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STARK WIDTHS AND SHIFTS PREDICTIONS FROM REGULARITIES FOR HIGHER MEMBERS OF SEVERAL Mg I AND Mg II SPECTRAL SERIES

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Abstract. Stark width and shift dependencies on the upper level ionization potential within several MgI and MgII spectral series have been found and discussed. After being well established using existing theoretical calculations the dependencies have been used to predict additional Stark broadening and shift data for several higher numbers of the investigated spectral series.

1. INTRODUCTION

A comprehensive set of Stark broadening data of MgI and MgII spectral lines [Dimitrijević and Sahal-Brechot, 1995a; Dimitrijević and Sahal-Bréchot, 1995b] has been used here to demonstrate the existence of Stark widths and shifts data regularities within several MgI and MgII spectral series. Namely, Stark parameters dependences on the upper level ionization potential of particular line within following spectral series :
MgI and MgII : 3s- np, 4s-np, 5s-np, 3p-ns, 4p-ns, 5p-ns, 3p-nd, 4p-nd, 5p-nd, 3d-np, 4d-np, 4f-nd have been found and discussed. Different kinds of regularities within Stark parameters of a given spectra can be explained on the bases of their dependence on the upper level ionization potential [Purić *et al.* 1991; Purić *et al.* 1993; Purić, 1993,]. A general form of that dependence is

$$\omega, d = A\chi^{-b} \tag{1}$$

where ω and d are the line width and shift in angular frequency units, respectively χ is the corresponding upper level ionization potential expressed in eV. Coefficients A and b depend on temperature and electron density but are independent of χ.

2. RESULTS AND DISCUSSION

It has been verified that the Eq.(1) is appropriate not only for the electron-impact width and shift but, also, for proton-, ionized helium- and ionized argon-impact parameters for the investigated ion spectral series. As the examples in Fig. 1. are given : a) electron-impact width (w_e) of Mg II 3p-ns and b) electron-impact width (w_e) of Mg I 3s - np spectral lines as the functions of the inverse value of the upper level ionization potential χ.

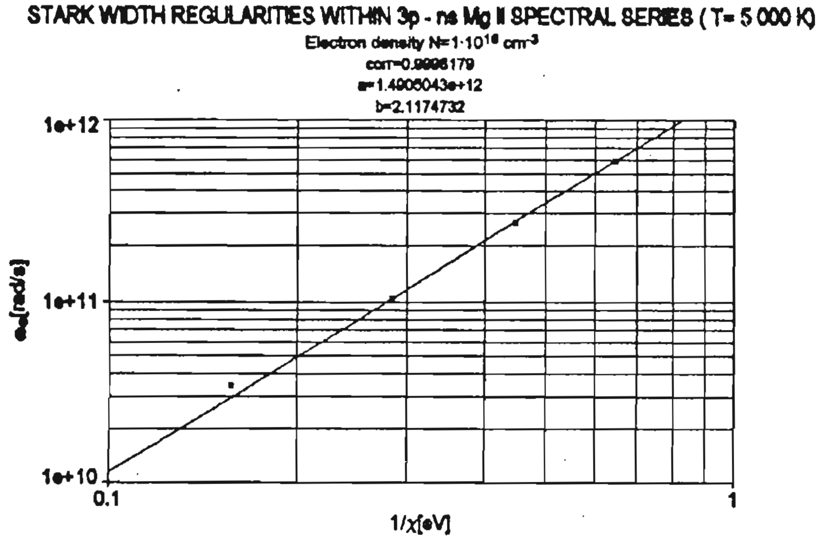
STARK WIDTH REGULARITIES WITHIN 3p - ns Mg II SPECTRAL SERIES (T= 5 000 K)
b=2.1174732
1e+12
1e+11
1e+10
0.1
1
1/χ[eV]

Fig. 1a.

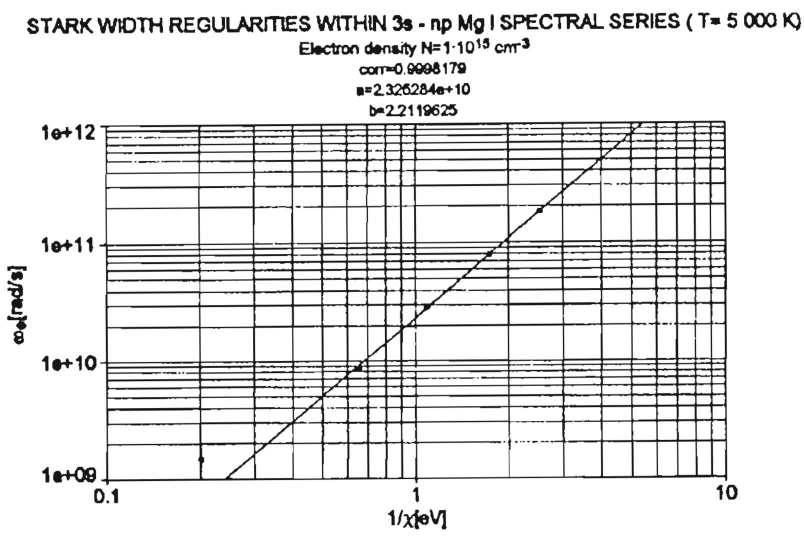
STARK WIDTH REGULARITIES WITHIN 3s - np Mg I SPECTRAL SERIES (T= 5 000 K)
Electron density N=1·10^15 cm^-3
corr=0.9998179
a=2.326284e+10
b=2.2119625
1e+12
1e+11
1e+10
1e+09
0.1
1
10
ωe[rad/s]
1/χ[eV]

Fig. 1b.

Perturber density = 0,1E+ 17cm^{-3}

Transitions	T	electron		proton		He II	
		A	b	A	b	A	b
MgII 3p-8s	5000	0,1097	0,06718	0,01608	0,01155	0,01338	0,008855
λ=1307,87 [A]	10000	0,09846	0,07242	0,01898	0,01662	0,01585	0,01329
x=1,1325 [eV]	20000	0,09202	0,06166	0,02360	0,02019	0,01827	0,01639
$\frac{1}{x}$=0,8830[eV]$^{-1}$	50000	0,1028	0,05067	0,02649	0,02424	0,02270	0,020445
	100000	0,1055	0,03931	0,03422	0,02679	0,02629	0,02292
	150000	0,1039	0,032015	0,02890	0,02840	0,02274	0,02274
MgII 3p-9s	5000	0,1594	0,1034	0,03069	0,01964	0,02489	0,01479
λ=1271,9 [A]	10000	0,1489	0,1174	0,034415	0,028845	0,02855	0,02291
x=0,8645 [eV]	20000	0,1443	0,09887	0,04216	0,03496	0,03189	0,02824
$\frac{1}{x}$=1,1567[eV]$^{-1}$	50000	0,1697	0,08250	0,04531	0,04198	0,03977	0,03584
	100000	0,1766	0,06331	0,06180	0,04580	0,004626	0,04031
	150000	0,1741	0,05048	0,04705	0,04827	0,05825	0,03857
MgII 4p-9s	5000	0,6567	0,3983	0,08945	0,06770	0,07315	0,05177
λ=3173,7 [A]	10000	0,58565	0,4319	0,1077	0,09779	0,08886	0,07834
x=1,1325 [eV]	20000	0,5456	0,36555	0,13535	0,1198	0,1038	0,09621
$\frac{1}{x}$=0,8830[eV]$^{-1}$	50000	0,6086	0,2965	0,1521	0,1434	0,1289	0,1209
	100000	0,6137	0,2275	0,2000	0,1572	0,1505	0,1362
	150000	0,6081	0,1881	0,1653	0,1664	0,18515	0,1347
MgII 4p-9s	5000	0,8774	0,5718	0,15025	0,1062	0,1176	0,07969
λ=2969,88,9 [A]	10000	0,8086	0,6556	0,1748	0,1574	0,1413	0,1252
x=0,8645 [eV]	20000	0,7707	0,5484	0,2183	0,1927	0,1620	0,1535
$\frac{1}{x}$=1,1567[eV]$^{-1}$	50000	0,8970	0,4475	0,2360	0,2308	0,2032	0,1971
	100000	0,89935	0,3395	0,3315	0,2487	0,2399	0,2231
	150000	0,8914	0,2776	0,2441	0,2617	0,3100	0,2124

Table 1.

By a comparison of the regularities found here and those presented elsewhere [Dimitrijević and Sahal-Bréchot, 1992 (Figures 1 - 7)] one can conclude that the method used here differs in the choice of the variable conveying atomic structure information. Prior work was based on the hydrogenic model. Consequently , it used integer principal quantum numbers instead of the upper level ionization potential. Although both parameters take into account the density of states perturbing the emitting state, the advantages of the present method are : (I) $\chi-$ based trend analyses achieve better fits; (ii) χ values the lowering of the ionization potential [Inglis and Teller, 1939] is taken into account, predicting merging with continuum when the plasma environment causes a line's upper state ionization potential to approach zero; and (iii) the χ dependence of w and d are theoretically expected [Purić *et al.* 1991; Purić *et al.* 1993; Purić, 1993]. Using the existing Stark parameters data for the investigated lines from Rb I spectral series the corresponding coefficients A and b from Eq. (1) are found. The corresponding correlation's factors were almost equal to unity. Therefore, the Eq. (1) can be used to calculate Stark parameters of the higher members of the spectral series not calculate so far. The results obtained by the above described procedure are given in Table 1. All data are normalized at an electron density N_e equal $1 \times 10^{23}\mathrm{m}^{-3}$.

3. CONCLUSION

Stark parameters dependence on the upper level ionization potential, after being well established within particular series can be used for prediction of these parameters for the members where not available so far. The electron-, proton- and ionized helium-, and ionized argon-impact widths and shifts predicted by intraseries regressions analyses are of the same accuracy as the results used in the course of the calculation of coefficients A and b that are used in Eq.(1) to generate widths and shifts for higher series members. This method is computationally simple, involving each line' s upper level ionization potential and one multiplicative and one exponential fitting parameter per spectral series and emitter temperature and electron density. Such method is conductive to the method' s incorporation into mathematical simulations of stellar atmosphere opacities.

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