ON THE STARK BROADENING OF Na 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 57 Na X multiplets.

1. INTRODUCTION

For the consideration of physical processes in stellar, laboratory and technological plasmas, the data on spectral lines from sodium and its various ionization stages are of interest. Recently, Griem and Moreno (1990) and Fill and Schöning (1994) pointed out the importance of such results for the development of soft x-ray lasers, where Stark broadening data are needed to calculate gain values, model radiation trapping and to consider photoresonant pumping schemes.

In order to provide the Na X Stark broadening parameters,we have calculated within the semiclassical-perturbation formalism (Sahal-Bréchot 1969ab), electron-, proton-, and He III-impact line widths and shifts for 57 Na X multiplets. A summary of the formalism is given in Dimitrijević *et al.* (1991).

2. RESULTS AND DISCUSSION

In accordance with our project to provide to astrophysicists and plasma physicists the needed Stark-broadening parameters (see Dimitrijević 1996, Dimitrijević and Sahal-Bréchot 1995 and references therein), electron-, proton-, and He III- impact Na X line widths and shifts have been calculated. Energy levels for Na X have been taken from Martin and Zalubas (1981). Our results for 57 Na X multiplets, for perturber densities 10^{17} - 10^{24} cm^{-3} and temperatures T = 200,000 - 5,000,000K will be published in Dimitrijević and Sahal-Bréchot (1998a,b).

Table 1

This table shows electron- and proton-impact broadening full half-widths (FWHM) and shifts for Na X (singlets) for a perturber density of 10^{19} cm^{-3} and temperatures from 200,000 up to 5,000,000 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. The asterisk identifies cases for which the collision volume multiplied by the perturber density (the condition for validity of the impact approximation) lies between 0.1 and 0.5.

PERTURBER DENSITY = 1.E+19cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS	
TRANSITION	T(K)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)
Na X 2S-2P	200000.	0.174	-0.351E-02	0.326E-03	-0.314E-02
1646.9 A	500000.	0.114	-0.421E-02	0.241E-02	-0.772E-02
C=0.16E+23	1000000.	0.839E-01	-0.387E-02	0.739E-02	-0.126E-01
	2000000.	0.629E-01	-0.371E-02	0.147E-01	-0.175E-01
	3000000.	0.536E-01	-0.348E-02	0.216E-01	-0.201E-01
	5000000.	0.441E-01	-0.296E-02	0.294E-01	-0.230E-01
Na X 3S-3P	200000.	10.1	-0.553	0.842	-1.46
5666.0 A	500000.	7.07	-0.564	2.23	-2.37
C=0.12E+23	1000000.	5.50	-0.554	3.58	-2.88
	2000000.	4.31	-0.478	5.12	-3.45
	3000000.	3.75	-0.415	6.27	-3.74
	5000000.	3.15	-0.343	7.63	-4.15
Na X 3S-4P	200000.	0.250E-01	-0.114E-02	*0.694E-02	-0.728E-02
182.2 A	500000.	0.179E-01	-0.119E-02	*0.131E-01	-0.103E-01
C=0.46E+19	1000000.	0.141E-01	-0.126E-02	*0.184E-01	-0.127E-01
	2000000.	0.111E-01	-0.114E-02	*0.250E-01	-0.146E-01
	3000000.	0.974E-02	-0.970E-03	*0.287E-01	-0.156E-01
	5000000.	0.825E-02	-0.760E-03	*0.340E-01	-0.171E-01
Na X 3P-4S	200000.	0.200E-01	0.166E-02	0.276E-02	0.392E-02
190.9 A	500000.	0.146E-01	0.172E-02	0.595E-02	0.588E-02
C=0.13E+20	1000000.	0.116E-01	0.165E-02	0.866E-02	0.718E-02
	2000000.	0.918E-02	0.139E-02	0.119E-01	0.853E-02
	3000000.	0.800E-02	0.122E-02	0.142E-01	0.924E-02
	5000000.	0.672E-02	0.101E-02	0.173E-01	0.992E-02
Na X 3P-5S	200000.	0.184E-01	0.173E-02	*0.481E-02	*0.504E-02
129.2 A	500000.	0.138E-01	0.185E-02	*0.776E-02	*0.707E-02
C=0.60E+19	1000000.	0.110E-01	0.176E-02	*0.105E-01	*0.859E-02
	2000000.	0.874E-02	0.152E-02	*0.141E-01	*0.101E-01
	3000000.	0.760E-02	0.132E-02	*0.159E-01	*0.107E-01
	5000000.	0.636E-02	0.107E-02	*0.200E-01	*0.116E-01

Table 1 continued

PERTURBER DENSITY = 1.E+19cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS	
TRANSITION	T(K)	WIDTH(Å)	SHIFT(Å)	WIDTH(Å)	SHIFT(Å)
Na X 3P-6S	200000.	0.261E-01	0.223E-02		
110.0 A	500000.	0.198E-01	0.243E-02		
C=0.26E+19	1000000.	0.158E-01	0.249E-02		
	2000000.	0.125E-01	0.231E-02		
	3000000.	0.109E-01	0.195E-02		
	5000000.	0.907E-02	0.154E-02		
Na X 4P-5S	200000.	0.262	0.205E-01	*0.754E-01	*0.678E-01
412.4 A	500000.	0.195	0.220E-01	*0.120	*0.975E-01
C=0.23E+20	1000000.	0.155	0.215E-01	*0.166	*0.119
	2000000.	0.123	0.189E-01	*0.218	*0.137
	3000000.	0.107	0.162E-01	*0.254	*0.144
	5000000.	0.903E-01	0.129E-01	*0.309	*0.163
Na X 4P-6S	200000.	0.182	0.141E-01		
264.6 A	500000.	0.137	0.153E-01		
C=0.96E+19	1000000.	0.109	0.159E-01		
	2000000.	0.866E-01	0.147E-01		
	3000000.	0.753E-01	0.124E-01		
	5000000.	0.630E-01	0.977E-02		
Na X 4P-7S	200000.	0.204	0.138E-01		
217.6 A	500000.	0.155	0.151E-01		
C=0.65E+19	1000000.	0.124	0.180E-01		
	2000000.	0.984E-01	0.175E-01		
	3000000.	0.854E-01	0.146E-01		
	5000000.	0.712E-01	0.110E-01		
Na X 4P-8S	200000.	0.259	0.127E-01		
195.2 A	500000.	0.199	0.153E-01		
C=0.35E+19	1000000.	0.159	0.222E-01		
	2000000.	0.126	0.229E-01		
	3000000.	0.110	0.188E-01		
	5000000.	0.914E-01	0.138E-01		

In Table 1, only a sample of results is shown. Parameter C (Dimitrijević and Sahal-Bréchot 1984), given also in Table 1, provides 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). Values for NV > 0.5 are not given and values for $0.1 < \mathrm{NV} \leq 0.5$ are denoted by an asterisk.

We hope that the present results will be of interest for the investigation of Stark broadening theory, especially for the investigation of behaviour of Stark broadening parameters along isoelectronic sequences, as well as for the various problems concerning the stellar, laboratory, fusion and laser produced plasma, and soft x-ray lasers modeling and research.

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