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DETERMINATION OF ION - BROADENING PARAMETER FOR C I 505.2 nm AND Ar I 419.8 nm LINES

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1. INTRODUCTION

Neutral atom spectral lines broadened by plasmas are asymmetric and often described by $j_{A,R}(x)$ function (Griem, 1974):

$$j_{A,R}(x) = \frac{1}{\pi} \cdot \int_0^{\infty} \frac{W_R(\beta)}{1 + (x - A^{4/3} \cdot \beta^2)^2} \, d\beta \qquad (1)$$

where A is ion-broadening parameter which is measure of the asymmetry of the profile (1). Due to great difficulties in measurements of A, usually measured Stark broadening parameters are Stark widths and shifts. For complete investigation of Stark broadened neutral atom lines by plasmas, experimental values of all three parameters are needed.

Very often argon is used as working gas in various plasma discharges for various applications, so argon lines can be used for diagnostics of such plasmas. Knowing all three Stark broadening parameters is, in these cases, of great importance. In this paper we present measured value of ion-broadening parameters for Ar I 419.8 nm and C I 505.2 nm emitted from wall-stabilized arc. Experimental procedures are described in (Djurović et al., 1977; Nikolić, 1998).

2. DETERMINATION OF ION-BROADENING PARAMETER A

Deconvolution procedure described in (Nikolić, 1998; Nikolić et al., 1999) was applied on experimental profiles. One of the values returned by this procedure are values of ion-broadening parameter A. Careful check (Nikolić et al., 1999) of this procedure was performed by applying it on numerically synthesized plasma broadened profile (1) with known Stark parameters. Returned values agreed with entered values of A within 1%. From this fact we can conclude that the main source of error in experimental determination of A is scattering of the points in recorded spectral line profiles. This error was estimated to be between 4% and 15%, from higher to lower electron densities. Experimental profiles, in the case of argon line, were recorded for the electron density interval ranged from $0.74 \cdot 10^{16}$ cm^{-3} to $2.9 \cdot 10^{16}$ cm^{-3}, and for plasma temperature range from 9200 K to 10800 K. Due to weak temperature dependence of A in such narrow interval (Griem, 1974), it is reasonable to suppose that A is not changing with temperature inside of error limits. Theory (Griem, 1974) gives values A_G that are changing with the plasma electron density N_e like:

$$A_G = A_N \cdot N_e^{1/4} \cdot 10^{-4} \quad (N_e \text{ in cm}^{-3}) \qquad (2)$$

where A_N is theoretical value of A for $N_e = 10^{16}$ cm^{-3} and for specified temperature (in this case 10000 K). One can notice from equation (2) that A is changing linearly with $N_e^{1/4}$.

This is shown, as an example, in Figure 1, which represents measured values of A as function of $N_e^{1/4}$ for argon Ar I 419.83 nm. Such kind of dependence was also found for investigated carbon C I 505.2 nm spectral line. Deconvolution procedure is based on fitting the parameters of theoretical profile to the experimental one. In this case, the theoretical profile is the convolution of $f_{A,R}(\lambda)$ (Eq. (1)) function and Gaussian profile due to Doppler and instrumental broadening. Details of this procedure could be found in (Nikolić, 1998; Nikolić et al., 1999). Solid lines in Figs. 2 and 3 present fitted profiles. It could be seen that obtained function describes experimental profile satisfactorily. Certain disagreements exists at the parts of the line wings of the experimental profile.

3. RESULTS

One of the fitted parameters in above mentioned procedure is the ion-broadening parameter A. Estimated values of A for C I 505.2 nm at two electron densities and for Ar I 419.83 nm at twelve electron densities are given in Table 1, together with the theoretical values A_G (Griem, 1974) and other experimental results A_{JW} (Jones and Wiese, 1984). Graphically these results are, in the case of C I 505.2 nm line, presented in Fig. 4. As it can be seen results obtained in this work are higher than other experimental and theoretical results. The error of parameter A determination is estimated to be about 15 % (Nikolić et al., 1999). The error is mainly caused by the scattering of the measured points of experimental profiles.

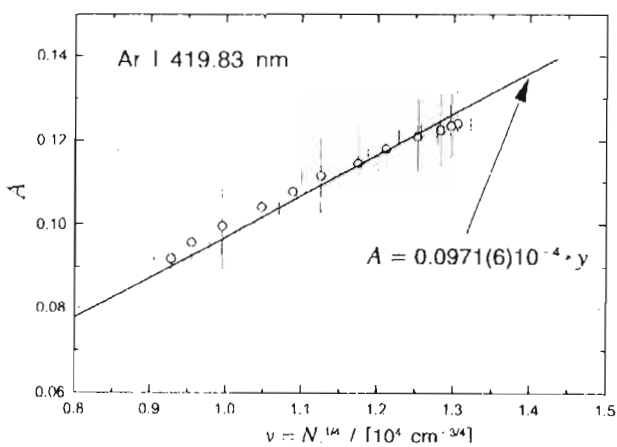

Figure 1. Measured values of A as a function $N_e^{1/4}$ for Ar I 419.83 nm line.

Table 1. Measured and theoretical values for parameter A.

	T / [K]	N_e / [10^{23} m^{-3}]	$N_e^{1/4}$ / [10^5 m$^{-3/4}$]	A This work	A_G	A_{JW}
C I 505.2 nm	9700(290)	2.2(2)	3.85(9)	0.091(14)	0.07724	0.094(14)*
	9700(290)	2.2(2)	3.85(9)	0.116(18)	-	-
	10000(300)	2.8(3)	4.11(9)	0.142(22)	0.08185	0.100(15)*
	10000(300)	2.8(3)	4.11(9)	0.158(24)		-
	10000(300)	2.8(3)	4.11(9)	0.160(24)	-	-
	10000	2.56	4	-	0.07617	0.097(15)*

Table 1. continued

	T / [K]	N_e / [10^{23} m^{-3}]	$N_e^{1/4}$ / [10^5 m$^{-3/4}$]	A This work	A_G	A_{JW}
Ar I 419.8 nm	10760(215)	2.9(2)	4.13(8)	0.124(7)	0.09784	-
	10730(215)	2.82(23)	4.10(8)	0.123(7)	0.09721	-
	10700(214)	2.70(22)	4.05(8)	0.122(9)	0.09621	-
	10550(211)	2.46(20)	3.96(8)	0.121(8)	0.09424	-
	10400(208)	2.15(17)	3.83(8)	0.118(9)	0.09136	-
	10250(205)	1.90(17)	3.71(7)	0.114(9)	0.982	-
	10050(200)	1.60(14)	3.56(7)	0.112(9)	0.08540	-
	9900(200)	1.40(13)	3.44(7)	0.11(1)	0.08282	-
	9720(194)	1.2(11)	3.31(7)	0.104(9)	0.07996	-
	9520(280)	0.98(9)	3.15(9)	0.10(1)	0.07630	-
	9400(280)	0.83(8)	3.02(9)	0.10(1)	0.07337	-
	9280(280)	0.74(7)	2.93(9)	0.092(11)	0.07146	-

*Values were obtained at T=11600 [K]

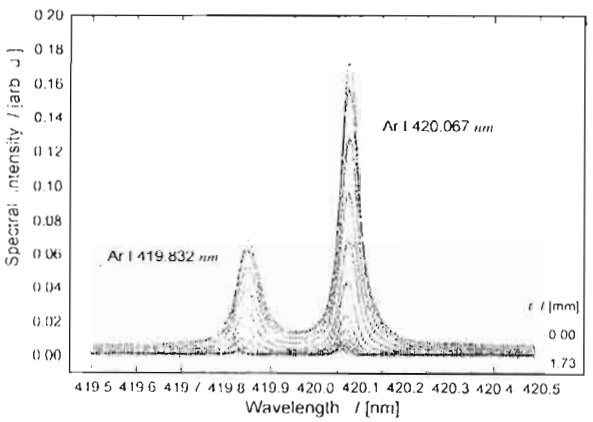

Figure 2. An example of experimental and fitted profiles for various positions along arc radius.

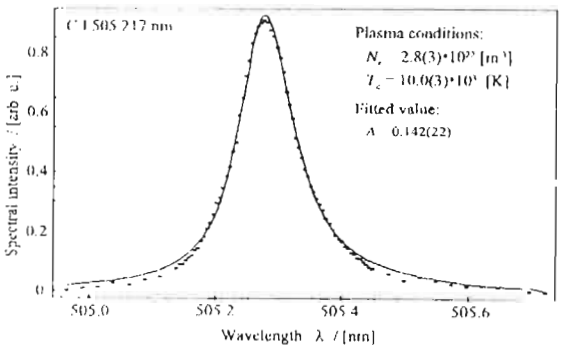

Figure 3. An example of experimental and fitted profiles for C I 505.2 nm line.

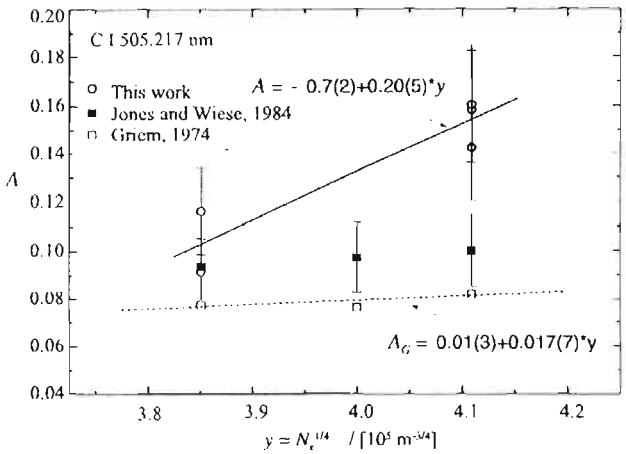

Figure 4. Obtained values of a parameter A vs. $N_e^{1/4}$ for carbon line

Disagreement between results obtained in this work and results obtained by (Griem, 1974) and (Jones and Wiese, 1984) is significant (outside error limits). The reason for this could be found in different methods used for the determination of A. In the future work, both methods should be applied to the same experimental profiles and in this way to make comparison between them.

REFERENCES

S. Djurović, Z. Mijatović, R. Kobilarov and N. Konjević, *J. Quant. Spectrosc. Radiat. Transfer* **57** (1997) 695.

H. R. Griem, *Spectral Line broadening by Plasmas*, Academic Press, New York (1974).

D. W. Jones and W. L. Wiese, *Phys. Rev. A* **30** (1984) 2602.

D. Nikolić, *MSc Thesis*, Faculty of Physics, University of Belgrade (1998).

D. Nikolić, S. Djurović, R. Kobilarov, Z. Mijatović and N. Konjević, *Third Yugoslav Conference on Spectral Line Shapes (Invited Lecture - In Press)*, Brankovac (1999).