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ON THE STARK BROADENING OF Tl III AND Pb IV LINES

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Abstract. Using a semiclassical approach, we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 2 Tl III, and electron-, proton-, and He III-impact line widths and shifts for 2 Pb IV multiplets, for perturber densities 10^{17}– 10^{20} cm^{-3} and temperatures T = 20,000 – 500,000 K, and T = 50,000 – 1,000,000 K, respectively.

1. INTRODUCTION

The interest for a very extensive list of line broadening data is particularly stimulated by the developement of space astronomy where an extensive amount of spectroscopic information over large spectral regions of all kind of celestial objects has been and will be collected, stimulating the spectral–line–shape research. Not only in astrophysics, but also in physics and plasma technology, a number of problems depend on very extensive list of elements and line transitions with their atomic and line broadening parameters. One may mention as examples calculation of stellar opacities, stellar atmospheres modelling and investigations, abundance determinations, interpretation and modelling of stellar spectra, laboratory plasma diagnostic, research and modelling, radiative transfer calculations and investigation of laser produced plasmas (not only in laboratory but as well in industry during the laser welding, melting and evaporation of different targets), and plasmas created in fusion research (particularly inertial confinement and pellet compression fusion), development and modelling of lasers, as well as of light sources.

In order to provide to astrophysicists and physicists the needed Stark broadening data, we have calculated within the semi-classical perturbation method (Sahal-Bréchot, 1969ab) Stark broadening parameters for 79 He I, 62 Na, 51 K, 61 Li, 25 Al, 24 Rb, 3 Pd, 19 Be, 270 Mg, 31 Se, 33 Sr, 14 Ba, 28 Ca II, 30 Be II, 29 Li II, 66 Mg II, 64 Ba II, 19 Si II, 3 Fe II, 2 Ni II, 12 B III, 27 Be III, 23 Al III, 10 Sc III, 32 Y III, 10 Ti IV, 39 Si IV, 90 C IV, 5 O IV, 114 P IV, 19 O V, 30 N V, 25 C V, 51 P V, 34 S V, 26 V V, 2 F VI, 30 O VI, 21 S VI, 14 O VII, 10 F VII, 10 Cl VIII, 20 Ne VIII, 4 K VIII, 30 K IX, 4 Ca IX, 8 Na IX, 48 Ca X, 57 Na X, 4 Sc X, 18 Mg XI, 7 Al XI, 4 Si XI, 10 Sc XI, 4 Ti XI, 9 Si XII, 27 Ti XII, 61 Si XIII and 33 V XIII multiplets.

Data for particular lines of F I, Ga II, Ga III, Cl I, Br I, I I, Cu I, Hg II, N III, F V and S IV also have been provided by us.

By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969ab), we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 2 Tl III and electron-, proton- and He III-impact line widths and shifts for 2 Pb IV multiplets, in order to continue our attempt to obtain a large set of reliable Stark broadening data. The used formalism has been reviewed shortly e.g. in Dimitrijević *et al.* (1991) and Dimitrijević and Sahal - Bréchot (1996).

2. RESULTS AND DISCUSSION

Energy levels for Tl III and Pb IV lines have been taken from Gutmann and Crooker (1973). All other details of calculations are given in Dimitrijević and Sahal-Bréchot (1998). Our results for electron-, proton-, and ionized helium-impact line widths

Table 1

This table shows electron- and proton-impact broadening full half-widths (FWHM) and shifts for Tl III for a perturber density of 10^{17} cm^{-3} and temperatures from 20,000 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 = 1.E+17cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS	
TRANSITION	T(K)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)
TlIII 6S 6P	20000.	0.170E-01	-0.341E-04	0.436E-03	-0.106E-04
1350.7 A	50000.	0.110E-01	-0.538E-04	0.822E-03	-0.270E-04
C= 0.12E+21	100000.	0.820E-02	-0.531E-04	0.109E-02	-0.483E-04
	200000.	0.650E-02	-0.726E-04	0.123E-02	-0.730E-04
	300000.	0.584E-02	-0.660E-04	0.132E-02	-0.887E-04
	500000.	0.523E-02	-0.657E-04	0.141E-02	-0.105E-03
TlIII 6S 7P	20000.	0.999E-02	0.653E-04	0.914E-03	-0.840E-05
618.6 A	50000.	0.746E-02	0.209E-04	0.120E-02	-0.200E-04
C= 0.59E+19	100000.	0.634E-02	0.103E-03	0.135E-02	-0.318E-04
	200000.	0.556E-02	0.649E-04	0.147E-02	-0.439E-04
	300000.	0.520E-02	0.662E-04	0.151E-02	-0.494E-04
	500000.	0.481E-02	0.745E-04	0.154E-02	-0.566E-04

and shifts for two Tl III multiplets, for perturber densities 10^{17}– 10^{20} cm^{-3} and temperatures T = 20,000 – 500,000 K, and electron-, proton-, and He III-impact line widths and shifts for two Pb IV multiplets, for perturber densities 10^{17}– 10^{20} cm^{-3} and temperatures T = 50,000 – 1,000,000 K, will be published elsewhere (Dimitrijević and Sahal-Bréchot, 1998). We present here in Tables 1 and 2, only data for perturber density of 10^{17} cm^{-3}, for Tl III and Pb IV respectively. We also specify a parameter C (Dimitrijević and S.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 full width at half maximum.

There is no experimental data concerning Tl III and Pb IV Stark broadening parameters. There is however a theoretical result (Purić, Dimitrijević and Lakićević (1978) for Tl III $6s^2S$-$6p^2P^o$ multiplet, obtained within the semiempirical approach (Griem, 1968). The obtained width for 15000 K is two times smaller than our lowest value at 20000 K. We hope that the presented results will be useful for astrophysical and laboratory plasma research, as well as for the theoretical considerations of systematic trends along isoelectronic sequences.

Table 2

This table shows electron- and proton-impact broadening full half-widths (FWHM) and shifts for Pb IV for a perturber density of 10^{17} cm^{-3} and temperatures from 50,000 up to 1,000,000 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+17cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS	
TRANSITION	T(K)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)
Pb IV 6S 6P	50000.	0.737E-02	-0.545E-04	0.290E-03	-0.272E-04
1108.7 A	100000.	0.534E-02	-0.647E-04	0.449E-03	-0.508E-04
C= 0.11E+21	200000.	0.404E-02	-0.750E-04	0.595E-03	-0.807E-04
	300000.	0.352E-02	-0.785E-04	0.641E-03	-0.978E-04
	500000.	0.304E-02	-0.723E-04	0.699E-03	-0.120E-03
	1000000.	0.259E-02	-0.687E-04	0.768E-03	-0.144E-03
Pb IV 6S 7P	50000.	0.347E-02	0.358E-04	0.390E-03	0.124E-04
464.8 A	100000.	0.276E-02	0.160E-04	0.470E-03	0.213E-04
C= 0.63E+19	200000.	0.228E-02	0.357E-04	0.530E-03	0.307E-04
	300000.	0.208E-02	0.260E-04	0.562E-03	0.367E-04
	500000.	0.188E-02	0.269E-04	0.586E-03	0.423E-04
	1000000.	0.166E-02	0.272E-04	0.610E-03	0.503E-04

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