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STARK BROADENING OF Co II SPECTRAL LINES FOR STELLAR SPECTRA INVESTIGATIONS

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Abstract. Stark Full Widths at Half Maximum for 46 Co II multiplets have been calculated in Majlinger et al. (2018) by modified semiempirical method described in Dimitrijević and Konjević (1980). The calculated results have been used to investigate the importance of Stark broadening mechanism for Co II lines in A type star and DA and DB white dwarf atmospheres (Majlinger et al., 2020). Stark broadening parameters from this paper will enter in the STARK-B database (http://stark-b.obspm.fr/). Here, as an example of obtained results, the influence of Stark broadening on two multiplets of ionized cobalt in atmospheres of DA and DB white dwarfs has been shown. It has been demonstrated that Stark broadening is more significant for DB white dwarfs and for larger wavelengths.

1. INTRODUCTION

Important applications of Stark broadening data are for research, analysis and synthesis of stellar spectra (see e.g. Dimitrijević and Sahal-Bréchot, 2014). One such element without the convenient Stark broadening parameters in literature is Co II. Its spectral lines have been observed in many stars as for example in so-called Cobalt Ap stars (Co-stars), where anomalous excess of cobalt abundance is observed as HD 200311 (Adelman, 1974) and HD 203932 (Gelbmann et al., 1997).

In order to provide Stark broadening parameters of Co II spectral lines for stellar plasma analysis, we have calculated Stark widths for 46 Co II multiplets using the modified semiempirical method (Dimitrijević and Konjević, 1980), and published them elsewhere (Majlinger et al., 2018, 2020b). Using these data we also investigated the influence of Stark broadening in atmospheres of A-type stars and DA and DB white dwarfs (Majlinger et al., 2020a).

In order to demonstrate the importance of obtained data for Co II Stark broadening parameters for investigation of Co II lines in stellar spectra we compare here as an example, using the obtained results, Stark and Doppler widths as functions of

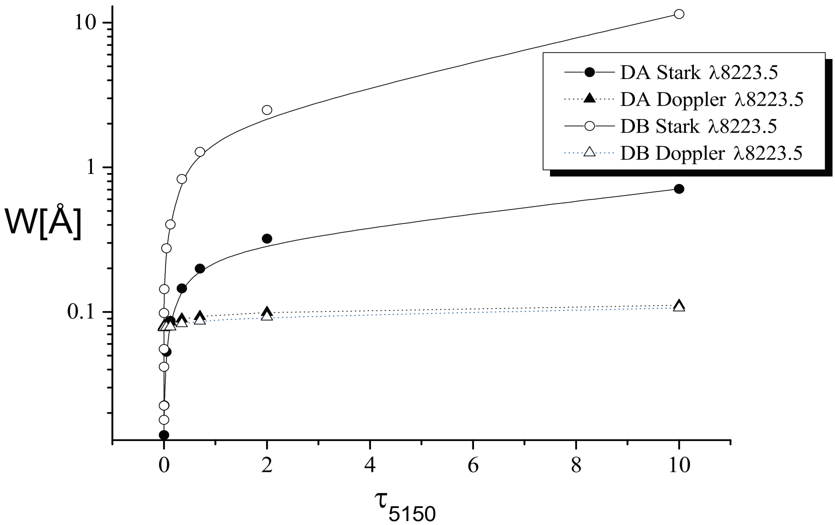

Figure 1: Comparison of Stark and Doppler broadening influence on Co II line λ8223.5 in the atmosphere of DA and DB white dwarf respectively, as a function of optical depth. Model parameters T_{eff} = 15000 K and log g = 8 are used (Wickramasinghe, 1972)

optical depth and temperature of atmospheric layers in the case of DA and DB white dwarfs.

2. RESULTS AND DISCUSSION

In Figs. 1-4 the comparisons of Stark and Doppler widths for Co II(^{4}P)4s b^{3}P - (^{4}P)4p z^{3}S^o, λ = 2613.4 Å and Co II (^{4}F)5s e^{5}F - (^{4}F)5p ^{5}G^o, λ = 8223.5 Å is shown for DA and DB white dwarf model atmospheres of Wickramasinghe (1972), with the effective temperature T_{eff} = 15000 K and the surface gravity log g = 8. In Figs. 1 and 2, the comparisons of Stark and Doppler widths for Co II λ = 8223.5 Å is given for the mentioned DA and DB white dwarf models as a function of the optical depth τ_{5150} for 5150 Å (Fig. 1) and as a function of layer temperature (Fig. 2). The same comparisons but for Co II λ = 2613.4 Å are shown in Figs. 3 and 4.

Co II λ = 2613.4 Å is in the ultraviolet part of the spectrum, while Co II λ = 8223.5 Å is in the infrared part of the spectrum. We can see that the influence of Stark broadening in comparison with Doppler broadening is larger for λ8223.5 in the infrared than for λ2613.4 in the UV part of the spectrum. This is the consequence of the fact that the larger wavelength means that the corresponding atomic energy levels are closer, so that the perturbation of the emitter during a collision is larger, since the probability for such transition is higher, and the resulting spectral line is broader. Additionally, Stark widths are proportional to λ^2 and Doppler ones to λ (see e.g. Majlinger et al., 2020ab).

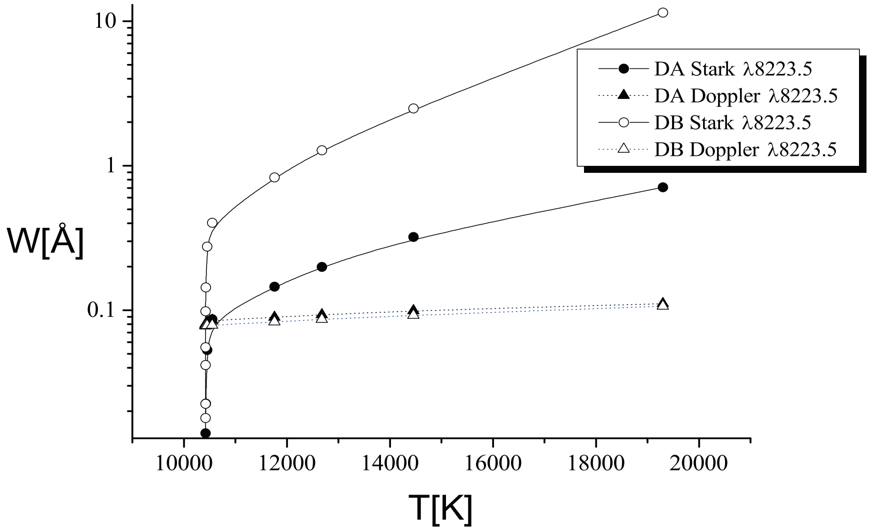

Figure 2: Same as in Fig. 1, but as a function of atmospheric layer temperature instead of optical depth, with the same model parameters.

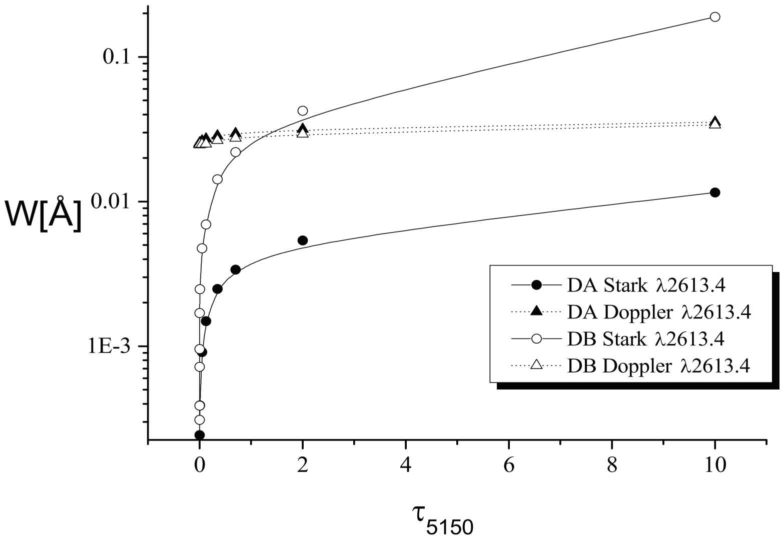

Figure 3: Comparison of Stark and Doppler broadening influence on Co II line $\lambda 2613.4$ in the atmosphere of DA and DB white dwarf respectively, as a function of optical depth. Same model parameters are used as for Fig.1 and Fig. 2.

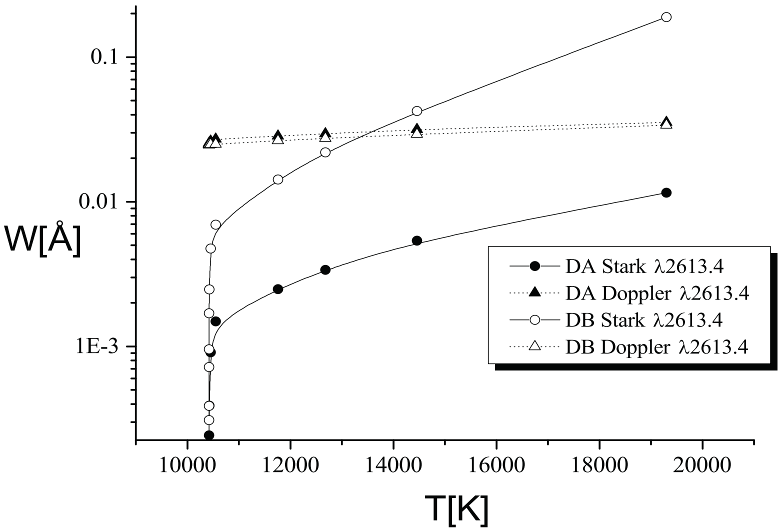

Figure 4: Same as in Fig. 3, but as a function of atmospheric layer temperature instead of optical depth, with the same model parameters.

We can see in Figs. 1-4 that Stark broadening is more important for helium-rich DB white dwarfs than for hydrogen-rich DA white dwarfs. This difference between the importance of Stark broadening in comparison with thermal Doppler broadening is due to the fact that a helium-rich DB white dwarf can generate more free electrons when helium atoms are mostly ionized, than hydrogen-rich DA white dwarf, causing higher perturber density (Majlinger et al., 2020b).

The Stark widths of 46 Co II multiplets obtained in Majlinger et al. (2018, 2020b) will be implemented in the STARK-B database (Sahal-Bréchot et al., 2015), which enter in the Virtual Atomic and Molecular Data Center - VAMDC (Dubernet et al., 2016, Albert et al., 2020).

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