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MEASURED STARK WIDTHS OF A 425.94 nm ArI SPECTRAL LINE

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SUMMARY: Stark widths of a 425.94 nm ArI spectral line have been measured in two different plasma sources with up to 3.8 × 10^{22} m^{-3} electron density and 16200 K electron temperature. The obtained data have been compared to the existing experimental and theoretical values.

1. INTRODUCTION

A number of experimental and theoretical papers have dealt with Stark broadening of ArI spectral lines (see e.g. Fuhr and Lesage, 1993: and references therein). Stark widths of ArI lines are important because of their use in diagnostics of the astrophysical and laboratorical plasmas (Griem, 1974). The existing experimental results of the Stark FWHM (full-width at half intensity maximum) (w) for the 425.94 nm ArI spectral lines are obtained for the electron temperature up to 14000 K (Gericke, 1961; Powell, 1972; Bues et al, 1969; Musielok et al, 1976; Jones et al, 1986). They show fluctuations in comparison to the only theoretical predictions, by Griem (1974). Besides the results of Musielok et al (1976), all other experimental data are lower than the calculated values based on the semiclassical approaches.

The aim of this work is to extend the observatio of the Stark width (w) values of the 425.9 nm spectral line ($4s'\,[\frac{1}{2}]^0 - 5p'\,[\frac{1}{2}]$, transition) up to 16200 K electron temperature in the electron density range: (1.4 - 3.8) × 10^{22} m^{-3}.

2. APPARATUS

Two different plasma sources with the same argon-helium mixture (72% + 28%) have been used as a working gas.

Apparatus A

The plasma was created in the Pyrex discharge tube described by Skuljan (1993) and Djeniže et al. (1994). The plasma was generated by a pulse discharge of a 0.3 μF condenser, charged up to 10 kV. The continuous glow discharge was simultaneously driven, in order to ensure a good shot-to-shot plasma reproducibility between water-cooled copper electrodes at the current of 50 mA and filling pressure of 270 Pa. Auxiliary ring shaped electrodes were positioned at the optical axis 8 cm apart, and they were used to drive the pulse discharge (see Fig. 1 in Djeniže et al, 1994). The plasma source consists of a Pyrex discharge tube of 5 mm id. and effective plasma length of 8 cm The electric properties of the pulse discharge were measured by Rogowski coil, and the following values were found: discharge current maximum (I_m)=4.0 kA, discharge period (τ)=5.0 μs, decrement (δ)=2.3 and circuit self-inductance (L)=1.7 μH.

Apparatus B

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 discharge tube of 8 mm id., has an effective plasma length of 22 cm between aluminum electrodes. Two holes, 2 mm in diameter, located axisymmetrically at the center of electrodes facilitate optical alignment and laser interferometric measurements of electron density. The capacitor bank of 8 μF was charged up to 2.0 kV at the 270 Pa filling pressure. From the discharge current oscillograms the following values have been determined I_m=3.4 kA, τ=27 μs, δ=10 and L=2.2. μH.

3. EXPERIMENT

Spectroscopic observations of the spectral lines have been made end-on along the axis of both discharge tubes. The line profiles have been recorded on a shot-by-shot basis using experimental setup system described elsewhere (Djeniže et al, 1991). We have obtained good plasma reproducibility (controled through continuum radiation; >96%) and satisfactory ArI line radiation intensity reproducibility (~90%).

Great care was taken to minimize the influence of self-absorption on Stark width determination. This is the reason why argon was diluted with helium (72% Ar and 28% He).

The measured profiles were of the Voigt type. A standard deconvolution procedure was used (Davies and Vaughan, 1963). Van der Waals and resonance broadening were estimated to be smaller by more than an order of magnitude in comparison to Stark, Doppler and instrumental broadening. The Stark width values were obtained with ±15% error.

The parameters of the plasmas were determined by standard diagnostics methods. The electron density (N) has been measured by a single wavelength He-Ne laser interferometer for the 632.8 nm transition with an estimated error of ±8%. In cases A and B, we found peak values of 3.8 × 10^{22} m^{-3} and 2.6 × 10^{22} m^{-3}, respectively. The electron temperature (T) was derived from the ratio of relative intensities of of ArII and ArI spectral lines, assuming the existence of the LTE. These were: 500.9 nm ArII and 695.5 nm ArI lines in the case A, and 426.6 nm ArII and 425.9 nm ArI lines in the case B. Peak values of 13000 K and 16200 K were found with a ±13% error. The required atomic parameters were taken from Wiese et al (1969).

4. RESULTS

The results of measured Stark FWHM (w_m - values) of the ArI 425.94 nm spectral line at the given T and N are given in Table 1.

Table 1.

Exp.	T [10^4 K]	N [10^{22} m^{-3}]	w_m [10^{-1} nm]	w_m/w_{th}
A	1.30	3.8	0.97	0.82
B	1.62	2.6	0.68	0.81
B	1.50	1.4	0.31	0.70

5. DISCUSSION

Calculations of total Stark FWHM were performed by using Eq. (226) from Griem (1974). The broadening parameters i.e. w_e and α, evaluated using semiclassical approach, were also taken from Griem (1974). Ratios of the measured (w_m) to the calculated total Stark width (w_{th}) values at the actual plasma parameters are also presented in Table 1. Our experimental values are lower than theoretical predictions. The average w_m/w_{th} value (three measurements) is 0.78.

The dependence on electron temperature of theoretical Stark widths (w_{th}) together with experimental values of other authors and our results is presented graphically in Fig. 1 at the electron densities obtained in various experiments. In case of electron concentrations of (0.8-1.4) × 10^{22} m^{-3}, when the ionic contribution to the total width is small, it is possible to normalize Stark FWHM values at the electron concentracion of 1 × 10^{22} m^{-3}. We did this with the experimental values of Bues (1969), Powell (1966) and our data at N=1.4 × 10^{-22} m^{-3}.

It is evident that the existing experimental data lie under the Griem's values, except for Musielok's (1976) values at 2.6 × 10^{22} m^{-3} electron density. The average ratio w_m/w_{th} (eight measurements) is 0.78. Our new experimental results confirm the difference between the existing experimental and theoretical results. Griem's calculations for this line provide, on the average, 28% higher FWHM values in comparison to all values.

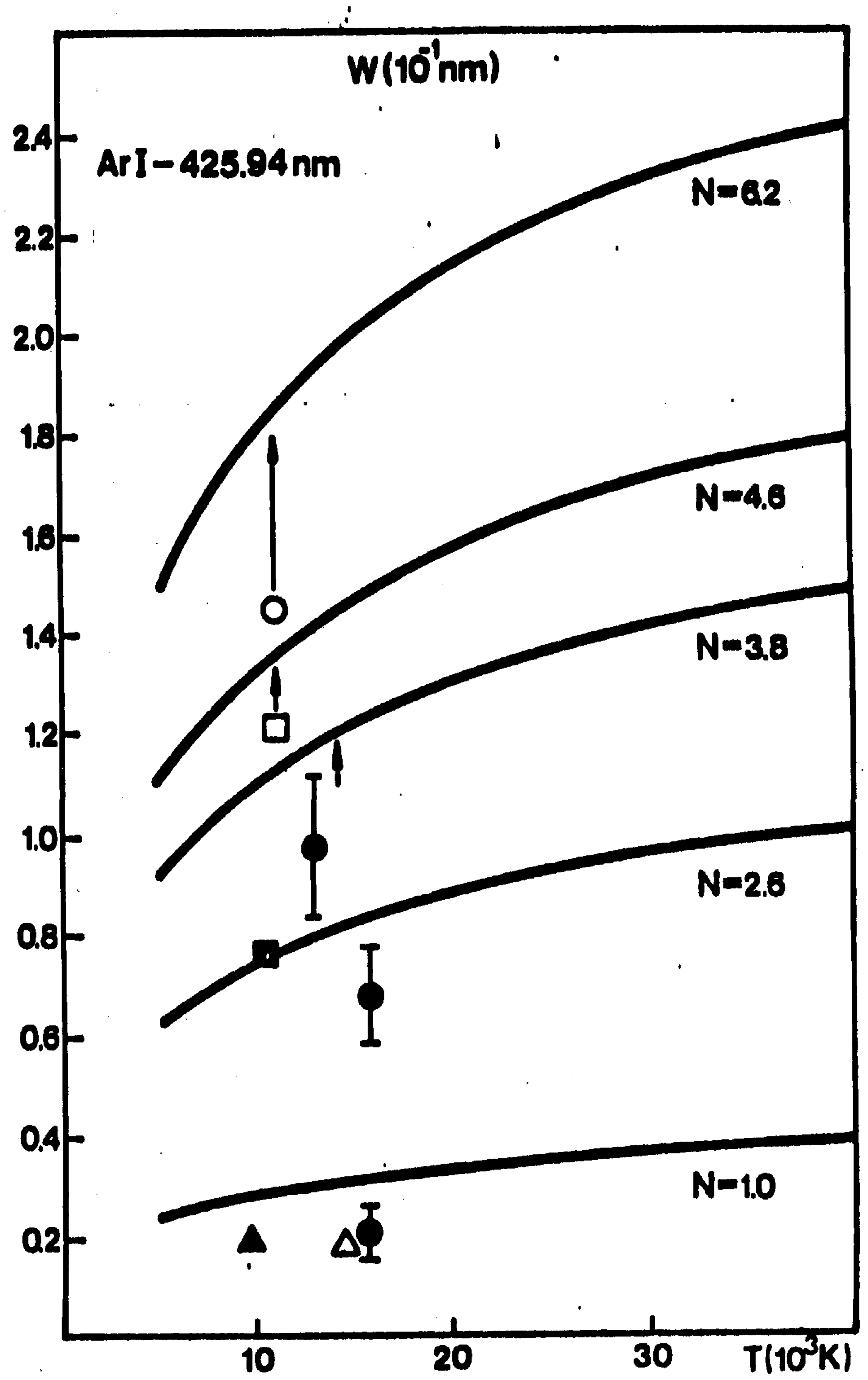

Fig. 1 Stark FWHM values vs. temperature (T) at various experimental electron densities (N in 10^{22} m^{-3}). •, this work; □, Gericke (1961); △, Powell (1966); ▲, Bues et al (1969); ■, Musielok et al (1976); o, Jones et al (1986) and —, Griem (1974).

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МЕРЕНЕ ШТАРКОВЕ ШИРИНЕ СПЕКТРАЛНЕ ЛИНИЈЕ 425.94 nm ИЗ СПЕКТРА ArI

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Оригинални научни рад

Штаркове ширине спектралне линије 425.94 nm из спектра ArI мерене су у двема различитим плазмама електронске концентрације до 3.8×10^{22} m^{-3} и електронске температуре 16200 K. Добијени резултати су упоређени са постојећим експерименталним и теоријским подацима.