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MEASURED STARK PARAMETERS OF THE NaI-D SPECTRAL LINES IN ARGON PLASMA

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Abstract. Stark widths and shifts of the NaI-D spectral lines (588.995 nm and 589.59 nm) have been measured in the argon plasma at the 38 000 K electron temperature and $3.5 \cdot 10^{23} m^{-3}$ electron density. The measured widths and shifts were compared with the existing theoretical predictions.

1. INTRODUCTION

Information on Stark broadening parameters (width and shift) of the sodium spectral lines (which are found in typical stars spectra) are of great astrophysical interest because they are necessary in the opacity calculations (Dimitrijević and Sahal-Brechot, 1985) and they are also useful for the diagnostics of astrophysical and laboratory plasmas (Griem, 1974). However, to the knowledge of the authors only three experiments (Purić *et al.*, 1976; Baur and Cooper, 1977; Djeniže *et al.*, 1992) dealt with the Stark widths and only three papers : Purić *et al.* (1976), Djeniže *et al.* (1992a) and Srećković and Djeniže (1994), are devoted to the measurements of the NaI-D spectral line Stark shifts.

The aim of this work is to extend the range of the experimental data concerning Stark parameter values of the NaI-D spectral lines (588.995 nm, 589.59 nm) at 38 000 K electron temperature, and also, a comparison of these values with the existing theoretical data calculated on the basis of various approximations : Dimitrijević and Sahal-Brechot (1985), Griem (1974) and Mazure and Nollez (1978) will be presented.

2. EXPERIMENT

The linear pulsed arc, that has been used as a plasma source, has been described elsewhere (Djeniže *et al.* 1991, 1992). A pulsed discharge occured in a Pyrex discharge tube of 5 mm i. d. and had an effective plasma length of 5.8 cm. Sodium atoms have been released as impurities by sputtering from a discharge tube (the Pyrex glass contains 4.4% of Na_2O). In order to release impurity atoms from glass walls more efficiently, and obtain highest possible electron density, we have used discharge of the condenser battery of 8 μF capacity charged up to 108 J, as described in details in Djeniže *et al.* (1992). The working gas was argon at a 130 Pa filling pressure. We have determined the following electrical characteristics of the discharge from the Rogowski coil signal : circuit inductance = 2.3 μH, equivalent circuit resistance = 0.29 Ω, period = 28 μs and the peak current = 6.6 kA.

Investigated spectral lines were well isolated from other spectral lines emitted by this plasma. We have obtained a good reproducibility (>90 %) of the investigated spectral line radiation intensities. The selfabsorption of the measured sodium spectral lines was small, owing to the low concentration of the investigated emitting atomic species in the plasma due to the method by which the sodium impurity atoms have been introduced.

The spectroscopic observations were made end-on, along the axis of the discharge tube. Scanning of the spectral line profiles was done by using a shot-to -shot technique, while advencing the exit slit-photomultiplier combination in small wavelength steps (Djeniže *et al.*, 1991). The photomultiplier signal was digitized using HAMEG 205-2 oscilloscope interfaced to a computer. The measured profiles were of the Voigt type. The standard deconvolution procedure (Davies and Voughan, 1963) was computerized using the least square algoritm. The estimated error of the obtained Stark FWHM (full-width at half maximum intensity) (w) was within $\pm$15 %.

The Stark shifts (d) were measured relative to the unshifted spectral lines emitted by the same plasma (Purić and Konjević, 1972). The Stark shifts were determined with $\pm$8% error. In Fig. 1 eleven NaI-D spectral line profiles recorded at different time (starting from 10 μs up to 60 μs with 5 μs increment) after the beginning of the discharge are presented. The red shift of the both NaI-D lines is evident.

The electron temperature (T) decay was found from the ratios of the relative intensities of 280.94 nm Ar IV, 328.58 nm Ar III and 335.09 nm ArII spectral lines with an estimated error of $\pm$11% assuming the existence of LTE. The electron density (N) decay was obtained using a single wavelength He-Ne laser interferometer at the 632.8 nm with an estimated error of $\pm$6%

Atomic parameters required for the diagnostic purposes (for ArIV, ArIII and ArII spectra) have been taken from Wiese *et al.* (1969).

Table 1 Measured Stark width and shift values

λ(nm)	T	N	w_m	d_m	$\frac{w_m}{w_G}$	$\frac{w_m}{w_{MN}}$	$\frac{w_m}{w_{DSB1}}$	$\frac{w_m}{w_{DSB2}}$	$\frac{d_m}{d_G}$	$\frac{d_m}{d_{MN}}$	$\frac{d_m}{d_{DSB1}}$	$\frac{d_m}{d_{DSB2}}$
588.995	3.8	3.5	2.62	0.38	1.34	1.25	1.88	1.42	0.98	0.92	0.61	0.47
589.59	3.8	3.5	2.28	0.41	1.16	1.08	1.62	1.23	0.106	0.99	0.66	0.50

3. RESULTS

The results of the measured Stark FWHM (w_m, in Å), and shift (d_m) values (in Å) at the given T (in 10^4 K) and N (in $10^{23}\mathrm{m}^{-3}$) are presented in Table 1. Ratios of the measured w_m and d_m values to the calculated w_G, w_{MN}, w_{DSB1}, w_{DSB2}, d_G, d_{MN}, d_{DSB1} and d_{DSB2} Stark width and shift values are also given. For the evaulation of the NaI-D spectral lines Stark width and shift values, at the given electron density and temperature, we use Eq. (226) and Eq. (227), respectively from Griem (1974), based on the quasistatic ion approximation. The necessary data like electron impact half width (w_e), shift (d_e) and ion broadening parameter (α) are taken from

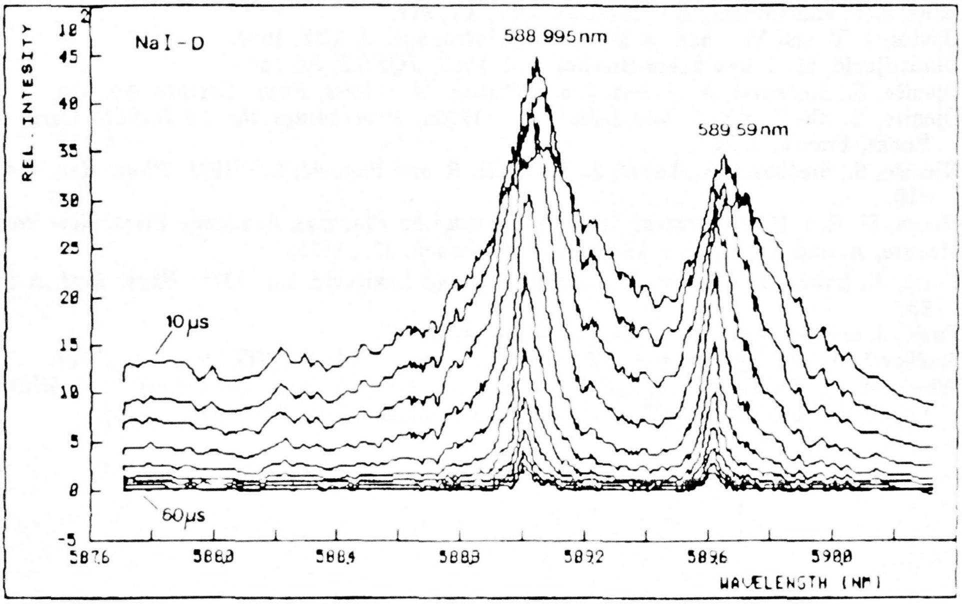

Fig. 1. Recorded spectral lines at various instants after the beginning of the discharge.

Griem (1974)-(G), and Dimitrijević and Sahal-Brechot (DSB_1). The values w_{DSB2} and d_{DSB2} are calculated width and shift data by Dimitrijević and Sahal-Brechot (1985), based on the ion impact approximation. In the case of the Model Microfield Method presented by Mazure and Nollez (MN) (1978), the total Stark width and shift values (w_{MN} and d_{MN}) were obtained using Fig. 1 in Mazure and Nollez (1978).

4. CONCLUSION

Our measured Stark shift values (d_m) are in excellent agreement with Griem's and Mazure and Nollez's predictions and are lower (about 39%) than those calculated by Dimitrijević and Sahal-Brechot on the basis of the quasistatic-ion approximation. Predicted d_{DSB2} data are higher than our d_m values up to a factor 2.1. In the case of the Stark width data there is also resonable agreement between our experimental values (w_m) and those obtained by the Model Microfield Method taking into account experimental accuracy and limited reliability of the theoretical model (the average ratio w_m/w_{MN} is 1.16).

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