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MEASURED STARK PARAMETERS OF THE Ni I 397.356 nm SPECTRAL LINE

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Abstract. Stark width and shift of NiI 397.356 nm spectral line, originating from $a^1D - z^3P^0$ (31) multiplet of $3d^9(a^2D)4s - 3d^9(a^2D)4p$ transition array, have been measured for the electron density range of $1.8 \times 10^{23} - 4.2 \times 10^{23}$ m^{-3} and for electron temperature range of 43 000 - 47 000 K in a pulsed linear arc plasma discharge in nitrogen.

1. INTRODUCTION

The abundance of nickel in the Universe makes the neutral and ionized nickel spectral lines of importance for astrophysical diagnostic purposes. Spectral lines of NiI and NiII are present in the spectras of G-K type of stars (Edvardson 1988; Tautvaisiene & Straizys 1991). The contribution of various mechanismus to the spectral line broadening is discussed in detail in Lanz et al. (1988). However, only two papers are devoted to the experimental investigation of NiI spectral lines (Djeniže et al. 1994; Skuljan et al. 1995). To the knowledge of the authors, experimental Stark width and shift of NiI 397.356 nm spectral line have not yet been published (Konjević and Wiese, 1984,1990; Fuhr & Lesage, 1993 and references therein).

The aim of this investigation is to provide, for the first time, experimental Stark FWHM (full-width at half intensity maximum) and shift of the NiI 397.356 nm spectral line, originating from $a^1D - z^3P^0$ (31) multiplet of $3d^9(a^2D)4s - 3d^9(a^2D)4p$ transition array.

Results were obtained using the plasma of a linear pulsed arc discharge in nitrogen described by Djeniže et al. (1996).

2. EXPERIMENT

A reliable plasma source has been constructed, the plasma was generated by a pulsed discharge of 8.0 μF condenser initially charged to 2.8 kV. As a working gas we used nitrogen of the pressure of 266 Pa.

The plasma source consist of Pyrex discharge tube of 5 mm i. d. and effective plasma length of 80 mm. Both electrodes are made of nickel and iron (98% Ni + 2% Fe). The quantity of nickel atoms sputtered from electrodes was sufficient for spectroscopic observation. The spectroscopic observations are made end-on, along the axis of the discharge tube.

The electric properties of the pulsed discharge were measured by Rogowski coil, the following values were found : discharge current maximum 6.0 kA, discharge period

100 μs, logarithmic decrement 0.9 and circuit self-inductance 2.4 μH.

Parameters of the pulsed plasma were determined by a standard diagnostic method. Electron temperature (T) was found from the ratios of the relative intensities of NIV 347.869 nm, NIII 393.852 nm and NII 399.00 nm spectral lines assuming existence of the LTE. The Measured electron temperature was in the range (43 000-47 000) K, with $\pm 15\%$ error. Atomic parameters required were taken from Wiese et al. (1966). The electron density (N) was found by a single wavelength laser interferometry using visible 632.8 nm He-Ne laser line. The measured electron density values were $(1.8-4.2)\times 10^{23}$ m $^{-3}$, within $\pm 8\%$ accuracy. Temporal evolution of electron temperature (T) and electron density (N) in the decaying plasma are given in Fig. 1.

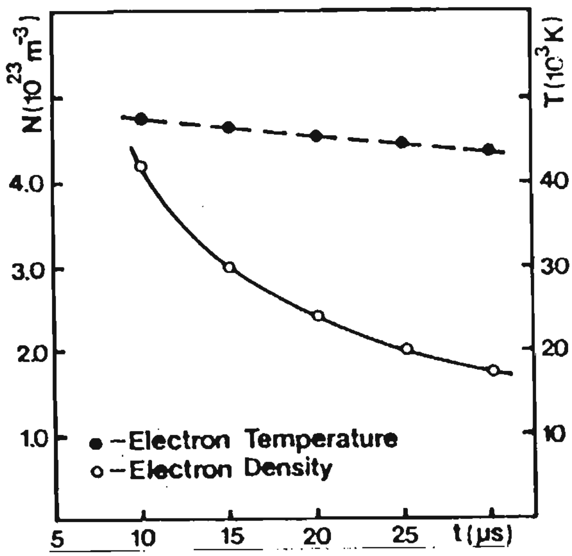

Fig. 1. Temporal evolution of electron temperature (T) and electron density (N) in the decaying nitrogen plasma.

Scanning of the spectral-line profile was done by using a shot-to-shot technique while advancing the exit slit photomultiplier combination in small wavelength steps described in Djeniže et al (1991; 1992). The photomultiplier signal was digitalized using HAMEG 205-2 oscilloscope interfaced to a computer.

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

The Stark width values were measured on 10, 12, 15 and 20 μs after the beginning of a discharge. Experimental error in evaluation of the measured Stark FWHM (w_m) was $\pm 15\%$, at given electron temperatute and density.

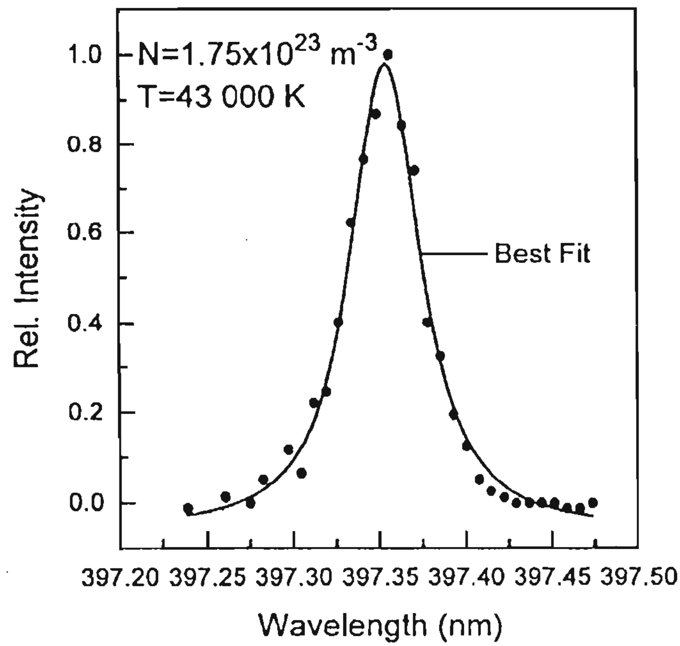

Fig. 2. Ni I 397.356 nm line profil at T=43 000 K and N=1.75×10^{23} m^{-3} :
• - experimental points, solid line corresponding Voigt profile (best fit).

Reproducibility of the plasma has been checked by monitoring of the radiation originating from working gas atoms. We found that plasma reproducibility was at least 95%. Also, reproducibility of the invesigated NiI spectral line radiation was abaut 90% what can be taken as acceptable considering the method by which the nickel atoms were introduced.

The selfabsorption of the measured spectral line 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.

The Stark shift was measured relatively to the unshifted spectral line emited by the same plasma, opserved at a later time and lower electron densities during the plasma decay (Purić & Konjević 1972). The Stark-shift data (d_m) were determined with absolute error of ± 0.001 nm at given electron temperature and density.

The NiI transition were identified using tables by Zaidel et al. (1977) and Moore (1952).

3. RESULTS

The results of measured w_m (in 10^{-1} nm) and d_m (in 10^{-1} nm) of investigated NiI 397.356 nm spectral line, originating from $a^1D - z^3P^0$ (31) multiplet of $3d^9(a^2D)4s - 3d^9(a^2D)4p$ transition array, at the given T (in 10^4 K) and N (in 10^{23} m^{-3}) are presented in Table 1.

Table 1. Measured Stark FWHM (w_m in 10^{-1} nm) and shift (d_m in 10^{-1} nm) values for NiI 397.356 nm spectral line, at given electron temperature (T in 10^4 K) and electron density (N in 10^{23} m^{-3}). A positive shift is toward the red.

T (10^4 K)	N (10^{23} m^{-3})	$w_m(10^{-1}$ nm)	$d_m(10^{-1}$ nm)
4.7	4.2	0.781	0.072
4.7	3.6	0.700	0.056
4.7	3.0	0.692	0.029
4.6	2.4	0.550	0.029

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

Acknowledgements

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