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The influence of Stark broadening on Xe VIII spectral lines in DO white dwarfs

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Recently, Stark broadening parameters have been calculated for a large number of Xe VIII spectral lines, for broadening by electron, proton, and He III impacts, using the impact semi-classical perturbation approach. The obtained results for 6s $^2S_{1/2}$–6p $^2P^o_{1/2}$ transition have been used here to study the influence of Stark broadening on spectral lines in DO white dwarf atmospheres and the importance of Stark broadening due to collisions with electrons, protons and He III ions is shown.

Keywords: Stark broadenig; atomic data; DO white dwarfs, Xe VIII

1 Introduction

In white dwarfs, pre white dwarfs, and post AGB (Asymptotic Giant Branch) star atmospheres, Stark broadening is usually the principal line broadening mechanism. Its influence on the spectral lines in DA and DB white dwarfs has been studied many times (Popović, Dimitrijević & Tankosić (1999); Tankosić, Popović & Dimitrijević (2003); Milovanović et al. (2004); Simić et al. (2006); Dimitrijević et al. (2011); Dufour et al. (2011); Larbi-Terzi et al. (2012); Simić, Dimitrijević & Sahal-Bréchot (2013); Simić, Dimitrijević & Popović (2014)), and its importance has been shown. DO white dwarfs are hotter than DA and DB ones, with effective temperatures from approximately 45 000 K up to around 120 000 K (Dreizler & Werner, 1996), and are even more interesting from the point of view of Stark broadening. However, concerning them there is only the study of Hamdi et al. (2008) who investigated the influence of

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Stark broadening on the Stark widths of Si VI spectral lines in atmospheres of DO white dwarfs. Recently, Werner et al. (2012) analyzed the spectrum of the DO white dwarf RE 0503-289 ($T_{\rm eff}$ = 70 000 K, Dreizler & Werner (1996)), obtained by FUSE (Far Ultraviolet Spectroscopic Explorer) and they found spectral lines of different highly charged xenon ions.

Our aim here is to study the influence of Stark broadening on Xe VIII spectral lines. For this reason we will use electron-, proton-, and He III-impact broadening parameters, widths and shifts, for Xe VIII 6s $^2S_{1/2}$–6p $^2P^o_{1/2}$ transition, obtained in Dimitrijević et al. (2015) using the impact semi-classical perturbation method (SCP, Sahal-Bréchot (1969a,b)).

2 Results and discussions

The electron-, proton-, and He III-impact widths and shifts for Xe VIII 6s $^2S_{1/2}$–6p $^2P^o_{1/2}$ transition from Dimitrijević et al. (2015), used here for investigation of the influence of Stark broadening in DO white dwarf spectra, are presented in Table 1.

Table 1 This table gives electron-, proton-, and doubly charged helium-impact broadening parameters for Xe VIII lines, from Dimitrijević et al. (2015) for a perturber density of 10^{17} cm^{-3} and temperatures from 20 000 to 500 000 K. Calculated wavelength of the transitions (in Å) is also given. The notation is W_e: electron-impact full width at half maximum of intensity, d_e: electron-impact shift, W_p: proton-impact full width at half maximum of intensity, d_p: proton-impact shift, $W_{He^{++}}$: doubly charged helium ion-impact full width at half maximum of intensity, $d_{He^{++}}$: doubly charged helium ion-impact shift. A positive shift is toward the red.

Transition	T [K]	W_e [Å]	d_e [Å]	W_{H^+} [Å]	d_{H^+} [Å]	$W_{He^{++}}$ [Å]	$d_{He^{++}}$ [Å]
6s ^{2}S–6p ^{2}P^o	20000	0.103	0.258E-02	0.203E-03	-0.152E-03	0.391E-03	-0.262E-03
1/2 - 1/2	50000	0.644E-01	-0.103E-02	0.747E-03	-0.426E-03	0.148E-02	-0.816E-03
2088.5 Å	100000	0.463E-01	-0.130E-02	0.160E-02	-0.819E-03	0.317E-02	-0.163E-02
	200000	0.344E-01	-0.125E-02	0.260E-02	-0.134E-02	0.519E-02	-0.268E-02
	300000	0.294E-01	-0.149E-02	0.325E-02	-0.161E-02	0.648E-02	-0.323E-02
	500000	0.246E-01	-0.135E-02	0.383E-02	-0.203E-02	0.766E-02	-0.407E-02

Electron-impact and Doppler widths are presented in Fig. 1 for the Xe VIII 6s $^2S_{1/2}$–6p $^2P^o_{1/2}$ (λ = 2088.5 Å) spectral line for three atmospheric models (Wesemael, 1981) with surface gravities log g = 6, 7 and 8, and $T_{\rm eff}$ = 80 000 K, as a function of logarithm of Rosseland optical depth (log τ). One can see that electron-impact broadening is dominant in comparison with the concurrent broadening mechanism, the Doppler broadening, for practically all relevant optical depths except the very low ones. Also we can see that the influence of electron-impact broadening increases rapidly with the increase of log g.

Figure 2 presents the proton-impact and Doppler widths for the same Xe VIII line, and for the same atmospheric models as in Fig. 1. Proton density is taken

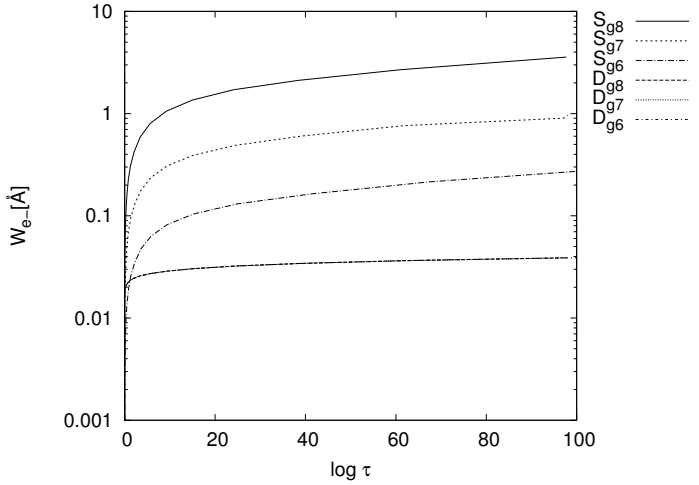


Figure 1 Electron-impact and Doppler widths for Xe VIII 6s $^2S_{1/2}$–6p $^2P^o_{1/2}$ (λ = 2088.5 Å) spectral line as a function of logarithm of Rosseland optical depth ($\log \tau$). Electron-impact (S) and Doppler (D) widths are shown for three atmospheric models (Wesemael, 1981) with surface gravities $\log g = 6$ (S_{g6}, D_{g6}), 7, 8, and $T_{\rm eff}$ = 80 000 K. The difference between Doppler curves for three surface gravities is so small that they are superimposed.

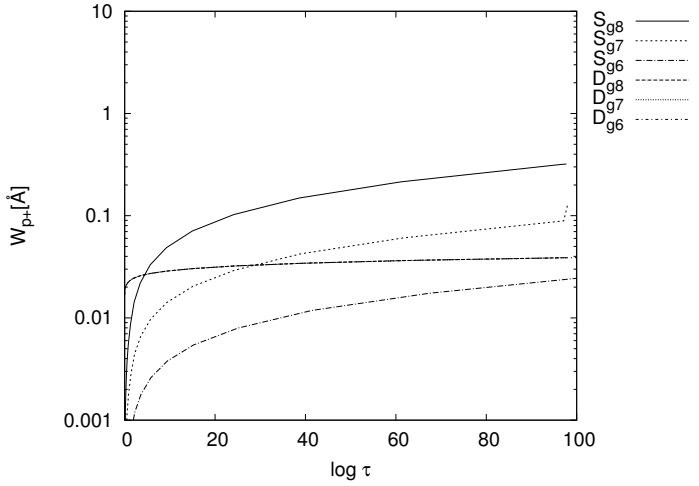


Figure 2 Same as in Fig. 1 but for proton-impact widths.

to be equal to electron density, so it is assumed a hydrogen atmosphere. One can see that the influence of proton-impact broadening is much lower in comparison with electron-impact and that of the lowest considered $\log g = 6$, the Doppler width is always dominant in comparison with proton-impact width for all considered optical depths and temperatures of atmospheric layers, while for the higher values of $\log g$ atmospheric layers where proton-impact broadening is dominant exist.

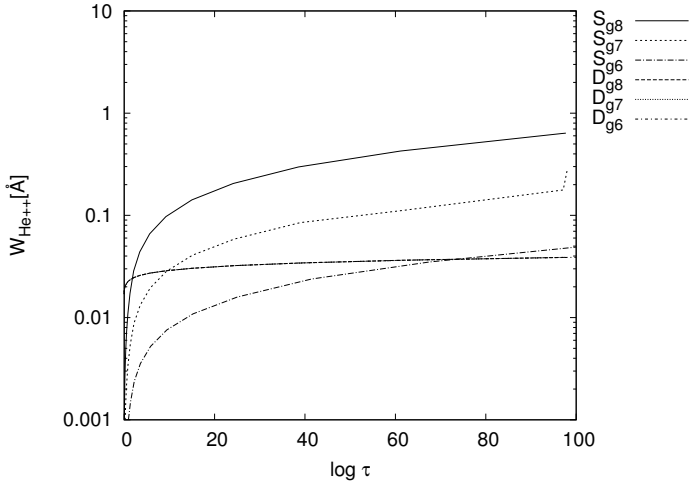


Figure 3 Same as in Fig. 1 but for He III-impact widths.

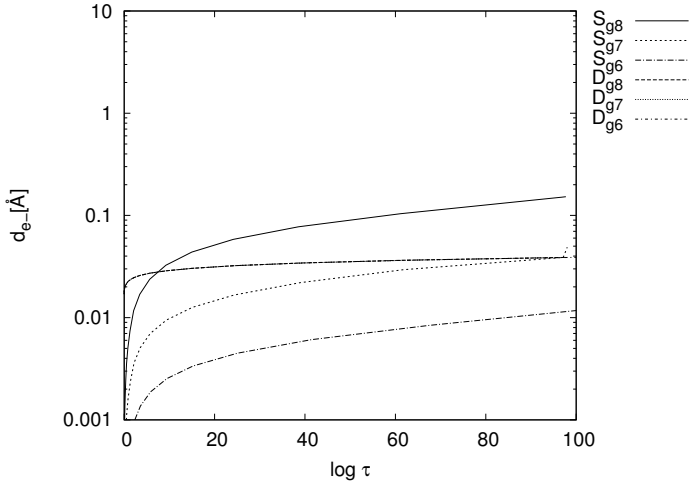


Figure 4 Same as in Fig. 1 but for electron-impact shifts and Doppler widths.

The same analysis has been performed in Fig. 3 for He III impacts, assuming that the He III density is equal to electron density. Of course this is just to demonstrate the importance of He III broadening and if several ions are important the true atmospheric composition should be taken. One can conclude that the influence of He III-impact broadening is higher than in the case of proton-impact and that it usually cannot be neglected in the case of a helium atmosphere, especially for higher surface gravities, optical depths and the corresponding atmospheric layer temperatures.

In Fig. 4 electron-impact shifts are presented for the same cases as in Fig. 1. In order to have an idea of their importance, the values of the corresponding Doppler widths are also shown. One can see that electron-impact shifts may be important

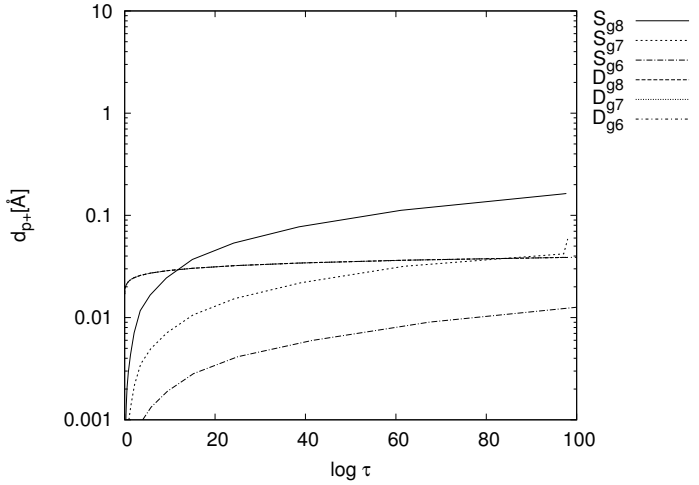


Figure 5 Same as in Fig. 1 but for proton-impact shifts and Doppler widths.

and that they cannot be neglected *a priori* without checking their significance for the relevant problem. The same is shown in Fig. 5 for proton-impact shifts.

Conclusions

The obtained results show that electron-impact broadening is dominant in practically all important layers of DO white dwarf atmospheres in comparison with Doppler width and that its importance increases with the increase of Rosseland optical depth, atmospheric layer temperature and particularly with the increase of surface gravity. It has been demonstrated that proton-impact and He III-impact widths may be also important as well as the corresponding shifts, and could not be neglected without checking.

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