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On the influence of Stark broadening of Cr I lines in the Cr-rich Ap star β CrB atmosphere

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Abstract. Using the semiclassical perturbation method, electron-, proton-, and ionized helium-impact line widths and shifts for the nine Cr I spectral lines from the $4p^7P^0 - 4d^7D$ multiplet, were calculated. The results were used to investigate the influence of Stark broadening effect in the Cr-rich Ap star β CrB atmosphere.

Key words. atomic processes: Stark effect – line: profiles – stars: chemically peculiar – stars: individual: β CrB

1. Introduction

Chromium is one of the most anomalous elements in Ap stars. It was shown to be concentrated in the deeper atmospheric layers in Ap stars β CrB and in γ Equ, where electron density is high enough to favor the Stark broadening mechanism, the most significant pressure broadening mechanism for A and B stars.

We present here new calculations of Cr I Stark line widths and shifts based on the semiclassical perturbation approach of Sylvie Sahal-Bréchot (Sahal – Bréchot 1969a,b). Electron-, proton-, and ionized helium-impact line widths and shifts for nine Cr I spectral lines from the $4p^7P^0 - 4d^7D$ multiplet, were calculated for a perturber density of 10^{14} cm^{-3} and for temperatures T = 2,500 − 50,000 K.

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2. Results and Discussion

The results were used to investigate the influence of Stark broadening effect on Cr I line shapes in the atmosphere of the Cr-rich Ap star β CrB. In spite of the rather large Stark damping constants, the effect is not observable in stars with solar Cr abundance. In hot stars where electron and proton densities are high, the Cr I, lines considered here are generally very weak, while in cooler stars (solar type) other broadening effects are more significant where these lines are strong enough. The only chance to look at Stark effect is in stratified at-

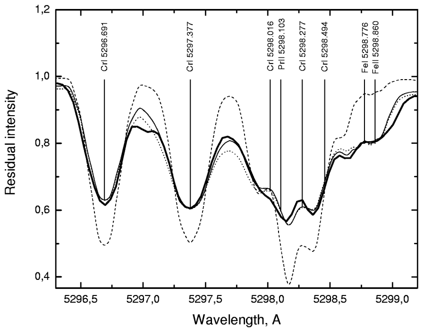

Fig. 1. A comparison between synthetic spectrum calculations and the observed spectrum (thick line) of magnetic Ap star β CrB in the region of Cr I 5297 Å line. Full thin line - calculations with stratification and Stark broadening data (Dimitrijević et al. 2005) decreased by 70 %; dashed line - the same Stark broadening data but homogeneous Cr and Fe abundances; dotted line - stratified Cr and Fe abundances, but Stark broadening calculated with the approximation formula.

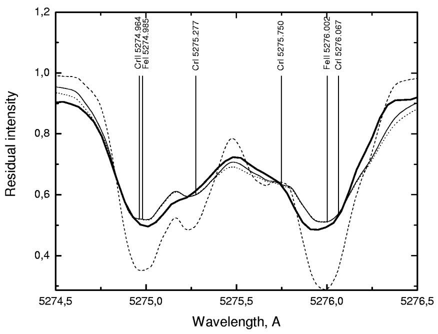

Fig. 2. Same as in Fig. 1 but for 5276 Å line.

mosphere of a Cr-rich Ap star, such as the well known magnetic star β CrB.

Our analysis of the Cr-rich Ap star β CrB line shapes was based on its spectrum obtained in February 1998 with the MuSiCoS spectropolarimeter mounted on the 2 m telescope at Pic du Midi observatory (R=35000).

From our investigation we can conclude (Dimitrijević et al. 2005):

(i) Although they belong to the same multiplet, the widths and shifts of the different lines can be quite different.

(ii) Contribution of the proton and He II collisions to the line width and shift is significant and is comparable and, depending of the electron temperature, even larger than electron-impact contribution.

(iii) Depending on the electron-, proton-, and He II density in stellar atmospheres, the Stark shift may contribute to the blue, as well as to the red, asymmetry of the same line.

(iv) To fit Cr I line wings well we need to decrease the calculated Stark widths by 60-70%, which is the same order of overestimation as for Si I lines (Dimitrijević et al. 2003). Used in the cases where the adequate semi-classical calculation is not possible due to the lack of reliable atomic data, the approximation formula of (Cowley 1971) also predicts the overestimated influence of Stark broadening in comparison with observations.

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