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STARK WIDTHS OF Fe I AND Ni I SPECTRAL LINES

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SUMMARY: Stark widths of 324.598 nm and 323.944 nm Fe I spectral lines and 324.306 nm Ni I spectral line are measured in a low pressure pulsed arc plasma superimposed to the positive column glow discharge in an argon-helium mixture at electron temperatures and densities ranging from 13 000 K to 17 000 K, and from 3.8 × 10^{22} m^{-3}, respectively.

1. INTRODUCTION

Iron is one of the most abundant elements in the universe. Its spectrum is of great astrophysical interest because it exists in a number of astronomical sources, including the most interesting Seyfert galaxies. Besides iron, nickel shows, also, important abundance in the astrophysical spectrum; especially in the G-K type stars spectrum. Howewer, only three papers are devoted to the experimental investigation of the Fe I spectral lines (Moity *et al.* 1975; Freudenstein and Cooper, 1979; Lesage *et al.* 1990), and only one paper deals with the measurements of the Ni I spectral lines Stark widths (Djeniže *et al.* 1994). To the knowledge of the authors (Konjević and Wiese, 1990; Konjević *et al.* 1984), experimental values of Stark widths of Fe I UV spectral lines have not yet been published.

The aim of this investigation is to provide, for the first time, experimental Stark FWHM (full-width at half intensity maximum) of the Fe I 323.944 nm and 324.598 nm lines (Zaidel *al.* 1977; Striganov and Sventickii, 1966), and of the Ni I 324.306 nm line from the 22 multiplet (Zaidel *et al.* 1977; Moore, 1958).

Results were obtained using plasma of a linear pulsed discharge superimposed to the glow discharge in the argon-helium mixture (Djeniže and Labat, 1983; Skuljan, 1993; Djeniže *et al.* 1994) under two different discharge conditions.

2. EXPERIMENT

A reliable plasma source has been constructed with a repetitive pulsed discharge superimposed to the continuous glow discharge (Fig. 1 in Djeniže *et al.* 1994). The glow discharge has been driven between water-cooled copper electrodes in the argon-helium mixture (72% + 28%) at 50 mA discharge

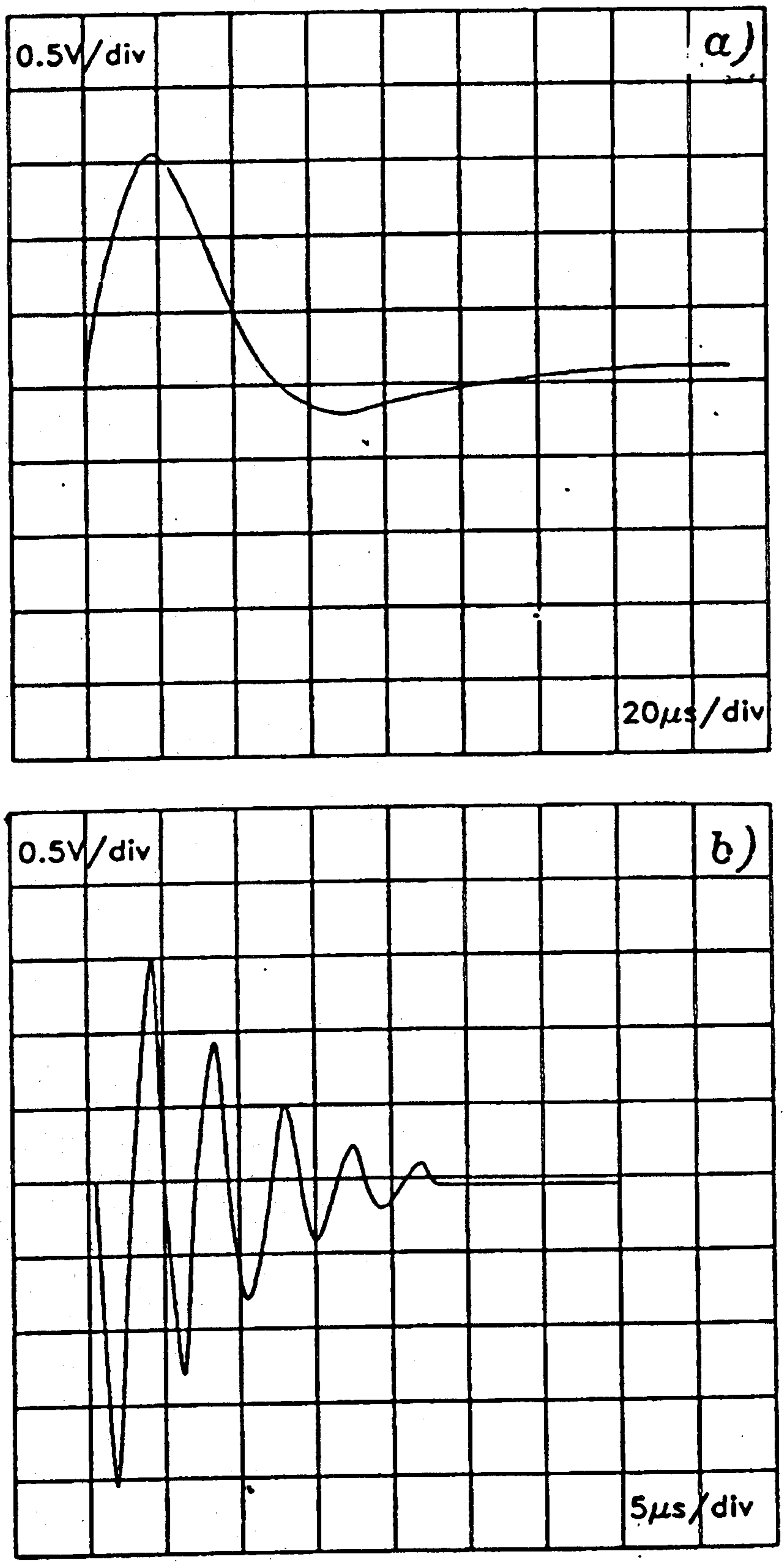

Fig. 1a,b Typical integrated signal of the Rogowski-coil: a) discharge of the slow capacitor battery, b) discharge of the fast capacitor battery.

current and 270 Pa filling pressure. The homogeneous positive-column plasma has been located along the optical axis of the discharge tube in the narrow glass cylinder with inner diameter of 5 mm and length of 80 mm. On each end of the cylinder, an auxiliary ring shaped electrode made of nickel and iron (98% Ni + 2% Fe) has been positioned. Separation between the auxiliary electrodes was 80 mm. These electrodes have been used to drive pulsed discharge from capacitors of 80 μF (slow) and 0.3 μF (fast) charged up to 1.2 kV and 10 kV respectively. Applied continuous glow discharge provides initial erosion of the auxiliary electrodes and good plasma reproducibility during the pulse.

The electric properties of the pulsed discharge were measured by Rogowski coil signals, for two conditions, are presented in Fig. 1). The following values were found: discharge current maximum = 5.9 kA and 3.9 kA, discharge period = 104 μs and 5 μs, decrement = 7.5 and 1.5, for the slow and fast discharge, respectively.

The quantity of iron and nickel atoms sputtered from auxiliary electrodes was sufficient for spectroscopic observations.

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 advancing 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 Voigt type due to the convolution of the Lorentzian Stark and Gaussian profiles caused by Doppler and instrumental broadenings. Van der Waals and resonance broadening are estimated to be smaller by more than an order of magnitude in comparison to Stark, Doppler and instrumental broadening. A standard deconvolution procedure (Davies and Vaughan, 1963) was used. The deconvolution procedure was computerized using the least square algorithm. A sample output is shown in Fig. 2.

The selfabsorption of the measured spectral lines can be neglected, owing to a very low concentration of the investigated emitting atomic species in the plasma considering the method by which these species were introduced in the plasma, especially in the case of the iron atoms because of the relatively low concentration of the iron in the auxiliary electrodes material O_1 and O_2 (Fig. 1 in Djeniže *et al.* 1994). The estimated (on the basis of the calibrated sensitivitie threshold of the opto-electrical detection system) iron and nickel atoms densities, in the space between electrodes O_1 and O_2, were 10^{12} m^{-3} and 10^{14} m^{-3}, respectively. Also, we have checked numerical integrity of the line profile with and without points close to the line centre and we found that there was no indication as to the presence of selfabsorption.

Experimental error in evaluation of the measured Stark FWHM (w_m) was ±15%. Parameters of the pulsed plasma were determined by a standard diagnostic method. Electron temperature (T) was found from the ratio of relative intensities of ArII 500.9 nm and ArI 696.5 nm spectral lines, assuming the existence of the LTE. The maximal electron temperature was 17 000 K and 13 000 K in the case of slow and fast discharge, respectively, within ± 15 % accuracy. Atomic parameters required were taken from Wiese *et al.* (1969). The electron density (N)

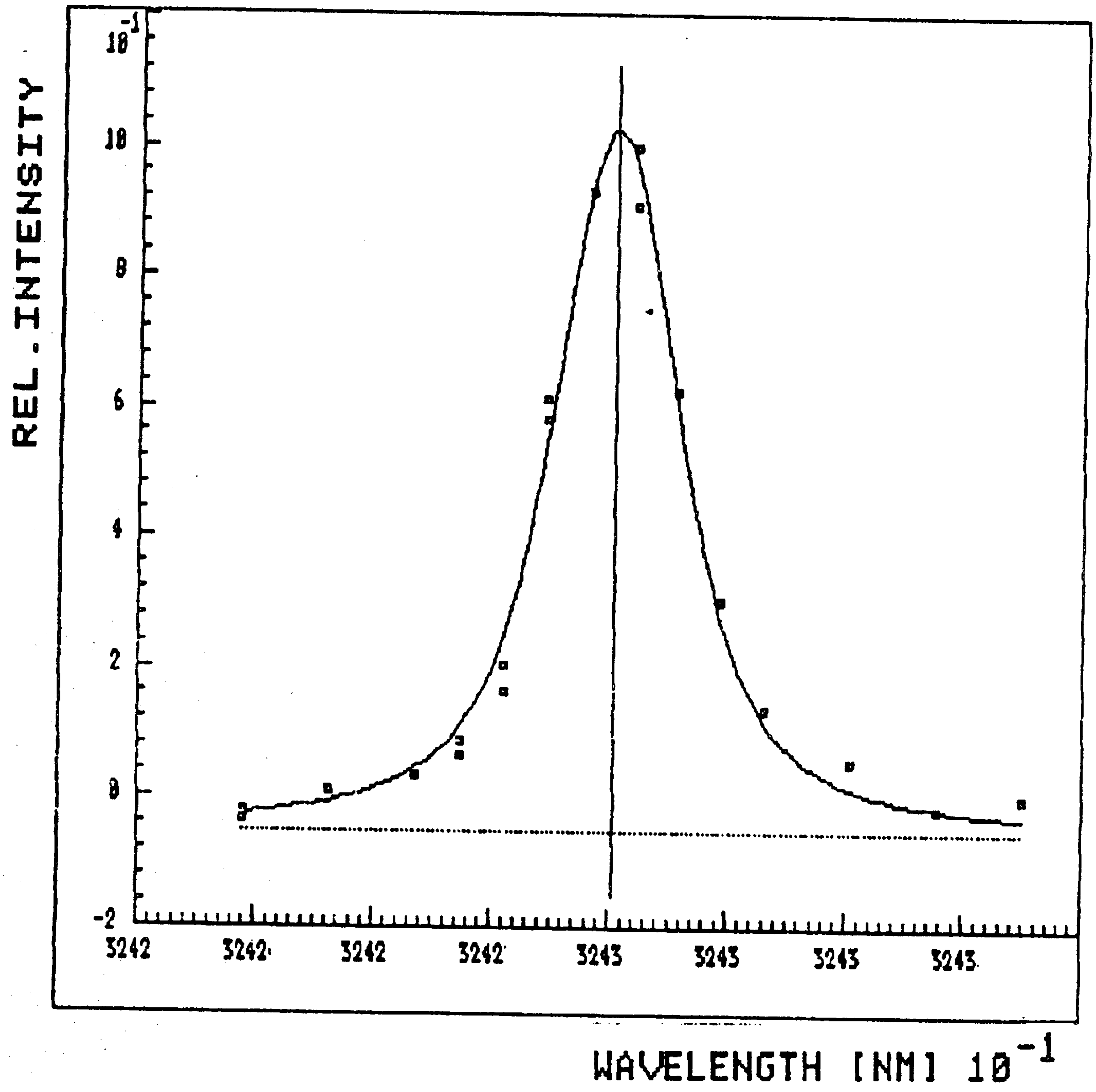

Fig. 2. Ni I 324.306 nm line profile: □ - experimental points, solid line corresponding Voigt profile (best fit).

was found by a single wavelength laser interferometry (Ashby *et al.* 1965), using 632.8 nm He-Ne laser line. The maximal electron density was 3.8×10^{22} m^{-3} and 5.5×10^{22} m^{-3} in the case of fast and slow discharge, respectively, within ± 8% accuracy.

The transitions of the investigated Fe I lines, not classified by Fuhr *et al.* (1988), were identified by Striganov and Sventickii (1966).

3. RESULTS

The results of measured Stark FWHM (w_m) (in nm) at given T and N are presented in Table 1.

To the knowledge of the authors no calculated Stark FWHM values exist for the spectral lines, investigated here.

Table 1. Measured Stark FWHM -w_m (in nm) values at given electron temperature T (in 10^4 K) and density N (in 10^{22} m^{-3}).

EMITTER	TRANSITION	λ (nm)	T(10^4 K)	N(10^{22} m^{-3})	w_m (nm)
Fe I	$a^5D - z^3D^o$	324.598	1.3	3.8	0.0262
	$z^5D^o - f^5D$	323.944	1.3	3.8	0.0357
Ni I	$a^2D - z^1F^o$	324.306	1.7	5.5	0.0197

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ШТАРКОВЕ ШИРИНЕ СПЕКТРАЛНИХ ЛИНИЈА ИЗ СПЕКТАРА Fe I И Ni I

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Оригинални научни рад

Штаркове ширине спектралних линија 324.598 nm и 323.944 nm из спектра Fe I и линије 324.306 nm из спектра Ni I су мерене у плазми импулсног лука на ниском притиску надодатог позитивном стубу тињавог пражњења у смеши аргон-хелијума у опсегу електронских температура: 13 000 K – 17 000 K и концентрација: $(3.8-5.5)\times 10^{22}\mathrm{m}^{-3}$.