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STARK BROADENING OF SEVERAL Ar I SPECTRAL LINES IN THE VISIBLE PART OF THE SPECTRUM

Milan S. Dimitrijević[1,2], Andjelka Kovačević[3], Zoran Simić[1] and Sylvie Sahal-Bréchot[2]

[1] *Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia; mdimitrijevic@aob.bg.ac.rs, zsimic@aob.bg.ac.rs*

[2] *Observatoire de Paris, LERMA, 5 Place Jules Janssen, 92190 Meudon, France; sylvie.sahal-brechot@obspm.fr*

[3] *Department of Astronomy, Faculty of Mathematics, Studentski Trg 15, 11000 Belgrade, Serbia; andjelka@matf.bg.ac.rs*

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Abstract. In order to complete data on Stark broadening parameters for Ar I line in the visible spectrum, we determined Stark widths and shifts due to electron, proton, and ionized helium impacts, for nine lines ($\lambda\lambda$ = 4191.0, 4259.4, 5912.1, 6043.2, 6045.0, 6752.9, 7503.9, 7514.6, 7724.2 Å), using jK coupling and semiclassical-perturbation theory.

The obtained results will enter the STARK-B database, which is a part of Virtual Atomic and Molecular Data Center.

Key words: physical data and processes: Stark broadening, line profiles, databases

1. INTRODUCTION

Argon spectral lines, which are useful not only for laboratory and technological plasmas but also were observed in stellar atmospheres, are of particular interest, especially in the visible spectrum. Stark broadening parameters of spectral lines are of interest for diagnostics, modelling and investigations of various plasmas in laboratory, technology, fusion research, laser designing, as well as for analysis, interpretation and synthesis of Ar I lines in stellar spectra.

As the continuation of our previous work on the theoretical determination of Stark broadening of Ar I lines (Dimitrijević et al., 2003, 2007, Milosavljević et al. 2003, Christova et al. 2010), and in order to supplement the STARK-B database (http://stark-b.obspm.fr/), a part of Virtual Atomic and Molecular Data Center (VAMDC - http://vamdc.org/, Dubernet et al., 2010, Rixon et al., 2011), we determined here Stark widths and shifts for nine lines at $\lambda\lambda$ = 4191.0, 4259.4, 5912.1, 6043.2, 6045.0, 6752.9, 7503.9, 7514.6, 7724.2 Å due to electron, proton, and ionized helium impacts, using the jK coupling and semiclassical-perturbation theory (Sahal-Bréchot 1969a,b, 1974, Dimitrijević & Sahal-Bréchot 1984).

Table 1. Stark full widths at half intensity maximum (W) and shifts (d) due to electron-, proton-, and ionized helium-impacts for Ar I, for a perturber density of 10^{16} cm^{-3}. The quantity C (given in Åcm^{-3}), when divided by the corresponding perturber width, gives an estimate for the maximum perturber density for which tabulated data may be used. The validity of the impact approximation has been estimated by checking if the collision volume (V) multiplied by the perturber density (N) is much less than one (Sahal−Bréchot, 1969ab). With an asterisk are denoted values where $0.1 < NV \leq 0.5$.

		Electrons		Protons		Ionized helium	
TRANSITION	T(K)	W(Å)	d(Å)	W(Å)	d(Å)	W(Å)	d(Å)
Ar I 4s -4p	2500.	0.0761	0.0512	0.0333	0.0129	0.0322	0.0101
$[3/2]_1 - [1/2]_0$	5000.	0.0851	0.0620	0.0341	0.0149	0.0329	0.0118
7514.6 Å	10000.	0.0967	0.0610	0.0350	0.0171	0.0335	0.0136
C=0.27E+20	20000.	0.119	0.0586	0.0361	0.0195	0.0342	0.0156
	30000.	0.135	0.0484	0.0369	0.0209	0.0347	0.0168
	50000.	0.162	0.0389	0.0380	0.0229	0.0354	0.0184
Ar I 4s′-4p′	2500.	0.0740	0.0464	0.0336	0.0121	0.0328	0.00951
$[1/2]_1 - [1/2]_0$	5000.	0.0820	0.0578	0.0343	0.0140	0.0334	0.0111
7503.9 Å	10000.	0.0929	0.0586	0.0351	0.0160	0.0339	0.0128
C=0.35E+20	20000.	0.115	0.0569	0.0360	0.0182	0.0345	0.0146
	30000.	0.131	0.0481	0.0367	0.0196	0.0349	0.0157
	50000.	0.157	0.0385	0.0377	0.0215	0.0355	0.0172
Ar I 4s′-4p′	2500.	0.0665	0.0379	0.0307	0.00961	0.0301	0.00759
$[1/2]_0 - [1/2]_1$	5000.	0.0713	0.0458	0.0312	0.0111	0.0305	0.00882
7724.2 Å	10000.	0.0795	0.0442	0.0316	0.0127	0.0309	0.0101
C=0.44E+20	20000.	0.0990	0.0412	0.0322	0.0144	0.0312	0.0115
	30000.	0.115	0.0342	0.0327	0.0155	0.0315	0.0124
	50000.	0.141	0.0272	0.0333	0.0169	0.0319	0.0136
Ar I 4s′-5p′	2500.	0.142	0.0941	*0.0524	*0.0218	*0.0488	*0.0164
$[1/2]_1 - [1/2]_0$	5000.	0.164	0.113	*0.0552	*0.0268	*0.0517	*0.0207
4259.4 Å	10000.	0.186	0.128	0.0577	0.0317	*0.0538	*0.0249
C=0.39E+19	20000.	0.212	0.125	0.0605	0.0367	*0.0558	*0.0292
	30000.	0.229	0.109	0.0624	0.0398	0.0571	0.0317
	50000.	0.257	0.0908	0.0651	0.0439	0.0589	0.0350
Ar I 4s′-5p′	2500.	0.117	0.0793	*0.0451	*0.0176	*0.0424	*0.0134
$[1/2]_0 - [3/2]_1$	5000.	0.134	0.0893	*0.0470	*0.0214	*0.0446	*0.0166
4191.0 Å	10000.	0.153	0.0997	0.0488	0.0252	*0.0461	*0.0198
C=0.40E+19	20000.	0.177	0.0962	0.0509	0.0291	*0.0475	*0.0231
	30000.	0.194	0.0837	0.0522	0.0315	0.0484	0.0251
	50000.	0.220	0.0695	0.0542	0.0346	0.0497	0.0277
Ar I 4p -4d	2500.	0.443	0.271	*0.135	*0.0591	*0.124	*0.0443
$[1/2]_1 - [3/2]_2$	5000.	0.505	0.315	*0.142	*0.0730	*0.132	*0.0565
6752.9 Å	10000.	0.585	0.315	0.150	0.0867	*0.138	*0.0681
C=0.60E+19	20000.	0.697	0.276	0.158	0.101	*0.144	*0.0798
	30000.	0.773	0.241	0.163	0.109	0.148	0.0868
	50000.	0.862	0.202	0.171	0.120	0.153	0.0960

Table 1. Continued

		Electrons		Protons		Ionized helium	
TRANSITION	T(K)	W(Å)	d(Å)	W(Å)	d(Å)	W(Å)	d(Å)
Ar I 4p -4d′	2500.	0.650	0.430	*0.162	*0.0856		
$[1/2]_1 - [3/2]_1$	5000.	0.721	0.495	*0.178	*0.112		
5912.1 Å	10000.	0.778	0.485	*0.194	*0.138	*0.167	*0.107
C=0.22E+19	20000.	0.843	0.432	*0.212	*0.163	*0.181	*0.128
	30000.	0.887	0.382	*0.224	*0.178	*0.190	*0.141
	50000.	0.937	0.309	0.240	0.197	*0.202	*0.157
Ar I 4p -5d	2500.	1.76	1.07				
$[5/2]_2 - [7/2]_3$	5000.	1.91	0.919				
6043.2 Å	10000.	2.24	0.667				
C=0.11E+19	20000.	2.53	0.504				
	30000.	2.60	0.376	*0.636	*0.487		
	50000.	2.67	0.213	*0.690	*0.547		
Ar I 4p′-6d	2500.	* 4.89	* 2.86				
$[3/2]_2 - [5/2]_3$	5000.	* 5.31	* 3.14				
6045.0 Å	10000.	* 5.73	* 3.01				
C=0.80E+18	20000.	6.32	2.36				
	30000.	6.61	1.92				
	50000.	6.78	1.48				

2. RESULTS AND DISCUSSION

Stark broadening parameters for nine Ar I lines have been determined within the semiclassical perturbation formalism, discussed in detail in Sahal-Bréchot (1969ab). The optimization and updates can be found in e.g. Sahal-Bréchot (1974), Dimitrijević & Sahal-Bréchot (1984). Energy levels have been taken from Bashkin & Stoner (1978). The obtained results for electron-, proton, and ionized helium-impact widths (FWHM) and shifts are shown in Table 1, for a perturber density of 10^{16} cm^{-3} and temperatures between 2500 and 50000 K. For perturber densities lower than tabulated, Stark broadening parameters may be scaled linearly.

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 1969a). When the impact approximation is not valid, the ion broadening contribution may be estimated by using quasistatic approach (Griem 1974, or Sahal-Bréchot 1991). In the region between where neither of these two approximations is valid, a unified type theory should be used.

The accuracy of the results obtained decreases when broadening by ion interactions becomes important.

For extrapolation of values from Table 1 towards higher electron densities, the results start to deviate from linear behavior due to Debye screening. This effect is more important for the shift than for the width and could be taken into account by the approximative method described in Griem (1974).

The obtained results will enter in the STARK-B database (http://stark-b.obspm.fr/), which is a part of Virtual Atomic and Molecular Data Center (VAMDC - http://vamdc.org/, Dubernet et al. 2010, Rixon et al., 2011). supported by EU in the framework of the FP7 "Research Infrastructures - INFRA-2008-1.2.2 - Scientific Data Infrastructures" initiative, with aim to build an interoperable e-Infrastructure for the exchange of atomic and molecular data.

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