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ON THE STARK BROADENING OF SINGLY IONIZED CALCIUM SPECTRAL LINES

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1. INTRODUCTION

Calcium is among the most abundant elements in stellar plasmas after hydrogen and helium. Particularly important for stellar spectral analysis are the well known resonance lines of Ca II, which are present in all spectra starting with B-type stars and reaching maximal intensity in stars of the K0 spectral type. Consequently, knowledge of reliable Ca II Stark-broadening parameters is of great importance for detailed investigation of stellar atmospheres, as well as for opacity research. Furthermore, Ca II lines are of particular interest for investigations of laboratory plasmas, since calcium is often present as an impurity.

By using the semiclassical-perturbation formalism [1-2] we have calculated electron-, proton-, and ionized helium-impact line widths and shifts for 28 Ca II multiplets. A summary of the formalism is given in Ref. [3]. Here, we discuss the results for Ca II, along with a comparison with other experimental [4-8] and theoretical results [9-12].

2. RESULTS AND DISCUSSION

In addition to electron-impact full halfwidths and shifts, Stark-broadening parameters due to proton- and ionized helium-impacts have been calculated. Thus, we have provided Stark broadening data for all of the important charged perturbers in stellar atmospheres. Our results as a function of perturber density and temperature will be published elsewhere [13-14].

Table 1. Comparison between the semiclassical calculation of width (FWHM) W and shift d, at electron density of 10^{17} cm^{-3} and T = 5000 K and 20,000 K. DSB - present results; JBG - Jones, Benett and Griem [11-12].

Transition	T(K)	W_{DSB} (Å)	W_{JBG} (Å)	d_{DSB} (Å)	d_{JBG} (Å)
3d-4p	5000	1.34	1.76	0.0595	-0.630
	20000	0.856	1.10	0.0228	-0.365
3d-5p	5000	0.303	0.326	-0.0363	-0.140
	20000	0.207	0.252	-0.0224	-0.0975
3d-6p	5000	0.413	0.484	-0.129	-0.242
	20000	0.333	0.436	-0.0783	-0.184
3d-4f	5000	0.174	0.206	0.0702	0.0997
	20000	0.116	0.155	0.0426	0.0697
3d-5f	5000	0.705	1.28	0.116	0.500
	20000	0.554	0.858	0.110	0.296
3d-6f	5000	1.26	2.92	0.165	1.16
	20000	1.19	2.10	0.202	0.713
4s-4p	5000	0.296	0.360	-0.0507	-0.167
	20000	0.188	0.248	-0.0324	-0.106

Table 1 (cont.)

Transition	T(K)	w_{DSB} (Å)	w_{JBG} (Å)	d_{DSB} (Å)	d_{JBG} (Å)
4p-5s	5000	0.935	0.870	0.377	0.445
	20000	0.510	0.594	0.242	0.316
4p-4d	5000	0.605	0.656	0.269	0.331
	20000	0.368	0.452	0.160	0.226
4p-5d	5000	0.587	0.688	0.317	0.361
	20000	0.438	0.566	0.213	0.274
5s-5p	5000	14.1	11.96	-5.29	-6.27
	20000	9.04	9.38	-3.34	-4.65
5p-5d	5000	11.0	10.38	4.80	5.48
	20000	8.13	8.64	3.66	4.17

Table 2. Comparison between the experimental Stark shifts for lines within 4s-4p Ca II multiplet(d_m) with different calculations. Semiclassical calculations: d_{DSB}-present results; d_{JBG} - Jones, Benett and Griem (1971) [11-12]; quantum-mechanical calculations: d_{QM}- Barnes (1971) [9] and Barnes and Peach (1970) [10]; N = electron density.

Trans.	λ(Å)	T K)	$N/10^{17}$ (cm^{-3})	d_m (Å)	d_m/d_{DSB}	d_m/d_{JBG}	d_m/d_{QM}	Ref.
4s-4p	3933.66	11400	0.40	-0.0046	0.30	0.09	0.11	4
		11600	0.64	-0.0155	0.64	0.19	0.24	4
		13000	1.08	-0.048	1.18	0.38	0.45	5
		14200	1.00	-0.09	2.49	0.71	0.94	6
		16000	1.00	-0.01	0.29	0.09	0.11	7
		25100	1.00	-0.06	2.11	0.60	0.72	8
		28000	1.00	-0.04	1.40	0.35	0.48	7
		29200	1.00	-0.05	1.79	0.52	0.60	8

In Table 1, the present results are compared with semiclassical calculations of Jones, Benett and Griem[11-12]. We see that widths fall within the error bars of both methods but for shifts large disagreements exist. In Table 2 we present as an example the comparison of our shift values for Ca II 4s-4p 3933.66 Å line, with experimental [4-8] and other theoretical calculations [9-12]. It should be noted that the shifts are of lesser accuracy for semiclassical calculations than the widths [15-17]. Additional reliable experimental data for the shifts would be very helpful from the theoretical point of view.

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