Publ. Astron. Obs. Belgrade No. 76 (2003), 229 - 232 *Contributed paper*

MEASURED STARK SHIFTS OF SEVERAL Ar III SPECTRAL LINES

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Abstract. Stark shifts of five doubly ionized argon (Ar III) spectral lines have been measured in 3d-4p and 3d-4p transitions in a mixture of Ar (72%) and He (28%) plasma created in the linear, low pressure, pulsed arc discharge at about 30 150 K electron temperature and 1.47 10^{23} m^3 electron density. They are the first published data in this field.

1. INTRODUCTION

Atomic data such as Stark shifts (d) are useful for plasma diagnostical purposes. The d values for the doubly ionized argon (Ar III) ions are poorly known. Only one work deals with their measurements (Kobilarov and Konjević, 1990). No calculated Ar III d values exist, to the knowledge of the authors (Lesage and Fuhr, 1999; Konjević et al., 2002). The aim of this work is to present 5 Ar III d values measured in optically thin argon-helium discharge. They are the first data in this field.

2. EXPERIMENT

The modified version of the linear low pressure pulsed arc (Djeniže et al., 2002ab; Srećković et al., 2000, 2001) has been used as an optically thin plasma source. A pulsed discharge was performed in a pyrex discharge tube of 5 mm inner diameter and plasma length of 14 cm. The working gas was Ar (72%) and He (28%) mixture at 130 Pa filling pressure in flowing regime.

The capacitor of 14 μF was charged up to 2.8 kV. The spectral line profile recording procedure is described in Djeniže et al. (2002a,b). The averaged photomultiplier signal (five shots at the same spectral range) was digitized using an oscilloscope, interfaced to a computer. A sample output, as an example, is shown in Fig. 1.

The electron temperature (T) was determined (from the 1^{st} μs up to the 60^{th} μs) from the ratios of the relative intensities (Saha equation) of Ar III (330.186 and 331.124 nm) and Ar II (329.364 and 330.723 nm) spectral lines with an estimated error of ±8 %, assuming the existence of LTE, according to the criterion in Griem (1974). Also, the electron temperature has been obtained on the basis of the Boltzmann–plot method (from the 20^{th} μs up to the 60^{th} μs) using nine Ar III (330.186; 331.124; 348.055; 335.853; 336.131; 334.476; 333.618; 302.398 and 302.709 nm) relative line intensities within upper energy level interval of 4.42 eV (ΔE_u) with an estimated error of ±14%. All the necessary atomic data were taken from NIST (2003).

The electron density (N) decay was measured using a well–known single laser interferometry technique for the 632.8 nm He–Ne laser wavelength with an estimated error of ±6 % . Recorded interference fringe in argon–helium plasma is presented in Fig. 2. The electron density and electron temperature decay are presented in Fig. 3.

Table 1: Measured Ar III Stark shift (d_m) values at given electron temperatures (T) and densities (N). A negative shift is towards the blue.

Transition	*Multiplet*	λ (nm)	T (10^3 K)	N (10^{23} m^{-3})	d_m (pm)
$3p^3 3d'$ – $3p^3(^2D^0)4p'$	$^3F^0$ – ^3F (8uv)	248.411	30.15	1.47	-0.7
		250.891	30.15	1.47	-0.4
	$^3D^0$ – ^3D (9uv)	272.484	30.15	1.47	0.0
	$^3D^0$ – ^3P (10uv)	229.718	30.15	1.47	-2.5
$3d^3 3d"'$ – $3p^3(^2P^0)4p"$	$^3P^0$ – ^3P (6)	347.129	30.15	1.47	-6.8

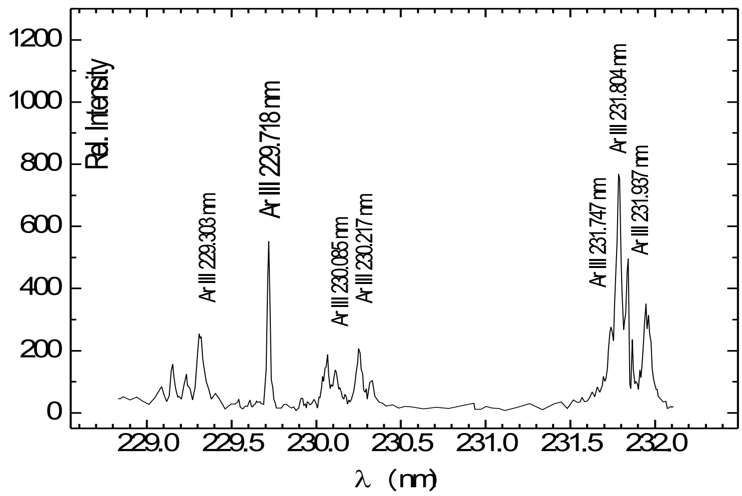

Fig. 1: Part of the recorded spectrum with several investigated Ar III spectral lines at the 20^{th} μs after the beginning of the discharge.

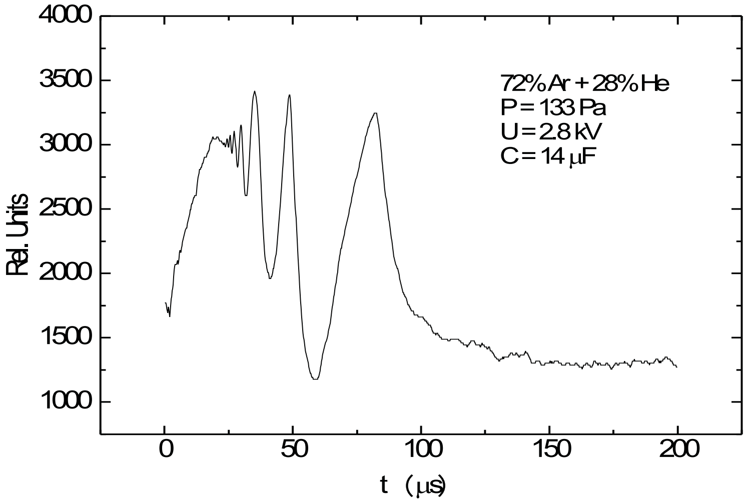

Fig. 2: Recorded interference fringe in argon-helium plasma

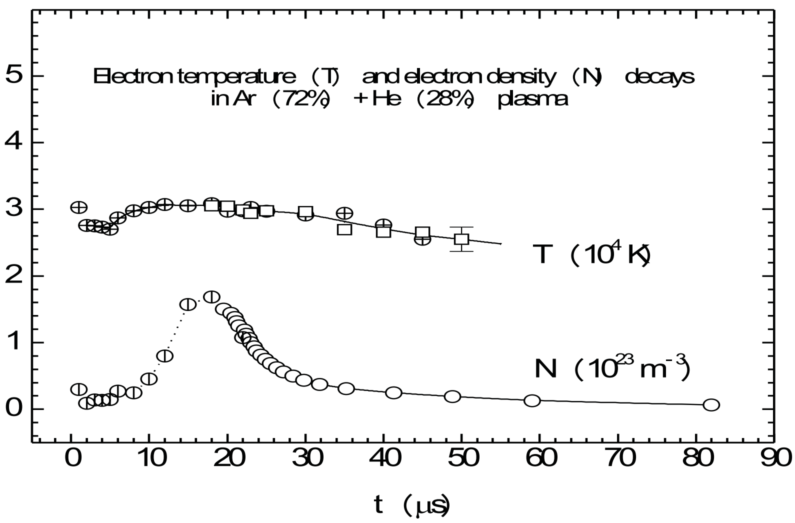

Fig. 3: Temporal evolution of the electron temperature (T) and electron density (N) during the plasma decay. $\oplus$, Saha equation; □, Boltzmann–plot.

3. STARK SHIFT MEASUREMENT

The stark shifts were measured relative to the unshifted spectral lines emitted by the same plasma (Srećković et al., 2000; Djeniže et al., 2002b and references therein). The Stark shift of the spectral line can be measured experimentally by evaluating the position of the spectral line center recorded at two electron density values during the plasma decay. In principle, the method requires recording of the spectral line profile at the higher electron density (N_1) that causes an appreciable shift and then, latter, when the electron concentration has dropped to a value (N_2) lower by at least an order of magnitude. The difference of the line center position in these two cases is Δd, so that the shift d_1 at the higher electro density N_1 is

$$d_1 = N_1 \Delta d/(N_2 N_1). \tag{1}$$

Stark shift data are determined with ± 0.8 pm error at a given N and T. Measured (d_m) Stark shifts are presented in Table 1.

4. CONCLUSION

We have obtained d values with negative sign.

Acknowledgments. This work is a part of project Determination of the atomic parameters on the basis of the spectral line profiles supported in part by the Ministry of Science, Technologies and Development of the Republic of Serbia.

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