

Emission lines in the optical spectrum of CH Cygni in quiescence can generally be treated as traces of the activity phenomenon. Their origin is in the hot component. They are formed in the slowly expanding regions associated with the companion which fits in the accepted model of CH Cygni as a binary star (Kotnlk–Karuza *et al.*, 1992).

Emission lines do not appear in the spectra of the observed M stars 30 Her and β And except for the Fe II lines which proved to be nearly universal in the M-type stars as a natural consequence of the stellar surface temperature. Their intensity shows a tendency to increase with later spectral class and higher luminosity.

Only the first members of the Balmer series were observed. Hα and Hβ appeared as single emission lines with variable intensity, Hδ being very weak and decreasing toward the end of the investigated period. Hα and Hβ show temporarily a typical structure consisting of two emission wings separated by the central absorption of a variable intensity and above the continuum level (Kotnik–Karuza *et al.*, 1992). The intensity of both lines gradually decreases until July 1988 when the central absorption completely disappears.

Hα and Hβ appear again in Jan 1989 as two component emission lines of increasing intensity. This can be treated as a probable sign of a new outburst which announced itself in summer 1989 by reappearance of the blue continuum and noticable emission lines.

In the spectra of 30 Her recorded 1967 and 1978 no Balmer lines were observed. In β And Hα and Hβ appear as strong absorption lines. Compared to these stars CH Cyg in its quiescence has not completely lost the symbiotic features, moreover they were enhanced towards the end of the period indicating the onset of a new activity phase. Other emission lines such as Fe II, [Fe II], [O III], [S II] and [Ne III] were weak but continued to exist even in 1988 at the period of the minimum brightness of the hot source.

The [O III] λ5007 has been observed only in CH Cyg as a feature characteristic for the whole quiescent phase including a rectangular form in summer 1987. It consists of more components of different velocities and profiles.

4 CONCLUSION

We find the investigation of the largest observed quiescent phase of CH Cygn to be extremely important in establishing the origin and physical conditions of the symbiotic phenomenon.

Determination of the excitation temperature and microturbulent velocity of neutral metals contained in the photosphere of the cool component, as well as the investigation of emission lines, leads to the conclusion that the emission line profiles are a more reliable and sensitive indicator of the transition to and from quiescence than the physical parameters.

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