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LINE FORMATION IN CH CYG: A SYMBIOTIC BINARY

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RESUMEN

Aplicando el método SAC (curvas de auto-absorción) a la binaria simbiótica CH Cyg, hemos determinado la temperatura de excitación de los niveles metaestables de las transiciones prohibidas del Fe II y la temperatura de excitación de los niveles de las líneas permitidas del Fe II. Con estos parámetros hemos estimado las dimensiones de las regiones de formación de las líneas del Fe II. Hemos podido concluir que las líneas estudiadas pueden formarse en una zona del viento estelar próxima de la componente más caliente.

ABSTRACT

Applying the SAC (Self absorption curve) method to the simbiotic binary CH Cyg, we determine the excitation temperature of the [Fe II] line formation region, and that of the permitted Fe II lines. We estimate the dimensions of the Fe II line formation regions, and we conclude that these lines can form in a region of the wind starting to fall towards the hot component.

Key words: **BINARIES: CLOSE — LINE: FORMATION— STARS: INDIVIDUAL (CH CYG) — STARS: MASS LOSS**

1. THE SYMBIOTIC BINARY CH CYG

CH Cyg is a symbiotic binary containing an M6 III cool component and a compact companion, which may be a magnetic white dwarf, but whose nature is not very clear (Leedjärv et al. 1994). The latter appears to accrete from the wind of the former at certain times at least. The period of the binary is 5700 days, and eclipses may occur (Mikolajewska et al. 1988). Interaction should occur between the wind of the cool component, a probable wind from a disk, and a jet which appeared in 1984.

2. OBSERVATIONS

The spectrum of CH Cyg studied in this paper was obtained on the 23^{rd} November 1980 with the coudé spectrograph of the 1.52-m telescope at the Observatoire de Haute Provence (OHP), France, using a IIIaJ photographic plate (GB 6205). The observed spectral range is $\lambda\lambda 3175 - 5517$ Å and the spectrum has a dispersion of 11.9 Åmm^{-1}, producing a resolution of 0.26Å.

3. ANALYSIS OF FE II LINES

3.1. The Method

In view of the abundant Fe II emission lines in the spectrum, it is possible to study the properties of their region of formation, using the "*self absorption curve*" (SAC) method (Friedjung & Muratorio 1987, Muratorio

& Friedjung 1988; Muratorio et al. 1992; Viotti et al. 1994). This method gives information, *independently*, about the populations of the upper and lower terms of the spectral lines, as long as deviations from LTE are almost constant for the levels inside the same term. This is not possible with classical emission line curve of growth methods. In fact

$$Y = \log\,[F_{ul}\lambda^3/g_l f_{lu}] = Q(\tau) + \log\,[N_u/g_u] + H\,. \qquad (1)$$

Here, $\log F_{ul}$ is the line flux, g_l is the lower level statistical weight, f_{lu} is the oscillator strength, N_u is a characteristic upper level column density, g_u the upper level statistical weight and H is a geometrical factor. $Q(\tau)$ is a fuction of τ, which depends on deviations from homogeneity in the line formation region. H depends on the distance, the radius of the line emitting region, and a characteristic line width. The line opacity τ is related to $X = \log g_l f \lambda$, so that

$$X = \log \tau - \log\,[N_l/g_l] + \text{const.} \qquad (2)$$

with N_l the characteristic lower level column density. Graphs of X vs. Y can be drawn for different multiplets having different upper and lower terms; thus relative shifts give relative upper and lower term populations, and therefore excitation temperatures when the populations do not deviate too much from a Boltzmann distribution. The upper metastable levels of the usually optically thin forbidden Fe II lines [$Q(\tau)=0$ in eq. (1)] are lower terms of optical permitted lines, and the relative populations of the same terms can be found assuming line formation in the same region.

3.2. Obtained Results

Applying the method to CH Cyg, we find that the [Fe II] lines give an excitation temperature of the metastable levels of 3800 K. The permitted lines suggest very similar temperatures T = 3500 K, both for their upper and lower (metastable) terms. A population ratio of the metastable terms to that of the permitted line

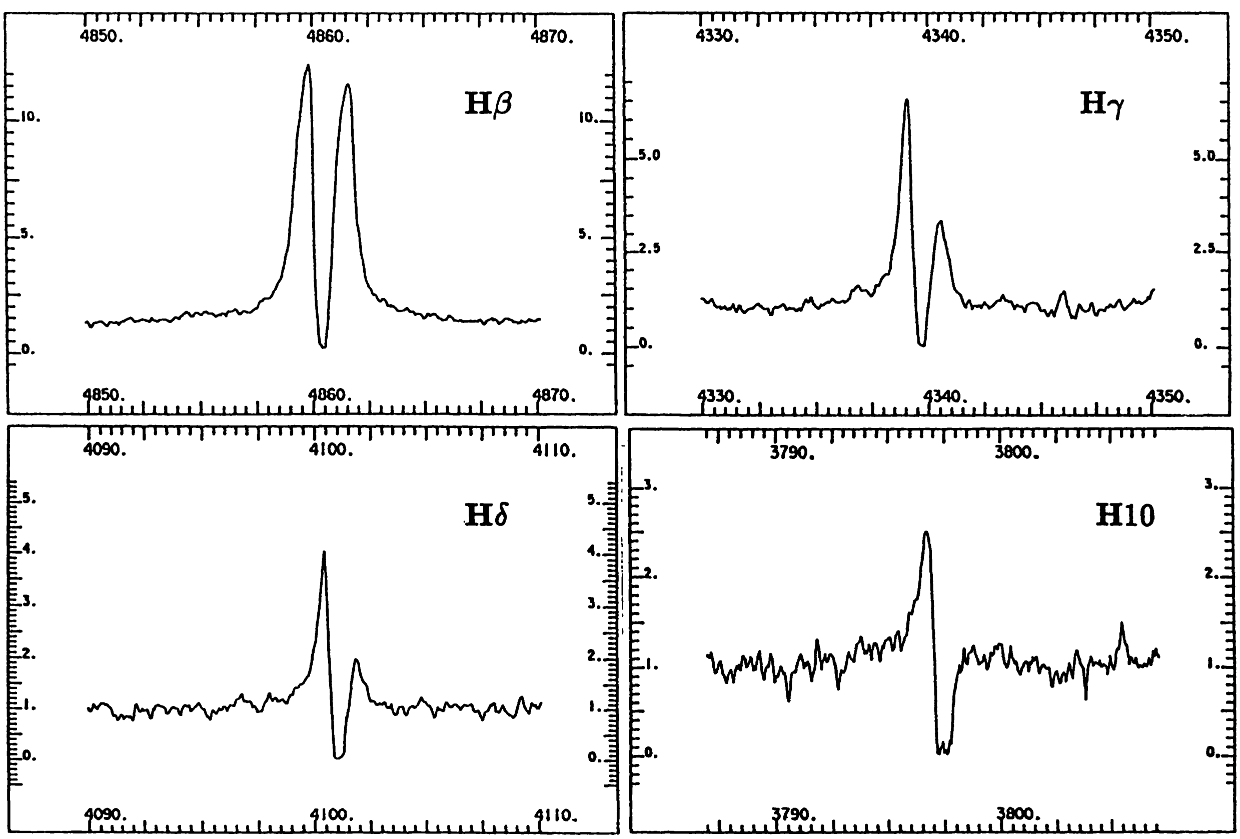

Fig. 1. Balmer lines of CH Cyg.

upper terms *in the region of formation of the permitted lines* of 4.28 dex is found by comparing the populations of the upper terms of the forbidden and permitted lines. This is an upper limit if the lines are formed in different regions, and also if Q(τ) is still finite for the weakest permitted lines seen. The maximum population ratio gives a maximum radius of R $\simeq$ 190 $R_\odot$ for the line formation region. If the population ratio is one corresponding to a Boltzmann law with a temperature of 3500 K, then the radius is R $\simeq$ 82 $R_\odot$. The FWHM values of at least the permitted Fe II lines of the order of 40–50 km s^{-1}, are larger than that corresponding to the Doppler effect of motions in the atmosphere of a cool giant or in normal regions of its wind. Lines could be formed in a region of the wind starting to fall towards the hot component.

4. THE BALMER LINES

The profiles of the Balmer lines near the beginning of the series are almost symmetrical with two peaks and a central absorption. As one proceeds along the Balmer series, the red peak fades more quickly and disappears. An "inverse P Cygni" profile is then seen for later lines of the series (see Fig. 1). The blending of the absorption component with the two emission components, whose relative intensity varies along the series, explains more easily its apparently increasing radial velocity for later lines in the series. The almost symmetric Hβ profile could be due to a rotating disk (Leedjärv et al. 1994), but the asymmetric shape of most Balmer profiles suggest asymmetry, perhaps in the accretion process.

REFERENCES

Friedjung, M., & Muratorio, G. 1987, A&A 188, 100

Leedjärv, L., Mikolajewski, M., & Tomov, T. 1994, A&A 287, 543

Mikolajewski, M., Szczerba, R., & Tomov, T. 1988 in The Symbiotic Phenomenon, ed. J. Mikolajewska, M. Friedjung, S.J. Kenyon, & R. Viotti (Kluwer: Dordrecht), 221

Muratorio, G., & Friedjung, M. 1988, A&A 190, 103

Muratorio, G., Viotti, R., Friedjung, M., Baratta, G.B., & Rossi C. 1992, A&A 258, 423

Viotti, R., Baratta, G.B., Friedjung, M., Muratorio, G., & Rossi, C. 1994, in STScI Workshop The analysis of Emission Lines, in press