Proc. VI Serbian-Bulgarian Astronomical Conference, Belgrade 7-11 May 2008,
Eds. M. S. Dimitrijević, M. Tsvetkov, L. Č. Popović, V. Golev
Publ. Astr. Soc. "Rudjer Bošković", No. 9, 2009, 421-424

ON THE STARK BROADENING OF Cr II $3d^5 – 3d^4$ 4p SPECTRAL LINES IN HOT STAR SPECTRA

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Abstract. In this paper, we presented Stark broadening parameters for four Cr II $3d^5$-$3d^4$ 4p multiplets calculated by the semiclassical perturbation approach. The obtained Stark broadening parameters were applied to the analysis of Cr II line profiles in hot star spectra.

1. INTRODUCTION

Recently, the effect of Stark broadening on the shapes of Cr II spectral line observed in stellar atmospheres of the middle part of the main sequence was investigated in Dimitrijević et al. (2007) and it was found that Stark broadening mechanism is important and should be taken into account especially in the study of Cr abundance stratification. Particularly interesting are resonance lines investigated here, since they are often present in stellar spectra.

There are no experimental and other theoretical data for the four Cr II multiplets. Here, we note that Cr II $3d^5\ ^4F$-$3d^4\ 4p\ ^4P^o$ 6073.4 Å belongs to forbidden transitions. We consider this transition because it was observed in laboratory.

Here, we analized the influence of Stark broadening effect for four Cr II $3d^5$-$3d^4$ 4p multiplets in hot A-type stellar atmospheres.

2. RESULTS AND DISCUSSION

Calculations have been performed within the semiclassical perturbation formalism, developed and discussed in Sahal-Bréchot (1969ab). For updates see e.g. Dimitrijević (1996). Atomic energy levels needed for calculations have been taken from Wiese and Musgrove (1989). The oscillator strengths have been calculated within the Coulomb approximation (Bates and Damgaard, 1949; and the tables of Oertel and Shomo, 1968). For higher levels, the method of van Regemorter et al. (1979) has been used.

Here, results are presented in Table 1, electron-, and proton-impact broadening parameters for four Cr II $3d^5$-$3d^4$ 4p multiplets for a perturber density of $10^{17}cm^{-3}$ and temperatures from 5000 up to 100000 K. The quantity C (given in Å cm^{-3}), when divided by the corresponding full width at half maximum, gives an estimate for the maximum perturber density for which tabulated data may be used.

Table 1. Electron-, and proton-impact broadening parameters for four Cr II $3d^5$-$3d^4$ 4p multiplets obtained by using the semiclassical perturbation method (Sahal-Bréchot 1969ab).

Transition	T(K)	W_e-(Å)	d_e-(Å)	W_{p+}(Å)	d_{p+}(Å)
	5000	0.514E-01	-0.334E-03	0.148E-02	-0.542E-04
CrII	10000	0.382E-01	-0.379E-03	0.268E-02	-0.120E-03
^6S-$^6P^o$	20000	0.282E-01	-0.438E-03	0.382E-02	-0.232E-03
2060.4 Å	30000	0.238E-01	-0.425E-03	0.431E-02	-0.311E-03
C=0.15E+21	50000	0.196E-01	-0.460E-03	0.473E-02	-0.405E-03
	100000	0.157E-01	-0.515E-03	0.528E-02	-0.547E-03
	5000	0.382	0.718E-01	0.102E-01	0.117E-02
CrII	10000	0.284	0.491E-01	0.175E-01	0.244E-02
^4F-$^4D^o$	20000	0.212	0.378E-01	0.244E-01	0.416E-02
4588.2 Å	30000	0.182	0.319E-01	0.268E-01	0.505E-02
C=0.40E+21	50000	0.155	0.265E-01	0.295E-01	0.639E-02
	100000	0.133	0.219E-01	0.329E-01	0.770E-02
	5000	0.480	0.743E-01	0.120E-01	0.874E-03
CrII	10000	0.358	0.514E-01	0.209E-01	0.188E-02
^4F-$^4F^o$	20000	0.268	0.399E-01	0.293E-01	0.337E-02
5279.6 Å	30000	0.229	0.338E-01	0.325E-01	0.425E-02
C=0.53E+21	50000	0.194	0.274E-01	0.357E-01	0.546E-02
	100000	0.165	0.229E-01	0.398E-01	0.679E-02
	5000	0.793	0.264	0.144E-01	0.411E-02
CrII	10000	0.577	0.197	0.258E-01	0.806E-02
^4F-$^4P^o$	20000	0.425	0.155	0.368E-01	0.127E-01
6073.4 Å	30000	0.357	0.134	0.414E-01	0.156E-01
C=0.70E+21	50000	0.294	0.110	0.459E-01	0.184E-01
	100000	0.255	0.920E-01	0.521E-01	0.221E-01

In order to see the influence of Stark broadening mechanism for Cr II spectral lines in stellar plasma conditions, we have calculated the Stark widths for Cr II multiplets ^6S-$^6P^o$ (2060.4 Å) and ^4F-$^4F^o$ (5279.6 Å) for a Kurucz's (1979) A type star atmosphere model with T_{eff} = 10000 K and log g =4.5. From Fig. 1 one can see the existence of atmospheric layers where Doppler and Stark widths are comparable and where Stark width is important in some photospheric and subphotospheric layers of A-type star. Also, we note here in the case of Cr II multiplet 5279.6 Å great importance for the transitions from visual range. In the following two Figs 2. and 3. we presented Cr II multiplet 5279.6 Å for different parameters of effective temperatures and logarithm of surface gravities for A type star. In the case with variable values for logarithm of surface gravity for an A type stars (Fig. 3) importance of Stark broadening increasing throughout of stellar atmospheres for higher value of this parameter.

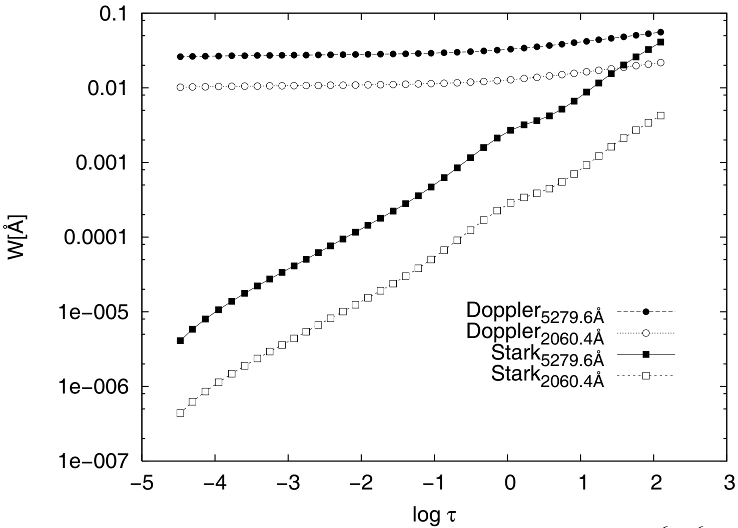

Figure 1: Thermal Doppler and Stark widths for Cr II multiplets ^{6}S-^{6}P^o (2060.4 Å) and ^{4}F-^{4}F^o (5279.6 Å), for an A type star atmosphere model with T_{eff} = 10000 K and log g = 4.5, as a function of the Rosseland optical depth.

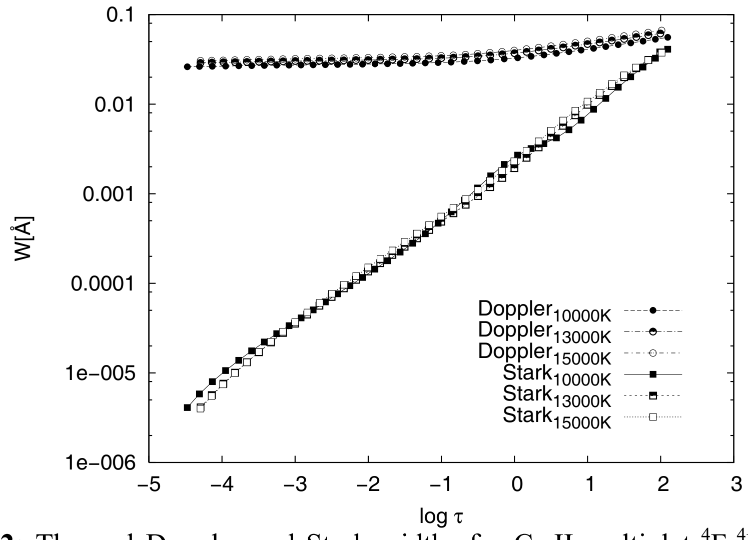

Figure 2: Thermal Doppler and Stark widths for Cr II multiplet ^{4}F-^{4}F^o (5279.6 Å), for an A type star atmosphere model with 10000 ≤ T_{eff} ≤ 15000 K and log g = 4.5, as a function of the Rosseland optical depth.

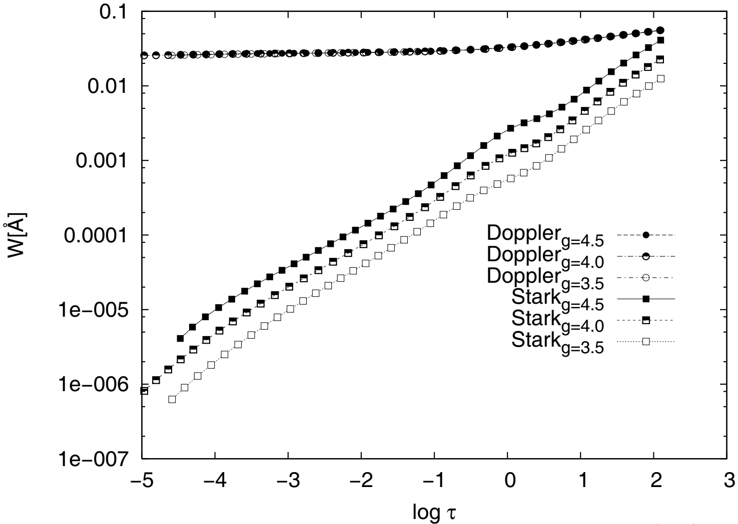

Figure 3: Thermal Doppler and Stark widths for Cr II multiplet ^4F-$^4F^o$ (5279.6 Å), for an A type star atmosphere model with $T_{eff} = 15000$ K and $3.5 \leq \log g \leq 4.5$, as a function of the Rosseland optical depth.

References

Bates, D.R. and Damgaard. A.: 1949, *Phil. Trans. Roy. Soc.*, London, Ser. A, **242**, 101.

Dimitrijević, M. S.: 1996, *Zh. Priklad. Spektrosk*, **63**, 810.

Dimitrijević, M. S., Ryabchikova, T., Simić, Z., Popović, L. Č. and Dačić, M.: 2007, *Astron. Astrophys*., **469**, 681.

Kurucz, R. L.: 1979, *Astrophys. J. Suppl. Ser.*, **40**, 1.

Oertel, G. K. and Shomo, L. P.: 1968, *ApJS*, **16**, 175.

Sahal-Bréchot, S.: 1969a, *Astron. Astrophys.*, **1**, 9.

Sahal-Bréchot, S.: 1969b, *Astron. Astrophys.*, **2**, 322.

van Regemorter, H., Hoang Binh Dy and Prud'homme, M.: 1979, *J. Phys.B*, **12**, 1073.

Wiese, W. L. and Musgrove, A.: 1989, *Atomic Data for Fusion Vol. 6*, *Spectroscopic Data for Titanium, Chromium and Nickel, Vol.2*, Chromium, Controled Fusion Atomic Data Center, Oak Ridge National Laboratory, Oak Ridge.