Publ. Obs. Astron. Belgrade No. 50 (1995), 51 – 54

STARK BROADENING OF P V LINES

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Abstract. Using a semiclassical approach, we have calculated electron-, proton-, and He III-impact line widths and shifts for 51 P V multiplets.

1. INTRODUCTION

Investigation of Stark broadening parameters of P V lines is the continuation of our effort to provide needed data for the analysis of laboratory and astrophysical plasmas (see Dimitrijević and Sahal-Bréchot 1995a and references therein). Stark widths and shifts of P V spectral lines are of interest for the plasma diagnostic as well as for the research of regularities and systematic trends. Recently e.g., estimates of the Stark widths for P V 4s-4p and 4p-4d transitions have been performed within a study on Stark broadening regularities within successive ionization stages of phosphorus (Srećković *et al.* 1990).

By using the semiclassical-perturbation formalism (Sahal-Bréchot, 1969ab), we have calculated electron-, proton-, and He III-impact line widths and shifts for 51 P V multiplets, in order to continue our research of multiply charged ion line Stark broadening parameters. A summary of the formalism is given in Dimitrijević *et al.* (1991).

2. RESULTS AND DISCUSSION

Energy levels for P V lines have been taken from Bashkin and Stoner (1975). Oscillator strengths have been calculated by using the method of Bates and Damgaard (1949) and the tables of Oertel and Shomo (1968). For higher levels, the method described by Van Regemorter *et al.* (1979) has been used. In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton-, and He III-impacts have been calculated. Our results for 51 P V multiplets, for perturber densities 10^{17} - 10^{22} cm^{-3} and temperatures T = 50,000 - 1,000,000K will be published in Dimitrijević and Sahal-Bréchot (1995b,c).

Here, in Table 1, we present only a sample of results obtained. We also specify a parameter c (Dimitrijević and Sahal-Bréchot, 1984), which gives an estimate for the

Table 1

This table shows electron-, proton-, and He III-impact broadening full half-widths (FWHM) and shifts for P V for a perturber density of 10^{17} cm^{-3} and temperatures from 50,000 up to 500,000 K. By deviding c with the full linewidth, we obtain an estimate for the maximum perturber density for which the line may be treated as isolated and tabulated data may be used.

PERTURBER DENSITY = 1xE+17cm-3

PERTURBERS ARE :		ELECTRONS		PROTONS		He III	
TRANSITION	T(K)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)
P V 3S 3P	50000.	0.626E-02	-0.594E-04	0.633E-04	-0.266E-04	0.122E-03	-0.519E-04
1121.8 A	100000.	0.447E-02	-0.762E-04	0.136E-03	-0.516E-04	0.266E-03	-0.103E-03
C= 0.11E+21	150000.	0.371E-02	-0.584E-04	0.190E-03	-0.713E-04	0.373E-03	-0.143E-03
	200000.	0.328E-02	-0.729E-04	0.224E-03	-0.875E-04	0.443E-03	-0.176E-03
	300000.	0.278E-02	-0.871E-04	0.278E-03	-0.108E-03	0.550E-03	-0.219E-03
	500000.	0.232E-02	-0.764E-04	0.329E-03	-0.139E-03	0.657E-03	-0.280E-03
P V 3S 4P	50000.	0.139E-02	0.178E-04	0.619E-04	0.890E-05	0.121E-03	0.174E-04
328.6 A	100000.	0.103E-02	0.166E-04	0.923E-04	0.156E-04	0.182E-03	0.310E-04
C= 0.34E+19	150000.	0.877E-03	0.202E-04	0.110E-03	0.201E-04	0.218E-03	0.406E-04
	200000.	0.792E-03	0.224E-04	0.117E-03	0.228E-04	0.233E-03	0.460E-04
	300000.	0.693E-03	0.220E-04	0.127E-03	0.277E-04	0.252E-03	0.561E-04
	500000.	0.598E-03	0.206E-04	0.138E-03	0.321E-04	0.275E-03	0.649E-04
P V 3S 5P	50000.	0.175E-02	0.497E-04	0.158E-03	0.299E-04	0.310E-03	0.583E-04
255.6 A	100000.	0.140E-02	0.570E-04	0.200E-03	0.439E-04	0.399E-03	0.875E-04
C= 0.95E+18	150000.	0.125E-02	0.646E-04	0.217E-03	0.529E-04	0.432E-03	0.107E-03
	200000.	0.116E-02	0.584E-04	0.228E-03	0.574E-04	0.453E-03	0.116E-03
	300000.	0.105E-02	0.566E-04	0.243E-03	0.638E-04	0.484E-03	0.130E-03
	500000.	0.934E-03	0.528E-04	0.258E-03	0.728E-04	0.514E-03	0.148E-03
P V 3S 6P	50000.	0.282E-02	0.104E-03	0.356E-03	0.694E-04	0.705E- 03	0.135E-03
229.8 A	100000.	0.238E-02	0.137E-03	0.404E-03	0.961E-04	0.804E- 03	0.192E-03
C= 0.42E+18	150000.	0.217E-02	0.124E-03	0.433E-03	0.107E-03	0.863E- 03	0.216E-03
	200000.	0.204E-02	0.122E-03	0.452E-03	0.115E-03	0.902E-03	0.234E-03
	300000.	0.187E-02	0.117E-03	0.471E-03	0.128E-03	0.938E-03	0.259E-03
	500000.	0.170E-02	0.114E-03	0.492E-03	0.145E-03	0.974E-03	0.293E-03
P V 4S 4P	50000.	0.170	-0.412E-02	0.600E-02	-0.260E-02	0.117E-01	-0.508E-02
3185.6 A	100000.	0.127	-0.405E-02	0.908E-02	-0.405E-02	0.179E-01	-0.812E-02
C= 0.32E+21	150000.	0.110	-0.481E-02	0.109E-01	-0.493E-02	0.217E-01	-0.996E-02
	200000.	0.997E-01	-0.485E-02	0.117E-01	-0.558E-02	0.233E-01	-0.113E-01
	300000.	0.882E-01	-0.432E-02	0.128E-01	-0.619E-02	0.255E-01	-0.125E-01
	500000.	0.767E-01	-0.423E-02	0.142E-01	-0.714E-02	0.283E-01	- 0.144E-01

Table 1 continued

PERTURBER DENSITY = 1xE+17cm-3

PERTURBERS ARE :		ELECTRONS		PROTONS		He III	
TRANSITION	T(K)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)
P V 4S 5P	50000.	0.217E-01	0.112E-03	0.172E-02	0.122E-03	0.337E-02	0.238E-03
845.8 A	100000.	0.174E-01	0.218E-03	0.218E-02	0.200E-03	0.433E-02	0.400E-03
C= 0.10E+20	150000.	0.156E-01	0.228E-03	0.235E-02	0.242E-03	0.468E-02	0.487E-03
	200000.	0.144E-01	0.142E-03	0.246E-02	0.279E-03	0.491E-02	0.562E-03
	300000.	0.131E-01	0.164E-03	0.262E-02	0.320E-03	0.523E-02	0.650E-03
	500000.	0.117E-01	0.142E-03	0.278E-02	0.367E-03	0.553E-02	0.740E-03
P V 4S 6P	50000.	0.218E-01	0.471E-03	0.256E-02	0.428E-03	0.506E- 02	0.833E-03
616.8 A	100000.	0.183E-01	0.753E-03	0.290E-02	0.597E-03	0.577E- 02	0.119E-02
C= 0.30E+19	150000.	0.166E-01	0.617E-03	0.310E-02	0.662E-03	0.618E-02	0.134E-02
	200000.	0.156E-01	0.605E-03	0.324E-02	0.718E-03	0.646E-02	0.145E-02
	300000.	0.144E-01	0.591E-03	0.337E-02	0.796E-03	0.671E-02	0.162E-02
	500000.	0.130E-01	0.586E-03	0.349E-02	0.906E-03	0.694E-02	0.182E-02
P V 5S 5P	50000.	1.88	-0.715E-01	0.121	-0.588E-01	0.238	-0.114
6872.7 A	100000.	1.53	-0.866E-01	0.156	-0.817E-01	0.311	-0.163
C= 0.69E+21	150000.	1.38	-0.805E-01	0.171	-0.906E-01	0.343	-0.183
	200000.	1.28	-0.819E-01	0.182	-0.983E-01	0.365	-0.199
	300000.	1.16	-0.783E-01	0.199	-0.109	0.398	-0.221
	500000.	1.04	-0.767E-01	0.215	-0.123	0.431	-0.251
P V 5S 6P	50000.	0.193	-0.123E-02	0.196E-01	-0.105E-02	0.388E-01	-0.204E-02
1710.8 A	100000.	0.163	-0.425E-03	0.222E-01	-0.157E-02	0.441E-01	-0.313E-02
C= 0.23E+20	150000.	0.149	-0.116E-02	0.237E-01	-0.192E-02	0.472E-01	-0.387E-02
	200000.	0.140	-0.995E-03	0.247E-01	-0.212E-02	0.492E-01	-0.429E-02
	300000.	0.129	-0.968E-03	0.257E-01	-0.236E-02	0.511E-01	-0.477E-02
	500000.	0.116	-0.815E-03	0.266E-01	-0.269E-02	0.527E-01	-0.546E-02
P V 6S 6P	50000.	13.5	-0.860	1.18	-0.629	2.34	-1.21
12638.2 A	100000.	11.6	-0.803	1.38	-0.780	2.76	-1.54
C= 0.13E+22	150000.	10.6	-0.804	1.51	-0.869	3.01	- 1.75
	200000.	10.0	-0.771	1.60	-0.933	3.22	-1.89
	300000.	9.25	-0.751	1.69	-1.02	3.38	-2.06
	500000.	8.34	-0.669	1.84	-1.13	3.63	-2.31
P V 3P 4S	50000.	0.276E-02	0.194E-03	0.441E-04	0.100E-03	0.869E-04	0.195E-03
544.0 A	100000.	0.203E-02	0.187E-03	0.103E-03	0.130E-03	0.301E-03	
C= 0.93E+19	150000.	0.173E-02	0.213E-03	0.142E-03	0.184E-03	0.284E-03	0.371E-03
	200000.	0.155E-02	0.223E-03	0.182E-03	0.205E-03	0.363E-03	0.415E-03
	300000.	0.136E-02	0.209E-03	0.219E-03	0.228E-03	0.440E-03	0.461E-03
	500000.	0.116E-02	0.199E-03	0.263E-03	0.259E-03	0.536E-03	0.526E-03

maximum perturber density for which the line may be treated as isolated when it is divided by the corresponding electron-impact full width at half maximum. For each value given in Table 1, the collision volume (V) multiplied by the perturber density (N) is much less than one and the impact approximation is valid (Sahal- Bréchot, 1969ab). When the impact approximation is not valid, the ion broadening contribution may be estimated by using quasistatic estimations (Sahal-Bréchot, 1991 and Griem, 1974). The accuracy of the results obtained decreases when broadening by ion interactions becomes important.

Estimates of the Stark widths for P V 4s-4p transitions obtained by using regularities within successive ionization stages (Srećković *et al.* 1990), give for full width a value of 0.14$\AA$ for T=40000 K and an electron density of 10^{17} cm^{-3}. We obtain a full width of 0.17$\AA$ at T = 50000 K, an excellent agreement encouraging the use of regularities and systematic trends for predictions and interpolations of Stark broadening parameters.

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