Journal of Research in Physics Vol.28, No. 3, 235-238 (1999)

MEASURED STARK WIDTHS OF SEVERAL Ar II AND Ar III SPECTRAL LINES

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1. INTRODUCTION

A number of experimental and theoretical papers have dealt with Stark broadening of singly (Ar II) and doubly (Ar III) ionized argon spectral lines (Lesage & Fuhr 1998, and references therein). The aim of this paper is to provide some new data on the Stark width of ionized argon spectral lines at 22 500 K electron temperature (T) and 1.90 10^{23} m^{-3} electron density (N). We have measured Stark FWHM (full-width at half intensity maximum, w) of four Ar II and seven Ar III spectral lines. The Stark widths of the 371.474 nm Ar II, as well of the 248.886 nm and 250.442 nm Ar III spectral lines have not been measured before, to the knowledge of the authors.

2. EXPERIMENT

The modified version of the linear low pressure pulsed arc (Djeniže et al 1989, Djeniže et al 1998) has been used as a plasma source. A pulsed discharge driven in a quartz discharge tube of 5 mm inner diameter and has an effective plasma length of 5.8 cm. The tube has end-on quartz windows. On the opposite side of the electrodes the glass tube was expanded in order to reduce sputtering of the electrode material onto the quartz windows. The working gas was argon and helium mixture (72% Ar + 28 % He) at 130 Pa filling pressure in flowing regime. Spectroscopic observation of isolated spectral lines were made end-on along the axis of the discharge tube. A capacitor of 14 μF was charged up to 2.5 kV. The line profiles were recorded by a shot-by-shot technique using a photomultiplier (EMI 9789 QB) and a grating spectrograph (Zeiss PGS-2, reciprocal linear dispersion 0.73 nm/mm in the first order) system. The exit slit (10 μm) of the spectrograph with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps (0.0073 nm). The photomultiplier signal was digitized using oscilloscope, interfaced to as computer. A sample output, as example, is shown in Fig.1. The measured profiles were of the Voigt type due to the convolution of the Lorentzian Stark and Gaussian profiles caused by Doppler and instrumental broadening. For electron density and temperature obtained in our experiment the Lorentzian fraction in the Voigt profile was dominant. Van der Waals and resonance broadening were estimated to be smaller by more than an order of magnitude in comparison to Stark, Doppler and instrumental broadening. A standard deconvolution procedure (Davies & Vaughan 1963) was used. The deconvolution procedure was computerized using the least square algorithm. (see Fig.2 for a example). The Stark widths were measured with ±8% error.

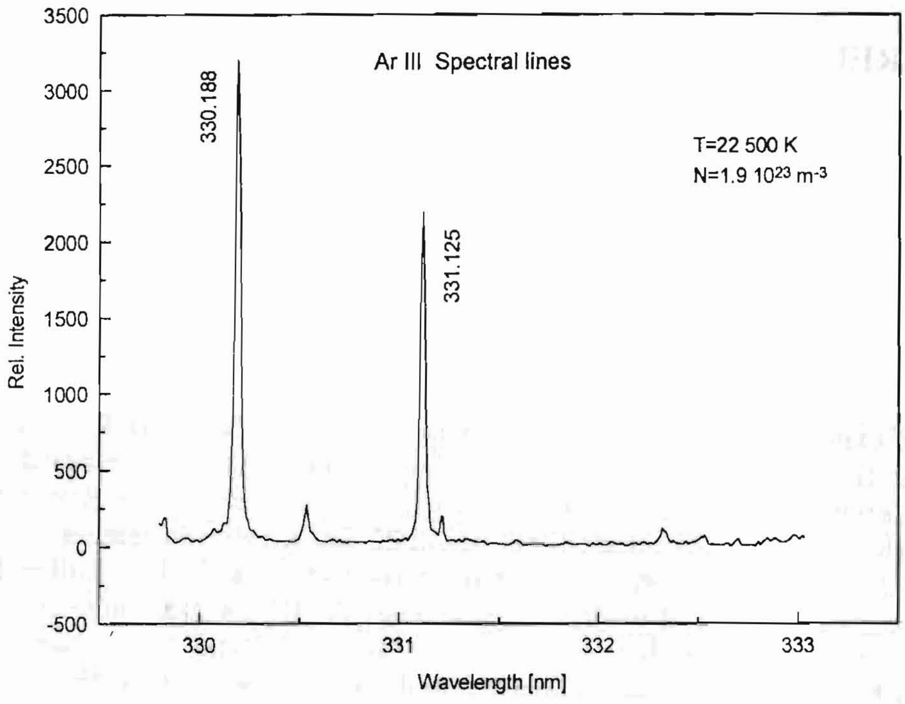

Fig.1.
Recorded spectrum at 15th μs after the beginning of the discharge (when the line profiles were analyzed) with the investigated Ar III spectral lines from the multiplet No.1.

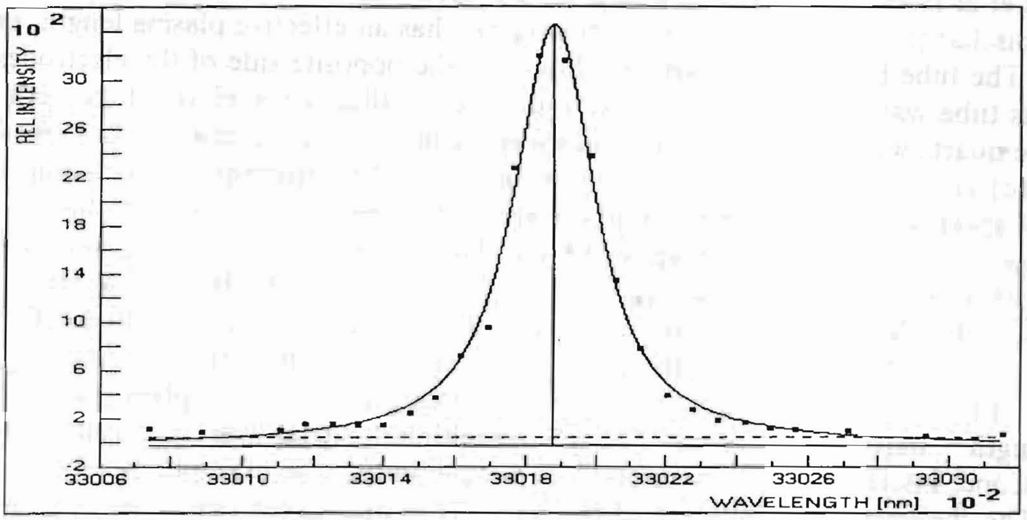

Fig.2.
Profile of the 3301.88 nm Ar III spectral line. *, experimental points; —, Voigt fitting

Great care was taken to minimize the influence of self-absorption on Stark width determinations. The opacity was checked by measuring line-intensity ratios within multiplets No. 1 and No.3 in the case of the Ar III spectrum. The values obtained were compared with calculated ratios of the products of the spontaneous emission probabilities and the corresponding statistical weights of the upper levels of the lines. It turns out that these ratios differed by less than ± 4 % in the 15^{th} μs of the discharge.

The plasma parameters were determined using standard diagnostics methods. The electron temperature was determined from the Boltzmann-slope of seven investigated Ar III lines with a corresponding upper-level energy interval of 8.32 eV. The necessary atomic parameters were taken from Wiese et al (1969) and Striganov & Sventickii (1966). At 15^{th} μs after the beginning of the discharge (when the spectral line profiles were analyzed) the found electron temperature was 22 500 K ± 10 % (see Fig.3).

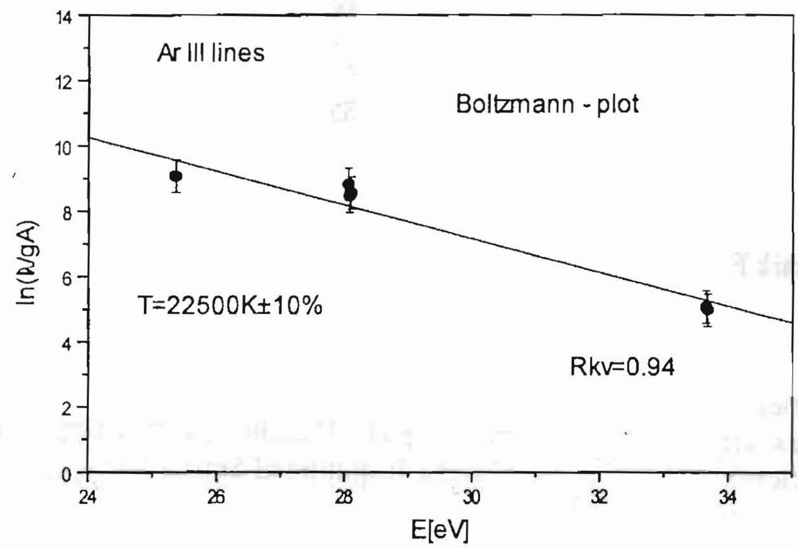

Fig.3.
Boltzmann-plot of seven Ar III spectral lines with 0.94 correlation factor.

For electron density measurement we used the convenient Stark width of the He II Paschen-α 468.57 nm spectral line. The obtained value was N= 1.90 10^{23} m^{-3} ±9 %.

3. RESULTS

Our experimental results of the measured Stark FWHM values (in 0.1 nm) at 22 500 K electron temperature and N = 1.90 10^{23} m^{-3} electron density are given in the Table 1.
It turns out that our measured Stark width values agree with those from other experimental works (Djeniže et al 1996, and references therein) in the case of Ar III spectral lines and with values presented by Pellerin et al (1997) in the case of Ar II spectral lines. The results of comparison between our new experimental Stark widths values and existing theoretical data will be presented in Djeniže et al (2000).

Emitter	Transition	λ (nm)	FWHM (0.1nm)
Ar II			
	3d ^{4}D - 4p ^{2}D^0	371.47	0.448
	4p ^{4}P^0 - 5s ^{4}P	372.04	1.100
	4s ^{4}P - 4p ^{4}S^0	372.93	0.386
	3d ^{4}D - 4p ^{4}D^0	401.38	0.413
Ar III	4p$'$ ^{3}P^0 - 4d$'$ ^{3}P^0	248.89	0.216
	4p$'$ ^{3}P - 4d$'$ ^{3}P^0	250.44	0.316
	4s ^{5}S^0 - 4p ^{5}P	330.19	0.260
		331.12	0.240
	4s$'$ ^{3}D^0 - 4p$'$ ^{3}F	333.61	0.280
		334.47	0.230
		335.85	0.250

Table 1.
Measured Stark FWHM at T=22 500 K electron temperature and N=1.9 10^{23} m^{-3} electron density.

Acknowledgment

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

References

Daviess J.T., Vaughan J.M., 1963 Aph.J. 137, 1302.
Djeniže S. et al., 1989, JQSRT 42, 429.
Djeniže S., Milosavljević V., Srećković A., 1998, JQSRT, TOM 59, 71.
Djeniže S., Bukvić S., Srećković A., Platiša M., 1996, J.Phys. B 29, 429.
Djeniže S., Bukvić S., Mišković D., 2000 (to be published)
Lesage A., Fuhr J., 1998, *Bibliography on Atomic Line Shapes and Shifts*, Supp.5 (April 1992 through December 1997) Publication de l'Observatoire de Paris.
Pellerin S., Musiol K., Chapelle J., 1997, JQSRT 57, 377.
Striganov R.A., Sventickii N.S., 1966, *Tablici Spectralnjih Linii*, Atomizdat, Moskva.
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).