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EXPERIMENTAL STARK SHIFT OF SEVERAL NII AND OII SPECTRAL LINES

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SUMMARY: Stark shift of four NII and seven OII spectral lines have been measured for the first time in the linear low pressure pulsed arc plasma and compared with existing theoretical values.

1. INTRODUCTION

Stark broadening parameters of singly-ionized atom spectral lines from the second period of the periodic system, have been reported in a number of papers (Fuhr and Lesage, 1993; and references therein). The great number of these papers indicate the interest for such data due to their applicability in study of astrophysical and laboratory plasmas. However, only four publications (Day and Griem, 1965; Berg et al, 1967; Baker and Burgess, 1979 and Djeniže et al, 1992) have been devoted to the experimental determination of the Stark shift of the singly ionized nitrogen (NII) spectral lines and only one paper (Djeniže et al, 1991) reported the experimental investigation of the OII spectral lines Stark shift.

The aim of this paper is to provide some new data on the Stark shift (d) of singly-ionized nitrogen and oxygen spectral lines, not measured before. We have measured Stark shift of four NII and seven OII spectral lines at 44 000 K and 34 000 K electron temperature, respectively. Our obtained data were compared with existing calculated values based on the semiclassical theory (for the three OII multiplets).

2. EXPERIMENT

The modified version of the linear low pressure pulsed arc (Kobilarov et al, 1989) has been used as a plasma source. A pulsed discharge driven in a quartz discharge tube of 8 mm id. and has an effective plasma length of 18 cm between aluminum electrodes. Holes, 2 mm in diameter, located axisymmetrically at the center of electrodes facilitate optical alignment and the laser interferometric measurements of electron density. The tube has end-on quartz windows. The working gases were nitrogen and oxygen at filling pressure of 70 Pa in both cases. The capacitor bank of 8 μF was charged up to 5.2 kV. From the discharge current oscillograms the following values have been determined: period $\tau = 30$ μs, decrement $\delta = 6.2$, resistance $R = 0.52\ \Omega$, inductance $L = 2.1\ \mu$H and peak current $I_m = 8.4$ kA, same for both gases.

Spectroscopic observations of isolated spectral lines have been made end-on along the axis of the discharge tube. The line profiles have been recorded on a shot-by-shot basis using experimental setup system described elsewhere (Djeniže et al, 1992). We have obtained a very good reproducibility (> 90%) of the investigated spectral line radiation intensities.

The Stark shifts were measured relative to the unshifted spectral lines emitted by the same plasma. The unshifted spectral lines were observed at later times during plasma decay and considerably lower electron densities (Purić and Konjević, 1972), and was corrected for the electron temperature decay (Popović et al, 1992). Stark shift data were determined with ±0.002 nm errors at a given electron temperature and density.

Parameters of the plasma were determined by a standard diagnostic methods. The electron density (N) has been measured using a single wavelength He-Ne laser interferometer for the 632.8 nm transition with an estimated error of ± 8%. The electron temperature (T) was found from the ratio of relative intensities of NIII 393.4 nm and NII 383.8 nm spectral lines in the case of the nitrogen plasma, and OIII 396.1 nm and OII 391.2 nm spectral lines in the case of the oxygen plasma, assuming existence of the LTE, with an estimated error of ± 12%. Atomic parameters required were taken from Wiese et al (1996). Temporal evolutions of the N and T in the decaying nitrogen and oxygen plasmas are graphically presented in Fig. 1.

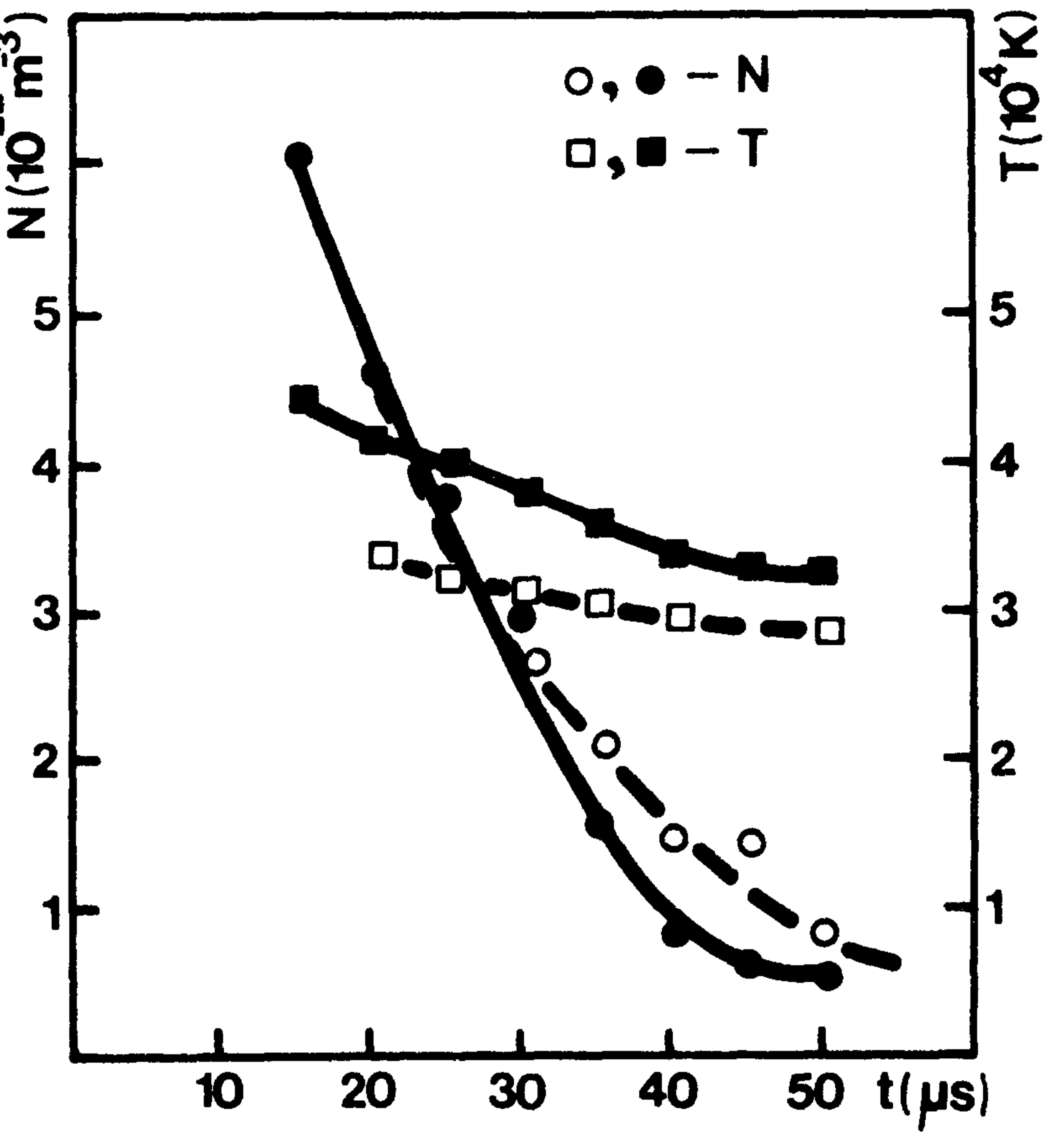

Fig. 1. Temporal evolutions of the electron density (N) and temperature (T) in the decaying nitrogen (—) and oxygen (- - -) plasmas.

Table 1 Measured Stark shift (d_m) values at given electron temperature (T) and density (N). The transition arrays and multiplet numbers are, also, given. The positive shift is toward a red.

Emitter	Transition	Mult	λ (nm)	T (10^4K)	N ($10^{22}m^{-3}$)	d_m (10^{-1} nm)
NII	2p3s – 2p3p	$^3P^0-^3P$ (5)	460.15	4.4	6.0	0.052
			462.11	4.4	6.0	0.022
	2p3p – 2p3d	$^3D-^3D^0$ (20)	478.82	4.4	6.0	0.017
	$2s2p^23p$ – $2s2p^23d$	$^5P^0-^5P$ (69)	532.09	4.4	6.0	0.0
OII	$2p^23s$ – $2p^23p$	$^4P-^4D^0$ (1)	464.91	3.4	4.6	0.039
		$^4P-^4P^0$ (2)	436.69	3.4	4.6	−0.026
		$^2P-^2D^0$ (5)	441.49	3.4	4.6	0.007
	$2p^23s'$ – $2p^23p'$	$^2D-^2F^0$ (15)	459.62	3.4	4.6	0.046
		$^2D-^2P^0$ (17)	391.20	3.4	4.6	0.0
	$2p^23p$ – $2p^23d$	$^2S^0-^2P$ (9)	339.02	3.4	4.6	−0.030
	$2p^23p'$ – $2p^23d'$	$^2F^0-^2G$ (36)	418.55	3.4	4.6	0.0

3. RESULTS AND DISCUSSION

The results of the measured Stark shift (d_m) values at a given electron temperature and density are given in the Table 1, together with transition arrays and multiplet numbers.

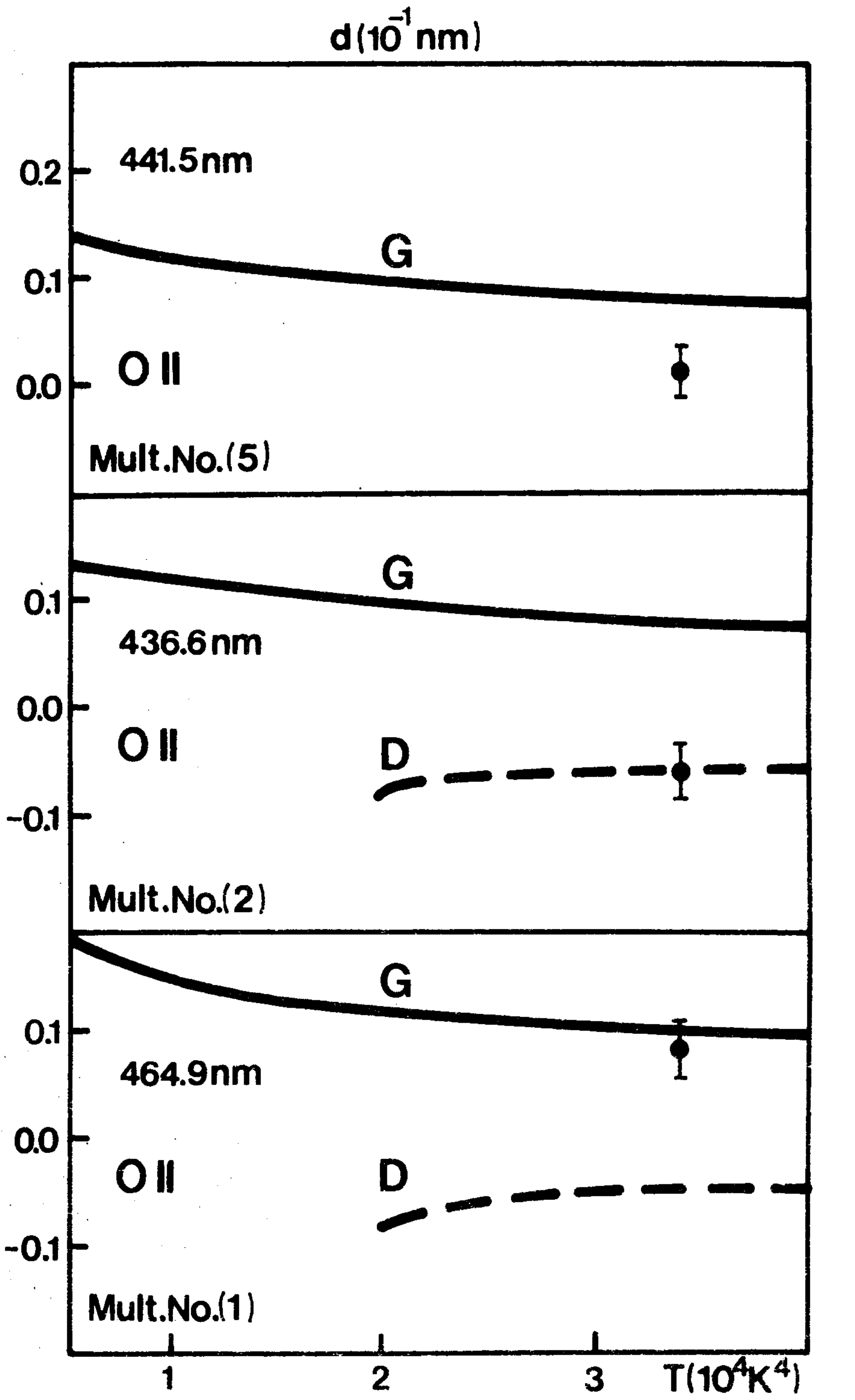

Fig. 2. Stark shifts d (10^{-1} nm) vs the electron temperature at 1×10^{23} m^{-3} electron density. G and D are Griem's (1974) and Dimitrijević's (1982) calculated values based on the semiclassical theory. • is our measured value.

The measured values d_m are generally very small, within experimental error (±0.002 nm) they are close to zero. Measurable shifts were found only for the NII 460.15 nm and OII 464.91 nm, 436.69 nm, 459.62 nm and 339.03 nm spectral lines.

To the knowledge of the authors calculated values of the Stark shift, for the investigated spectral lines, exist only for the three multiplets from the OII spectra. These were performed by Griem (1974) and Dimitrijević (1982). The dependence on electron temperature of theoretical G (Griem, 1974) and D (Dimitrijević, 1982) Stark shifts together with our (•) experimental results at 1×10^{23} m^{-3} electron density are presented in Fig. 2.

It is evident, that the various calculations, G and D, provide different Stark shift sign for the Mult. No. 1 and Mult. No. 2 in OII spectra. Our d_m values agree well with Griem's (1974) values in the case of the Mult. No. 1 and with Dimitrijević (1982) values in the case of the Mult. No. 2. For the OII 441.4 nm spectral line our d_m value is much smaller in comparison to Griem's value.

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ЕКСПЕРИМЕНТАЛНИ ШТАРКОВ ПОМЕРАЈ НЕКИХ СПЕКТРАЛНИХ ЛИНИЈА ИЗ СПЕКТРА NII И OII

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Оригинални научни рад

Штарково померање четири линије из спектра NII и седам линија из спектра OII, до сада експериментално не истраживаних, мерено је у плазми линеарног импулсног лука на ниском притиску и упоређено са постојећим теоријским вредностима.