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Preliminary report

STARK BROADENING PARAMETER TABLES FOR Al III LINES

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SUMMARY: Using a semiclassical approach, we have calculated electron–, proton–, and ionized helium–impact line widths and shifts for 13 Al III multiplets as a function of temperature for perturber densities 10^{17} - 10^{19} cm^{-3}.

1. INTRODUCTION

Absorption lines of Al III are very strong in hot star atmospheres (see e. g. Struve, 1930), where Stark broadening is the principal pressure broadening mechanisme. Moreover, results presented may be used for the diagnostic and modelling of an electrodynamic macro-particle accelerator arc plasma created by the evaporation of an Al-foil (see e. g. Rasheigh and Marshall, 1978; or Rolader and Batteh, 1989) and for spectroscopy of laboratory plasma (Davis and Morin, 1971).

In order to provide reliable data for Al III lines broadened by collisions with charged perturbers in stellar and laboratory plasmas, we have calculated recently electron–, proton– and ionized helium–impact line widths and shifts for 23 Al III multiplets, using the semiclassical–perturbation formalism (Sahal–Bréchot, 1969ab). The obtained results for perturber density of $10^{15} cm^{-3}$, together with discussion, analysis and comparison with existing theoretical and experimental data will be published in the principal article elsewhere (Dimitrijević, and Sahal–Bréchot, 1993). Since data are not linear with perturber density (N), due to the Debye screening effect, we will present here the data for N = 10^{17} – 10^{19} cm^{-3}, for 13 Al III multiplets. Additional data for 9 low lying multiplets for perturber densities of 10^{17} – 10^{20} cm^{-3} may be found in the article of Dimitrijević et al (1993) devoted to the diagnostic and modelling of an electrodynamic macro-particle accelerator arc plasma

2. RESULTS AND DISCUSSION

Energy levels for Al III 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

Table 1. This table gives electron–, proton–, and ionized–argon– impact broadening parameters for Al III lines, for perturber densities of 10^{17} - 10^{19} cm^{-3} and temperatures from 10,000 K to 500,000 K. Transitions and averaged wavelengths for the multiplet (in $\AA$) are also given. By dividing c by the electron–impact full halfwidth, 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 = 0.1E+18 cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS		IONIZED HELIUM	
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
ALIII 3S-5P	10000.	0.208E-01	0.131E-02	0.172E-02	0.154E-03	*0.207E-02	*0.142E-03
560.4 A	20000.	0.166E-01	0.843E-03	0.230E-02	0.268E-03	*0.248E-02	*0.229E-03
C= 0.25E+19	50000.	0.139E-01	0.797E-03	0.271E-02	0.421E-03	0.289E-02	0.345E-03
	100000.	0.128E-01	0.755E-03	0.297E-02	0.505E-03	0.304E-02	0.417E-03
	200000.	0.119E-01	0.651E-03	0.310E-02	0.601E-03	0.312E-02	0.489E-03
	500000.	0.106E-01	0.575E-03	0.317E-02	0.714E-03	0.318E-02	0.558E-03
ALIII 3P-5S	10000.	0.411E-01	0.200E-01	0.118E-02	0.176E-02	0.114E-02	0.147E-02
856.2 A	20000.	0.316E-01	0.148E-01	0.217E-02	0.268E-02	0.208E-02	0.221E-02
C= 0.57E+19	50000.	0.259E-01	0.112E-01	0.360E-02	0.368E-02	0.305E-02	0.304E-02
	100000.	0.230E-01	0.873E-02	0.455E-02	0.442E-02	0.382E-02	0.360E-02
	200000.	0.202E-01	0.696E-02	0.559E-02	0.508E-02	0.447E-02	0.417E-02
	500000.	0.169E-01	0.511E-02	0.690E-02	0.602E-02	0.515E-02	0.510E-02
ALIII 3P-5D	10000.	0.769E-01	0.135E-01	*0.732E-02	*0.563E-02		
740.5 A	20000.	0.661E-01	0.122E-01	*0.983E-02	*0.789E-02	*0.872E-02	*0.626E-02
C= 0.55E+18	50000.	0.560E-01	0.108E-01	*0.128E-01	*0.114E-01	*0.108E-01	*0.907E-02
	100000.	0.497E-01	0.926E-02	*0.157E-01	*0.131E-01	*0.138E-01	*0.106E-01
	200000.	0.436E-01	0.728E-02	0.168E-01	0.147E-01	*0.146E-01	*0.117E-01
	500000.	0.356E-01	0.532E-02	0.198E-01	0.187E-01	*0.185E-01	*0.131E-01
ALIII 3D-5P	10000.	0.169	0.653E-02	0.129E-01	0.120E-02	*0.157E-01	*0.111E-02
1600.0 A	20000.	0.135	0.609E-02	0.175E-01	0.210E-02	*0.188E-01	*0.180E-02
C= 0.20E+20	50000.	0.113	0.600E-02	0.206E-01	0.331E-02	0.219E-01	0.272E-02
	100000.	0.105	0.567E-02	0.226E-01	0.397E-02	0.232E-01	0.331E-02
	200000.	0.978E-01	0.495E-02	0.239E-01	0.475E-02	0.239E-01	0.389E-02
	500000.	0.871E-01	0.438E-02	0.249E-01	0.565E-02	0.244E-01	0.447E-02
ALIII 3D-5F	10000.	0.390	-0.157E-01				
1352.8 A	20000.	0.326	-0.835E-02				
C= 0.96E+17	50000.	0.259	0.534E-02				
	100000.	0.217	0.266E-02				
	200000.	0.180	0.276E-02				
	500000.	0.138	-0.123E-02				
ALIII 4S-5P	10000.	0.271	0.154E-02	0.200E-01	0.111E-03	*0.241E-01	*0.111E-03
1912.3 A	20000.	0.216	0.131E-03	0.267E-01	0.237E-03	*0.288E-01	*0.230E-03
C= 0.29E+20	50000.	0.183	0.746E-03	0.315E-01	0.508E-03	0.335E-01	0.456E-03
	100000.	0.171	0.184E-03	0.344E-01	0.727E-03	0.355E-01	0.630E-03
	200000.	0.159	0.117E-03	0.356E-01	0.924E-03	0.363E-01	0.770E-03
	500000.	0.141	0.938E-04	0.369E-01	0.118E-02	0.372E-01	0.974E-03
ALIII 4P-5S	10000.	0.907	0.335	0.300E-01	0.321E-01	0.318E-01	0.269E-01
3710.5 A	20000.	0.710	0.241	0.499E-01	0.489E-01	0.499E-01	0.405E-01
C= 0.11E+21	50000.	0.599	0.183	0.745E-01	0.676E-01	0.671E-01	0.556E-01
	100000.	0.549	0.144	0.926E-01	0.811E-01	0.807E-01	0.656E-01
	200000.	0.498	0.113	0.110	0.921E-01	0.912E-01	0.752E-01
	500000.	0.428	0.848E-01	0.129	0.111	0.100	0.910E-01

PERTURBER DENSITY = 0.1E+18 cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS		IONIZED	HELIUM
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
ALIII 4P-5D	10000.	0.720	0.893E-01	*0.628E-01	*0.501E-01	*0.587E-01	*0.383E-01
2212.8 A	20000.	0.617	0.875E-01	*0.853E-01	*0.703E-01	*0.749E-01	*0.556E-01
C= 0.49E+19	50000.	0.524	0.880E-01	*0.111	*0.101	*0.943E-01	*0.805E-01
	100000.	0.468	0.752E-01	*0.138	*0.117	*0.119	*0.941E-01
	200000.	0.412	0.609E-01	0.148	0.131	*0.129	*0.104
	500000.	0.338	0.440E-01	0.173	0.167	*0.165	*0.117
ALIII 4D-5P	10000.	5.92	-0.115	0.287	-0.154	*0.340	*-0.129
7891.9 A	20000.	4.82	-0.166	0.414	-0.233	*0.426	*-0.193
C= 0.11E+21	50000.	4.06	-0.151	0.517	-0.321	0.512	-0.263
	100000.	3.72	-0.132	0.608	-0.385	0.566	-0.313
	200000.	3.38	-0.103	0.662	-0.439	0.618	-0.366
	500000.	2.91	-0.598E-01	0.735	-0.516	0.692	-0.445
ALIII 4D-5F	10000.	4.16	-0.223				
4151.2 A	20000.	3.47	-0.163				
C= 0.90E+18	50000.	2.78	-0.301E-01				
	100000.	2.34	-0.491E-01				
	200000.	1.95	-0.356E-01				
	500000.	1.50	-0.576E-01				
ALIII 4F-5D	10000.	3.69	0.537	*0.297	*0.241		
4702.6 A	20000.	3.11	0.451	*0.403	*0.336	*0.353	*0.271
C= 0.22E+20	50000.	2.59	0.444	*0.543	*0.490	*0.465	*0.401
	100000.	2.29	0.378	*0.639	*0.548	*0.565	*0.430
	200000.	1.99	0.305	0.722	0.633	*0.573	*0.503
	500000.	1.61	0.218	0.873	0.812	*0.745	*0.573
ALIII 5S-5P	10000.	14.4	-2.58	0.932	-0.346	*1.10	*-0.290
12786.7 A	20000.	11.9	-1.82	1.26	-0.528	*1.33	*-0.441
C= 0.13E+22	50000.	10.8	-1.40	1.53	-0.733	*1.58	*-0.608
	100000.	10.4	-1.22	1.71	-0.872	1.70	-0.708
	200000.	9.80	-1.03	1.87	-1.02	1.77	-0.816
	500000.	8.67	-0.765	2.02	-1.21	1.81	-0.962
ALIII 5P-5D	10000.	15.0	1.42	*1.16	*0.933	*1.09	*0.714
9597.1 A	20000.	12.9	1.45	*1.58	*1.31	*1.39	*1.03
C= 0.92E+20	50000.	11.3	1.48	*2.03	*1.87	*1.77	*1.50
	100000.	10.3	1.26	*2.52	*2.17	*2.23	*1.76
	200000.	9.29	1.01	2.72	2.41	*2.41	*1.96
	500000.	7.76	0.715	3.15	3.12	*3.04	*2.20

PERTURBER DENSITY = 0.1E+19 cm-3

ALIII 3S-5P	10000.	0.208	0.124E-01	*0.145E-01	*0.114E-02		
560.4 A	20000.	0.166	0.795E-02	*0.217E-01	*0.233E-02		
C= 0.25E+20	50000.	0.139	0.758E-02	*0.269E-01	*0.395E-02		
	100000.	0.128	0.751E-02	*0.298E-01	*0.494E-02		
	200000.	0.119	0.647E-02	*0.310E-01	*0.599E-02	*0.312E-01	*0.487E-02
	500000.	0.106	0.575E-02	0.317E-01	0.714E-02	*0.318E-01	*0.558E-02

PERTURBER DENSITY = 0.1E+19 cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS		IONIZED	HELIUM
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
ALIII 3P-5S	10000.	0.411	0.192	*0.117E-01	*0.114E-01	*0.110E-01	*0.857E-02
856.2 A	20000.	0.316	0.142	*0.216E-01	*0.214E-01	*0.209E-01	*0.167E-01
C= 0.57E+20	50000.	0.259	0.108	*0.354E-01	*0.330E-01	*0.304E-01	*0.265E-01
	100000.	0.230	0.860E-01	*0.462E-01	*0.425E-01	*0.384E-01	*0.341E-01
	200000.	0.202	0.692E-01	*0.559E-01	*0.504E-01	*0.447E-01	*0.413E-01
	500000.	0.169	0.511E-01	0.690E-01	0.602E-01	*0.515E-01	*0.510E-01
ALIII 3P-5D	10000.	0.756	0.805E-01				
740.5 A	20000.	0.653	0.839E-01				
C= 0.55E+19	50000.	0.555	0.837E-01				
	100000.	0.494	0.825E-01				
	200000.	0.433	0.709E-01				
	500000.	0.354	0.532E-01				
ALIII 3D-5P	10000.	1.69	0.599E-01	*0.109	*0.888E-02		
1600.0 A	20000.	1.35	0.573E-01	*0.166	*0.183E-01		
C= 0.20E+21	50000.	1.13	0.569E-01	*0.204	*0.311E-01		
	100000.	1.05	0.563E-01	*0.226	*0.388E-01		
	200000.	0.978	0.492E-01	*0.238	*0.473E-01	*0.238	*0.387E-01
	500000.	0.871	0.438E-01	0.249	0.565E-01	*0.244	*0.447E-01
ALIII 3D-5F	10000.	3.09	-0.109				
1352.8 A	20000.	2.69	-0.943E-01				
C= 0.96E+18	50000.	2.23	-0.711E-01				
	100000.	1.92	-0.365E-01				
	200000.	1.62	-0.163E-02				
	500000.	1.27	-0.123E-01				
ALIII 4S-5P	10000.	2.71	0.139E-01	*0.168	*0.845E-03		
1912.3 A	20000.	2.16	0.168E-02	*0.253	*0.214E-02		
C= 0.29E+21	50000.	1.83	0.652E-02	*0.311	*0.491E-02		
	100000.	1.71	0.259E-02	*0.344	*0.719E-02		
	200000.	1.59	0.908E-03	*0.356	*0.923E-02	*0.363	*0.769E-02
	500000.	1.41	0.938E-03	0.369	0.118E-01	*0.372	*0.974E-02
ALIII 4P-5S	10000.	9.07	*3.19	*0.283	0.209	0.286	0.157
3710.5 A	20000.	7.10	*2.31	*0.489	0.391	0.487	0.308
C= 0.11E+22	50000.	5.99	*1.76	*0.729	0.597	0.662	0.482
	100000.	5.49	*1.42	*0.933	0.784	0.814	0.625
	200000.	4.98	*1.12	*1.10	0.915	0.912	0.747
	500000.	4.28	0.848	1.29	1.11	1.00	0.910
ALIII 4P-5D	10000.	7.08	0.408				
2212.8 A	20000.	6.10	0.540				
C= 0.49E+20	50000.	5.19	0.662				
	100000.	4.65	0.663				
	200000.	4.10	0.592				
	500000.	3.37	0.440				

PERTURBER DENSITY = 0.1E+20 cm-3

PERTURBERS ARE:		ELECTRONS		PROTONS		IONIZED	HELIUM
TRANSITION	T(K)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)	WIDTH(A)	SHIFT(A)
ALIII 3S-5P	10000.	*2.07	*0.105				
560.4 A	20000.	1.66	0.680E-01				
C= 0.25E+21	50000.	1.39	0.688E-01				
	100000.	1.28	0.696E-01				
	200000.	1.19	0.626E-01				
	500000.	1.06	0.570E-01				
ALIII 3P-5S	10000.	*4.10	*1.57				
856.2 A	20000.	3.15	1.21				
C= 0.57E+21	50000.	2.58	0.954				
	100000.	2.30	0.778				
	200000.	2.02	0.654				
	500000.	1.69	0.504				
ALIII 3P-5D	10000.	*5.71					
740.5 A	20000.	*5.30					
C= 0.55E+20	50000.	4.86	0.273				
	100000.	4.49	0.426				
	200000.	4.02	0.489				
	500000.	3.34	0.493				
ALIII 3D-5P	10000.	*16.8	*0.449				
1600.0 A	20000.	*13.5	*0.484				
C= 0.20E+22	50000.	11.3	0.515				
	100000.	10.5	0.521				
	200000.	9.78	0.476				
	500000.	8.71	0.434				

used.

Our results are shown in Table 1 for perturber densities of $10^{17} - 10^{19}$ cm^{-3} and temperatures of T = 10,000; 20,000; 50,000; 100,000; 200,000; and 500,000 K. 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 electron–impact full width at half maximum. The presented data, together with the data for a perturber density of 10^{15} cm^{-3} published in the principal article (Dimitrijević and Sahal–Bréchot, 1993, where data for 23 Al III multiplets have been presented) and data for the 9 low lying multiplets, for perturber densities $10^{17} - 10^{20}$ cm^{-3} (Dimitrijević et al, 1993) enable in all cases of interest a good interpolation for densities when a departure from the linear behaviour with N exists.

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 in Table 1; values for $0.1 < NV \leq 0.5$ are denoted by an asterisk. When the impact approximation is not valid, the ion broadening contribution may be estimated by using quasistatic formulae (cf. Sahal–Bréchot (1991) or Griem (1974)).

The analysis of present results and comparison with available experimental and theoretical data is given in Dimitrijević and Sahal – Bréchot (1993).

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ТАБЕЛЕ ПАРАМЕТАРА ШТАРКОВОГ ШИРЕЊА ЛИНИЈА Al III

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Претходно саопштење

Користећи семикласичан прилаз, израчунате су ширине и помераји спектралних линија, проузроковани сударима са електронима, протонима и јонима хелијума, за 13 мултиплета Al III. Резултати су дати у функцији температуре и концентрације пертурбера.