Publ. Astron. Obs. Belgrade No. 65 (1999), 63 – 66

ON THE STARK WIDTH REGULARITIES IN THE DOUBLY IONIZED SULFUR SPECTRUM

S. DJENIŽE
Faculty of Physics, University of Belgrade
P.O.B. 368, 11000 Belgrade, Serbia, Yugoslavia

1. INTRODUCTION

Extensive studies of the star atmospheres (and other cosmic emitters) on the basis of the shape and position of spectral lines emitted by atomic or ionic emitters, have enhanced the effort to develop a fast and reliable method to find the Stark widths of spectral lines.If the Stark broadening is the principal pressure broadening mechanism in plasmas (with $10^{22} - 10^{27}$ m^{-3} electron density), on the basis of Stark HWHM (half-width at half intensity maximum,w) values it is possible to obtain the other basic plasma parameters e.g. electron temperature (T) and density (N),essential in the modeling of the stellar atmospheres or other laboratory plasmas (Lesage 1994; Seaton 1987). The simplest way to quick and reliable estimation of the values of w is to use established regularities for a given type of quantum transition in a particular ionic spectrum.The main objective of this study is to establish regularities of Stark HWHM values using existing experimental results and,on that basis,to predict the w values for spectral lines of the doubly ionized sulfur atoms,that have not been measured or calculated before.Trends of the Stark HWHM values within four types of transitions (3d-4p, 4s-4p ,4p-4d ,4p-5s) have been established in doubly ionized (S III) sulfur spectrum.On that basis Stark HWHM values for 14 strong spectral lines, not measured or calculated before,have been predicted. These can be applied in the plasma spectroscopy.

2. REGULARITIES

The simplest way to estimate the value of a Stark HWHM is to use established regularities of w along the same type of quantum transition in the ionic spectra (Djeniže *et al.* 1989, and references therein). Namely,on the basis of the existing experimental results of a Stark HWHM of the spectral lines that belong to the 4p-4d transition in the Ar II spectrum it was found that simple analytical relationship exists between w and the corresponding upper- level ionization potential (I) of a particular spectral line for the same type of transitions.This relationship, normalized to a $N = 10^{23}$ m^{-3} electron density,is of the form:

$$w(\mathrm{rad/s}) = aT^{-1/2}I^{-b}. \qquad (1)$$

The upper-level ionization potential I (in eV) specifies the emitting ion, while the electron temperature T (in K) characterizes the assembly. The coefficients a and b are independent of I and T.Successful application of Eq.(1) (including all existing experimental w data) in the cases of nine singly ionized spectra is presented by Djeniže *et al.* (1999). Inclusion all existing experimental Stark HWHM data for S III spectral lines in Eq.(1), in the cases of the investigated transitions,leads to the coefficients a and b which are presented in Fig.1. The found Stark HWHM trends along various type of the transition are graphically presented in Fig.1.The error bars of 10%, in Fig.1, show the magnitude of the scatter of the experimental data of reduced Stark HWHM ($wT^{1/2}$) values. Stark width values, predicted on the basis of Eq.(1), at T= 40 000 K electron temperature (as example) and $N = 10^{23}$ m^{-3} electron density,are presented in Table 1. The necessary atomic data are taken from Wiese *et al.* (1969).

Table 1. Predicted Stark FWHM (2w) values at T=40 000 K electron temperature and $N = 10^{23}$ m^{-3} electron density with their estimated accuracies.

Transition	Multip.	λ (nm)	2w(nm)	Acc(%)
3d - 4p	$^3P^0 - ^3D$			
	(1)	363.02	0.0133	13
	(2)	332.49	0.0111	13
	$^3P^0 - ^3S$			
	(3)	323.42	0.0105	13
		323.32	0.0105	13
	$^3D^0 - ^3D$			
	(7)	436.47	0.0192	13
		446.78	0.0201	13
4s - 4p	$^3F^0 - ^3D$			
	(4)	425.36	0.0199	10
		428.50	0.0201	10
	$^3P^0 - ^3P$			
	(5)	383.83	0.0165	10
		383.78	0.0164	10
		386.64	0.0166	10
	$^3P^0 - ^3S$			
	(6)	371.78	0.0156	10
4p - 5s	$^3P^0 - ^3P^0$			
	(19UV)	266.54	0.0191	15
		270.28	0.0197	15

3. RESULTS

3d - 4p transition

Four spectral lines from two multiplets (parenthesis in Fig.1) in the 3d - 4p transition have been investigated in only one experiment (Platiša *et al.* 1979). Measured

Stark HWHM values satisfy our Eq.(1). Predicted Stark width data for six spectral lines, not measured or calculated before, are presented in Table 1.

4s - 4p transition

Six spectral lines from three multiplets in the 4s - 4p transition have been investigated in two experiments (Platiša *et al.* 1979; Djeniže *et al.* 1990). Measured Stark HWHM values satisfy our Eq.(1). Predicted Stark width data for six spectral lines,not measured or calculated before,are presented in Table 1.

4p - 4d transition

Seven spectral lines from three multiplets in the 4p - 4d transition have been investigated in only one experiment (Platiša *et al.* 1979). Measured Stark HWHM values satisfy our Eq.(1).

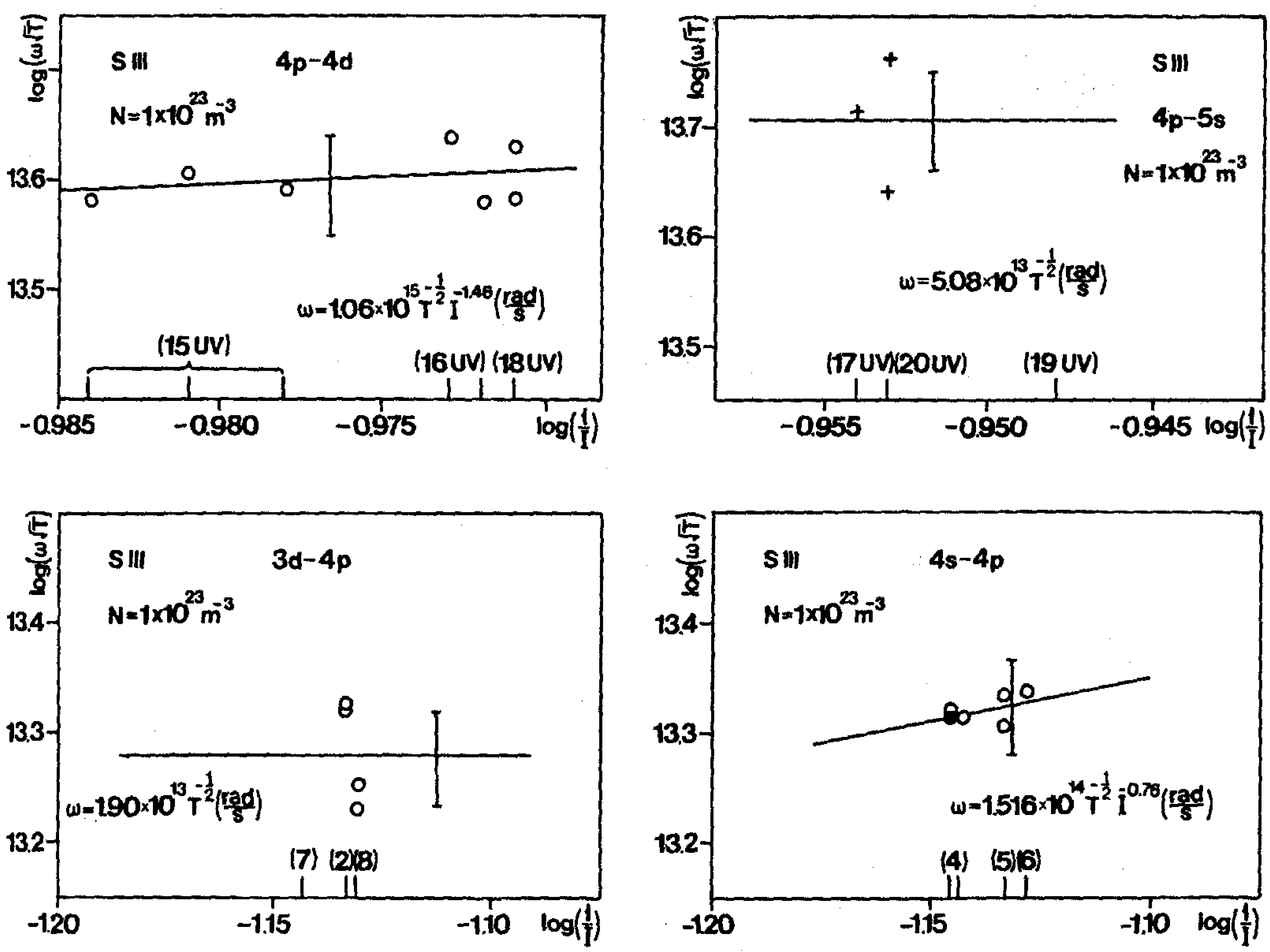

Fig. 1. Reduced Stark HWHM ($wT^{1/2}$) versus inverse value of the upper-level ionization potential for various transitions. o, Platiša *et al.* (1979); •, Djeniže *et al.* (1990) and +, Dimitrijević *et al.* (1996).

4p - 5s transition

Three spectral lines from two multiplets in the 4p - 5s transition have been investigated in only one experiment (Dimitrijević *et al.* 1996). Measured Stark HWHM values satisfy our Eq.(1). Predicted Stark width data for two spectral lines,not measured or calculated before,are presented in Table 1.

4. CONCLUSION

The reduced Stark HWHM ($wT^{1/2}$) values show tolerable mutual scatter. It is within 13% in comparison to the values calculated on the basis of the established trends. It should be pointed out that the investigated spectral lines origin from the upper levels (i) whose energies lie in the narrow energy interval (ΔE_i) (0.07 eV; 0.53 eV, 0.29 eV and 0.02 eV for the 3d - 4p, 4s - 4p, 4p - 4d and 4p - 5s transitions, respectively). In the cases of the 3d - 4p (ΔE_i = 0.07 eV) and 4p - 5s (ΔE_i = 0.02 eV) transitions the Stark HWHM dependence on the upper-level ionization potential (I) is very weak,practically negligible. These facts confirm the statement published by Wiese and Konjević (1982).They pointed out that all Stark widths for lines within a transition array should be nearly equal because of similar positions of their upper energy levels. Stark width values of the spectral lines that belong to the 4s - 4p and 4p - 4d transitions in the S III spectrum present convenient atomic data needed in a plasma spectroscopy (Djeniže 1999).

Acknowledgements

This research is a part of the project "Plasma Spectroscopy" supported by Ministry of Science and Technology of the Republic of Serbia.

References

Dimitrijević, M.S., Djeniže, S., Srećković, A., Platiša, M.: 1996, *Phys. Scripta*, **53**, 545.
Djeniže, S., Malešević, M., Srećković, A., Milosavljević, M., Purić, J.: 1989, *J. Quant. Spectr. Radiat. Transfer*, **42**, 429.
Djeniže, S., Srećković, A., Platiša, M., Konjević, R., Labat, J., Purić, J.: 1990, *Phys. Rev. A*, **42**, 2379.
Djeniže, S., Srećković, A., Labat, J., Platiša, M.: 1999, *Phys. Scripta*, **59**, 98.
Djeniže, S.: 1999, *Phys. Scripta* (to be published).
Lesage, A.: 1994, Proceed. of the XXIInd General Assembly of the International Astronomical Union, le Haie.
Platiša, M., Popović, M., Dimitrijević, M.S., Konjević, N.: 1979, *J. Quant. Spectr. Radiat. Transfer*, **22**, 333.
Seaton, M.J.: 1987, *J. Phys. B* **20**, 6363.
Wiese, W.L., Smith, M.W., Miles, B.M.: 1969, Atomic Transition Probabilities, Vol. II NSRDS-NBS 22 (DC. U.S.Government Printing Office, Washington).
Wiese, W.L., Konjević, N.: 1982, *J. Quant. Spectr. Radiat. Transfer* **28**, 185.