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STARK BROADENING OF Ca X LINES

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Abstract. Using a semiclassical approach, we have calculated electron-, proton-, and He III-impact line widths and shifts for 48 Ca X multiplets.

1. INTRODUCTION

Investigation of Stark widths and shifts of Ca X is obviously of interest for the laboratory plasmas, fusion plasmas and laser produced plasmas research as well as for testing and developping of the Stark broadening theory for multicharged ion lines. Due to the abundance of calcium, such data are of interest as well for the consideration of solar and stellar plasma, particularly for subphotosperic layers as well as radiative transfer considerations. They are also of importance for the investigations of regularities and systematic trends particularly along isoelectronic sequences.

This contribution is the continuation of our efforts to provide needed data for the analysis of laboratory and astrophysical plasmas (see Dimitrijević 1996, Dimitrijević and Sahal-Bréchot 1995 and references therein). By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969ab), we have calculated electron-, proton-, and He III-impact line widths and shifts for 48 Ca X multiplets. A summary of the formalism is given in Dimitrijević *et al.* (1991).

2. RESULTS AND DISCUSSION

Energy levels for Ca X 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 48 Ca X multiplets, for perturber densities 10^{18} - 10^{22} cm^{-3} and temperatures T = 200,000 - 2,000,000K will be published in Dimitrijević and Sahal-Bréchot (1997a,b).

Table 1

This table shows electron- and proton-impact broadening full half-widths (FWHM) and shifts for Ca X for a perturber density of 10^{18} cm^{-3} and temperatures from 200,000 up to 2,000,000 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 = 1.E+18cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS	
TRANSITION	T(K)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)
Ca X 3S 3P	200000.	0.498E-02	-0.601E-04	0.302E-04	-0.282E-04
563.1 A	500000.	0.322E-02	-0.532E-04	0.983E-04	-0.676E-04
C=0.56E+21	1000000.	0.238E-02	-0.679E-04	0.179E-03	-0.113E-03
	2000000.	0.180E-02	-0.605E-04	0.264E-03	-0.160E-03
	3000000.	0.155E-02	-0.581E-04	0.303E-03	-0.188E-03
	5000000.	0.130E-02	-0.561E-04	0.351E-03	-0.214E-03
Ca X 3S 4P	200000.	0.481E-03	0.314E-05	0.138E-04	0.190E-05
111.0 A	500000.	0.321E-03	0.343E-05	0.279E-04	0.438E-05
C=0.84E+19	1000000.	0.244E-03	0.303E-05	0.383E-04	0.691E-05
	2000000.	0.191E-03	0.315E-05	0.441E-04	0.951E-05
	3000000.	0.168E-03	0.310E-05	0.477E-04	0.107E-04
	5000000.	0.145E-03	0.267E-05	0.529E-04	0.123E-04
Ca X 3S 5P	200000.	0.571E-03	0.831E-05	0.366E-04	0.857E-05
82.8 A	500000.	0.395E-03	0.112E-04	0.574E-04	0.152E-04
C=0.22E+19	1000000.	0.310E-03	0.103E-04	0.666E-04	0.208E-04
	2000000.	0.250E-03	0.994E-05	0.761E-04	0.249E-04
	3000000.	0.224E-03	0.910E-05	0.817E-04	0.275E-04
	5000000.	0.196E-03	0.773E-05	0.890E-04	0.310E-04
Ca X 3S 6P	200000.	0.858E-03	0.227E-04	0.830E-04	0.230E-04
73.2 A	500000.	0.614E-03	0.238E-04	0.111E-03	0.358E-04
C=0.97E+18	1000000.	0.494E-03	0.221E-04	0.126E-03	0.432E-04
	2000000.	0.408E-03	0.206E-04	0.142E-03	0.515E-04
	3000000.	0.369E-03	0.185E-04	0.151E-03	0.573E-04
	5000000.	0.327E-03	0.151E-04	0.164E-03	0.632E-04
Ca X 4S 4P	200000.	0.103	-0.161E-02	0.259E-02	-0.175E-02

[redacted]

Table 1 continued

PERTURBER DENSITY = 1.E+18cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS	
TRANSITION	T(K)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)
Ca X 4S 5P	200000.	0.651E-02	0.153E-04	0.377E-03	0.250E-04
267.0 A	500000.	0.453E-02	0.195E-04	0.588E-03	0.531E-04
C=0.23E+20	1000000.	0.357E-02	0.214E-04	0.678E-03	0.771E-04
	2000000.	0.290E-02	0.217E-04	0.772E-03	0.101E-03
	3000000.	0.259E-02	0.159E-04	0.830E-03	0.112E-03
	5000000.	0.227E-02	0.134E-04	0.906E-03	0.128E-03
Ca X 4S 6P	200000.	0.591E-02	0.114E-03	0.542E-03	0.127E-03
187.4 A	500000.	0.424E-02	0.109E-03	0.719E-03	0.202E-03
C=0.64E+19	1000000.	0.341E-02	0.102E-03	0.821E-03	0.247E-03
	2000000.	0.282E-02	0.952E-04	0.921E-03	0.295E-03
	3000000.	0.255E-02	0.826E-04	0.972E-03	0.324E-03
	5000000.	0.226E-02	0.661E-04	0.106E-02	0.360E-03
Ca X 5S 5P	200000.	1.05	-0.299E-01	0.545E-01	-0.355E-01
3061.4 A	500000.	0.745	-0.305E-01	0.892E-01	-0.560E-01
C=0.31E+22	1000000.	0.593	-0.296E-01	0.107	-0.685E-01
	2000000.	0.483	-0.271E-01	0.129	-0.815E-01
	3000000.	0.432	-0.236E-01	0.146	-0.900E-01
	5000000.	0.378	-0.195E-01	0.166	-0.986E-01
Ca X 5S 6P	200000.	0.514E-01	-0.467E-04	0.415E-02	-0.159E-03
521.4 A	500000.	0.371E-01	-0.117E-03	0.548E-02	-0.320E-03
C=0.49E+20	1000000.	0.300E-01	-0.148E-03	0.623E-02	-0.446E-03
	2000000.	0.248E-01	-0.131E-03	0.700E-02	-0.557E-03
	3000000.	0.224E-01	-0.106E-03	0.745E-02	-0.618E-03
	5000000.	0.198E-01	-0.105E-03	0.818E-02	-0.703E-03
Ca X 6S 6P	200000.	7.11	-0.279	0.540	-0.350
5528.8 A	500000.	5.19	-0.266	0.754	-0.493
C=0.55E+22	1000000.	4.22	-0.257	0.905	-0.594
	2000000.	3.50	-0.208	1.08	-0.696
	3000000.	3.15	-0.179	1.20	-0.755
	5000000.	2.77	-0.151	1.37	-0.814
Ca X 3P 4S	200000.	0.561E-03	0.277E-04	0.704E-05	0.237E-04
152.6 A	500000.	0.380E-03	0.355E-04	0.282E-04	0.436E-04
C=0.16E+20	1000000.	0.292E-03	0.331E-04	0.495E-04	0.601E-04
	2000000.	0.230E-03	0.311E-04	0.712E-04	0.720E-04
	3000000.	0.202E-03	0.300E-04	0.835E-04	0.801E-04
	5000000.	0.172E-03	0.260E-04	0.102E-03	0.913E-04

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 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.

We hope that the present results will be of interest for the the stellar, laboratory, fusion and laser produced plasma investigation and modeling.

References

Bashkin,S., Stoner, J.O.Jr.: 1975, "Atomic Energy Levels and Grotrian Diagrams", Vol. 1, North Holland, Amsterdam.

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

Dimitrijević, M. S., 1996, *Zh. Prikl. Spektrosk.* **63**, 810.

Dimitrijević, M.S., and Sahal-Bréchot,S.: 1984, *JQSRT* **31**, 301.

Dimitrijević, M.S. and Sahal-Bréchot, S.: 1995, *Astron. Astrophys. Suppl. Series* **109**, 551.

Dimitrijević M.S. and Sahal-Bréchot, S.: 1997a, *Astron. Astrophys. Suppl. Series* submitted.

Dimitrijević M.S. and Sahal-Bréchot, S.: 1997b, *Bull. Astron. Belgrade* **152**, in press.

Dimitrijević, M.S., Sahal-Bréchot, S. and Bommier,V.: 1991, *Astron. Astrophys. Suppl. Series* **89**, 581.

Griem, H.R.: 1974, "Spectral Line Broadening by Plasmas", Academic Press, New York.

Oertel,G.K. and Shomo,L.P.: 1968, *Astrophys.J. Suppl. Series* **16**, 175.

Sahal-Bréchot, S.: 1969a, *Astron.Astrophys.* **1**, 91.

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

Sahal-Bréchot, S.: 1991, *Astron.Astrophys.* **245**, 322.

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