Journal of Research in Physics Vol. 28, No. 3, 255-258 (1999)

EXPERIMENTAL STARK PARAMETERS FOR Ar I 426.63 nm AND Ar II 426.65 nm SPECTRAL LINES

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1. INTRODUCTION

Large number of papers deals with shapes and shifts of plasma broadened argon lines (Konjević and Wiese, 1990 and references therein) and the reported results exhibit significant scattering. The results presented here are the part of an systematic and high precision experimental study of plasma broadened argon spectral lines. The Stark parameters of argon spectral lines emitted from wall-stabilized arc plasma can be found directly from recorded experimental profiles (Nikolić, 1998) whether they are isolated or overlapped. Experimental results are compared with theoretical predictions (Griem, 1974) in the range of electron number density $N_e \in (0.74, 2.9)\cdot 10^{22}$ m^{-3}. Such comparison exhibits discrepancy between measured and theoretical widths and shifts in the case of Ar I line, while theoretical data for Ar II line are not available.

2. EXPERIMENTAL

The emission plasma source is a wall-stabilized arc operated in argon at atmospheric pressure. For diagnostic purpose, the gas mixture containing 96% of argon and 4% of hydrogen enters the region between central part of the arc and electrode sections, and leave the arc through the outlets near electrodes with the flow rate of 0.03 l/min. The flow rate of the working gas (argon) was 3 l/min. The arc is operated at current of 30 A, supplied by an current-stabilized power supply with a 0.3% stability. The side-on observations were performed with a 1m monochromator equipped with a 1200 g/mm grating and 36000 step/rev stepping motor. The spectra are recorded by a data acquisition and processing system (Djurović et al., 1996). For the shift measurements, the emission from the Geissler tube at low-pressure argon discharge served as reference source of unshifted lines. The light from the arc plasma and from the reference source was alternatively focused onto the entrance slit of the monochromator by the means of the light chopper. An electron number density N_e in the range $(0.74, 2.9)\cdot 10^{22}$ m^{-3} is determined from the width of Balmer H_β line (Vidal et al.,1973) with overall uncertainty under 11%. As described in (White et al.,1958; Popenoe and Shumaker,1965), the electron temperature T_e in the range $(9300, 10800)$ K is obtained from plasma composition data with overall uncertainty under 5%.

3. RESULTS AND DISCUSSION

The Abel inversion procedure described in (Djurović, 1998) was applied on side-on recorded spectral line profiles. Modelling procedure (Nikolić, 1998) is used for obtaining the Stark electron widths and shifts, ion-broadening parameter as well as Stark full halfwidths (w_m). The spectral line profiles from the reference source were fitted to Gaussian profiles by least square method. The shift of plasma broadened lines is measured at the maximum (d_{mp})

of the extracted $j_{A,R}(x)$ profile and as electron shift d_e of extracted Lorentzian profile in the case of Ar II line . The experimental results of w_m, d_{mp} are represented in Table 1 along with available theoretical (semiclassical) (Griem, 1974) full halfwidths w_t and shifts d_{tp}.

Table 1. Measured and theoretical values for Stark widths and shifts

N_e (10^{22} m^{-3})	T_e (K)	Ar I 426.63 nm				Ar II 426.65 nm	
		w_m (0.1 nm)	w_m / w_t	d_{mp} (0.1 nm)	d_{mp} / d_{tp}	w_e (0.1 nm)	d_e (0.1 nm)
2.90	10760	0.280	0.45	0.177	0.80	0.262	0.179
2.82	10730	0.276	0.45	0.174	0.81	0.258	0.177
2.70	10700	0.267	0.46	0.166	0.80	0.250	0.174
2.46	10550	0.258	0.49	0.164	0.86	0.243	0.163
2.15	10400	0.231	0.50	0.142	0.84	0.214	0.151
1.90	10250	0.202	0.50	0.123	0.82	0.198	0.137
1.60	10050	0.189	0.56	0.116	0.90	0.179	0.122
1.40	9900	0.161	0.55	0.096	0.85	0.159	0.107
1.20	9720	0.146	0.58	0.089	0.91	0.133	0.096
0.98	9520	0.121	0.60	0.075	0.93	0.119	0.084
0.83	9400	0.112	0.66	0.064	0.93	0.099	0.068
0.74	9280	0.101	0.67	0.059	0.96	0.092	0.061

The measured widths and shifts are corrected for Van der Waals broadening (Griem, 1974), while resonance broadening effects are found negligible. The theoretical shifts are corrected for the Debye shielding effects (Griem, 1974). The error for both, halfwidth and shift measurements is estimated from under 8% to under 15% ranging from the highest to the lowest electron number densities. Figure 1 represents the temperature dependence of ratio of measured and theoretical shifts for Ar I 426.63 nm line. Weighted linear regression gives relatively weak temperature influence either for this work only (greater slope) or with the respect to all available results of other authors (smaller slope).

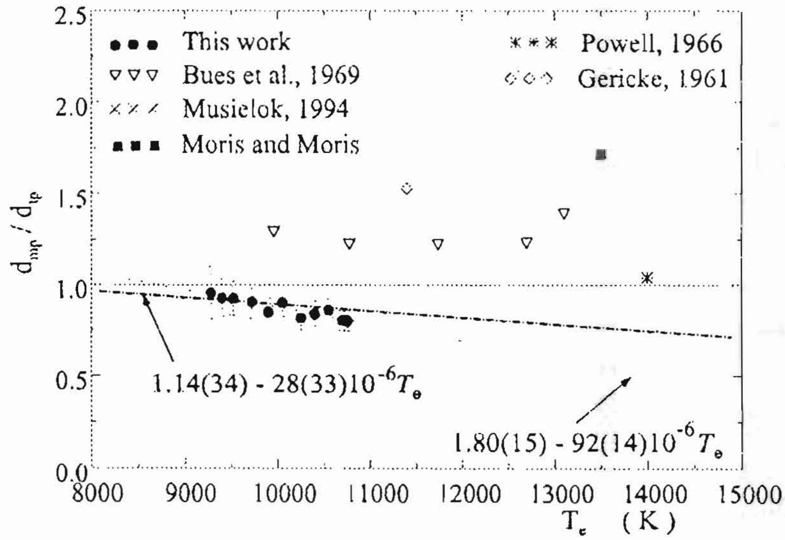

Fig. 1. Temperature dependence of measured to theoretical shifts ratio for Ar I 426.63 nm

Figure 2 gives the temperature dependence of ratio of measured and theoretical widths for Ar I 426.63 nm line. Weighted linear regression suggests relatively stronger (compared to shifts) temperature influence either for this work only (greater slope) or with the respect to all available results of other authors (smaller slope). According to (Nikolić, 1998), in the case of the Ar I 426.63 nm line, weighted mean for the d_{mp} / d_{tp} ratio is 0.85(2), while for w_m / w_t this value is 0.51(1).

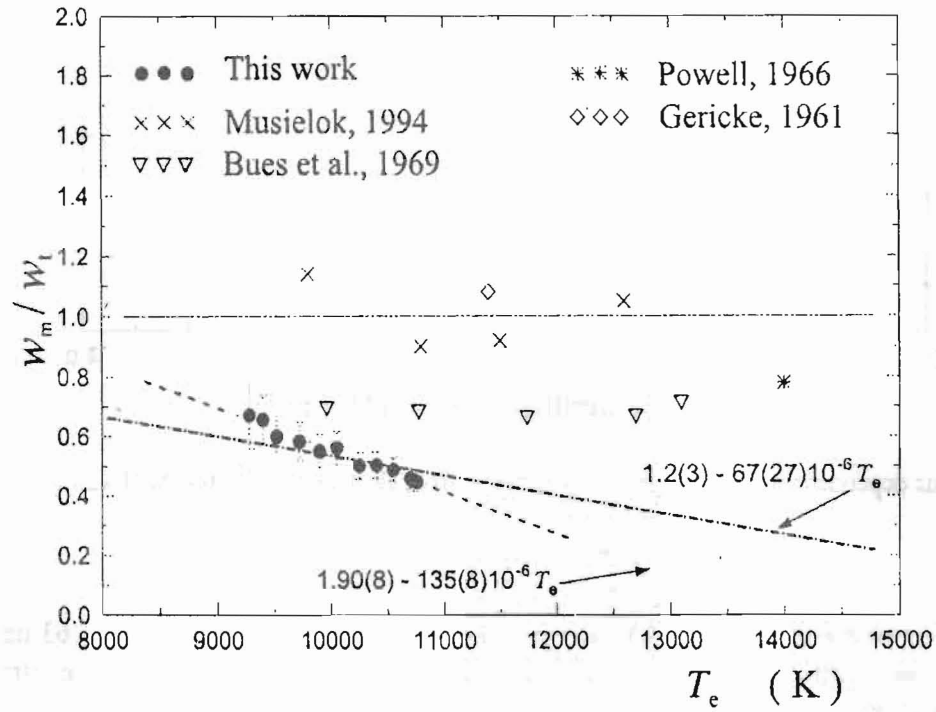

Fig. 2. Temperature dependence of measured to theoretical widths ratio for Ar I 426.63 nm

From the Figs. 1 and 2 it is obvious that results of the other authors are significantly scattered and systematically higher than values obtained in this work. Possible reason is due to overlapping of these close Ar I and Ar II spectral lines. The overlapping was detected from the fact that the red wing asymmetry of the recorded profile increases as electron number density decreases. Satisfactory fitting (Nikolić, 1998) of such experimental profiles is achieved only with the assumption of the existence of a close Ar II 426.65 nm line.

Figure 3 shows confirmed linear dependence of electron Stark widths and shifts from electron number density for Ar II 426.65 nm line. Due to lack of theoretical predictions (Griem, 1974), comparisons with the respect to the theory are not presented. Since the spectral lines of the single ionized atoms can be modelled with Voigt profiles (Griem, 1974), extracted Stark profile is of Lorentzian type, so the full measured halfwidth is: $w_m = 2 \cdot w_e$, while the measured shift at the maximum is $d_{mp} = d_e$.

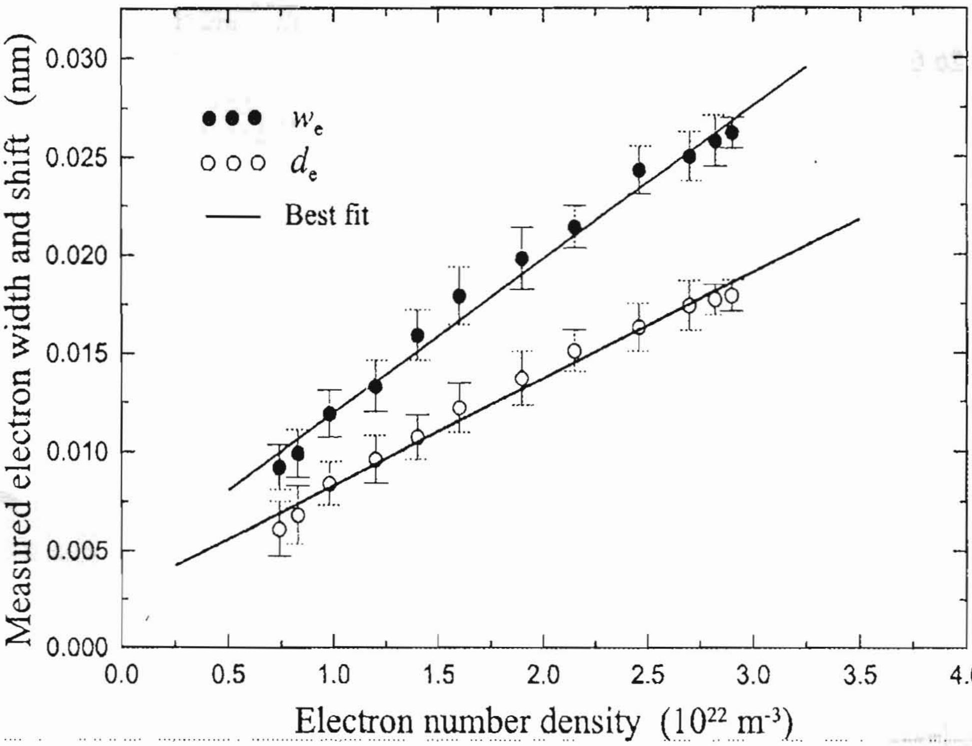

Fig. 3. Linear dependence of electron widths and shifts from electron density for Ar II 426.65 nm

The presence of Ar II 426.65 nm spectral line on the red wing of Ar I 426.63 nm line has to be taken into account, specially at high electron densities where the stronger overlapping effects can occurred.

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