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# PLASMA BROADENED 433.3 nm AND 433.5 nm Ar I SPECTRAL LINES

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**Abstract.** Two close plasma broadened spectral lines of neutral argon, 433.3 nm and 433.5 nm were experimentally investigated. Obtained widths and shifts were compared with the results of other authors. Some discrepancies with the results of other authors are explained by rough approximation in deconvolution procedure used by other authors.

## 1. INTRODUCTION

Many experimental papers are devoted to study of neutral argon spectral lines (Konjević et al. 1976, 1984, 1990) in order to obtain Stark broadening parameters. A few questions about the accuracy of existing data is still opened. This accuracy is influenced by several procedures: *a)* spectral intensity measurements, *b)* wavelength measurements and *c)* separation of different line broadening mechanisms. In the last one the critical is deconvolution of Gaussian (instrumental + Doppler) and Stark broadened profile $j_{A,R}(x)$ which is asymmetric and defined as (Griem 1974):

$$j_{A,R}(x) = \frac{1}{\pi} \int_0^\infty \frac{H_R(\beta) d\beta}{1 + ((\lambda - (\lambda_0 + d_e))/w_e - A^{4/3}\beta^2)^2}$$

where $x$ is reduced wavelength, $H_R(\beta)$ is microelectric field distribution, $R$ is dimensionless parameter and $A$ is ion broadening parameter. Incorrect deconvolution procedure introduce systematic error in line width measurements up to 25 %. This is particularly important when strongly asymmetric lines, like Ar I 433.3 nm and 433.5 nm lines, are in the question.

The aim of this study was to obtain Stark broadening parameters of Ar I 433.3 nm and 433.5 nm lines, reliable as much as possible.

## 2. EXPERIMENTAL

Particular attention was paid on precise spectral intensity measurements, since this is the first step in the measurements and produces unrecoverable errors. Wall stabilized arc, as very stable plasma source, was used. The arc operated under atmospheric pressure with 99 % Ar + 1 % $H_2$ gas mixture. $H_2$ was introduced for plasma diagnostics purposes. An averaging technique (Mijatović et al. 1995) for spectral intensity measurements was applied introducing the error less than 1%.

Radiation from the arc was focused 1:1 onto the entrance slit of 1-m monochromator equipped with 1200 g/mm grating, photomultiplier and stepping motor. The accuracy of wavelength settings was 0.0025 nm. The height of entrance slit was 0.3 mm while width of entrance end exit slit was 20 $\mu$m resulting in 0.018 nm instrumental width. Plasma was observed side-on at twelve positions along the plasma column radius.

Geissler tube was used for shit measurements (Mijatović et al. 1995).

Plasma electron densities ranging $(0.74 - 2.90)\times10^{16}$ cm$^{-3}$ were determined from $H_\beta$ line width (Vidal et al. 1974), while the temperatures ranging 9000 - 10800 K were determined from plasma composition data (White et al. 1958).

After Abel inversion numerical procedure for deconvolution (Nikolić et al. 1998) was applied. Contribution of Van der Waals and resonance broadening was extracted also.

## 3. RESULTS AND DISCUSSION

An example of experimental line profiles (after Abel inversion) is presented in Fig. 1, together with the reference line used for shift measurements. As it can be seen from the Fig. 1 fitted profile (Gaussian + $j_{A,R}(x)$) is in very good agreement with measured ones. This agreement ensures high quality data of width and shift measurements.

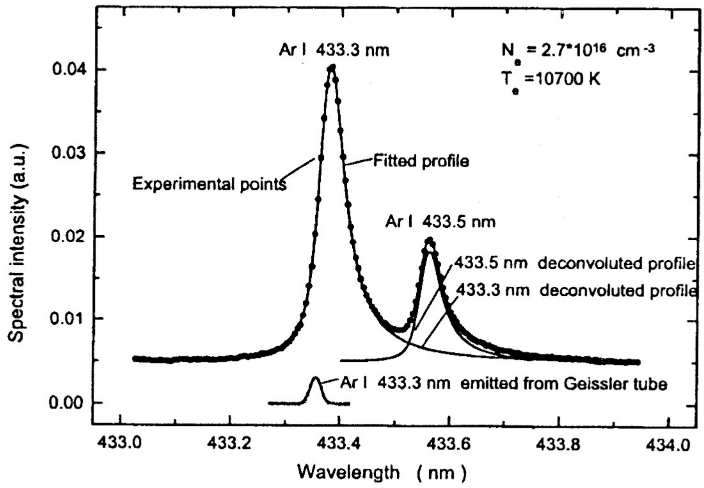


Figure 1. An example of experimental, fitted and deconvoluted line profiles of 433.3 nm and 433.5 nm lines.

The obtained widths and shifts for 433.3 nm line are plotted versus electron density in Fig. 2. Experimental results of other authors (Bues et al. 1966-67; Musielok 1994) are included also together with the errors ranging 15 - 30 % (30 % is presented) estimated by critical reviews (Konjević et al 1976, 1984 and 1990). The exception is result taken from Musielok (1994). For this point the error of 10 % stated by the author is taken. Theoretical data for this line are not available.

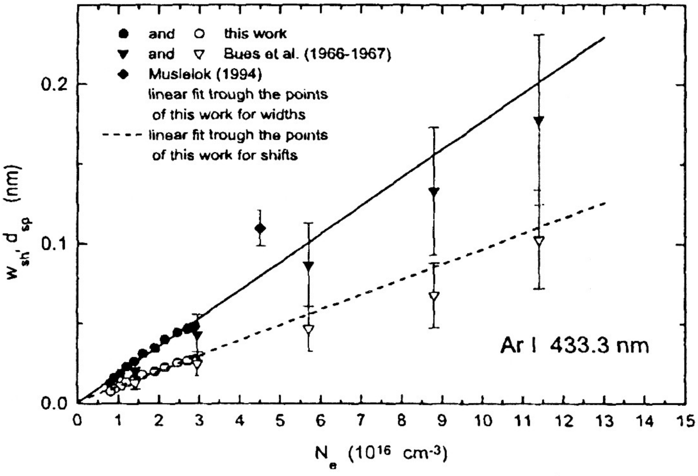


Figure 2. Measured widths and shifts of Ar I 433.3 nm line vs electron density. Full symbols - widths, open symbols - shifts.

As it can be seen from Fig. 2 agreement between experimental results is inside error bars. It should be noted that deconvoluton procedures used in '60 and '70-ties have not taken asymmetry of the lines into account.

Ratios of measured to theoretical values (Griem 1974) for widths and shifts of 433.5 nm versus electron density is given in Fig. 3. Results of other authors (Bues et al. 1966-67: Schulz and Wende 1968) are also included together with the errors estimated by (Konjević and Roberts 1976).

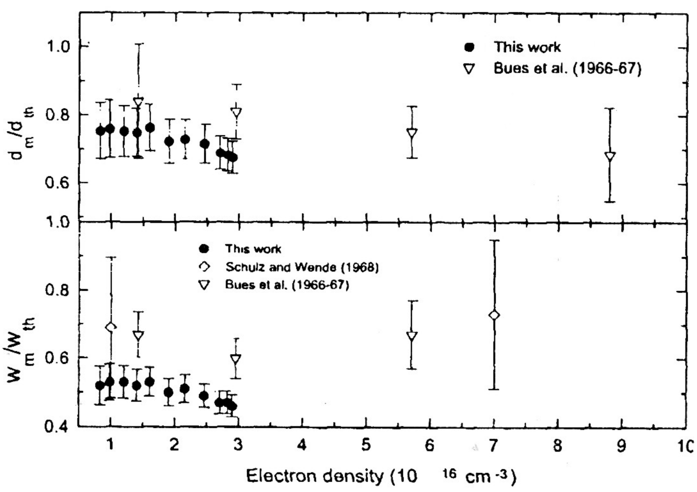


Figure 3. Ratios of measured to theoretical values of shift and width of Ar I 433.5 nm line vs electron density.

Disagreement between results of this work and the results of other authors is considerable in the case of Ar I 433.5 nm line. Results of other authors are systematically higher in both cases, shifts and widths. This can be explained by overlapping of the 433.3 nm and 433.5 nm lines. It can be seen from Fig. 1 that vicinity of neighbour line influences much more the shape of 433.5 nm line, while the shape of 433.3 nm line is almost uninfluenced. This is due to the difference in intensity of these two lines. Contribution of blue wing of weaker line (less than one half) to the intensity and shape of stronger one is almost negligible, while the contribution of red wing of stronger line to the intensity and shape of the weaker one is considerable. From Fig. 1 can be seen that the last influence contributes in wider and more shifted weaker line (compare fitted profile and separated profile of weaker line).

Finally, it can be concluded that, besides quality in spectral intensity measurements, in case overlapping lines, correct procedures for separation and deconvolution of the investigated lines must be applied in order to obtain high precision data.

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