

ON THE STARK BROADENING OF SOME Ar I SPECTRAL LINES

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The investigation of the influence of Stark effect on the shape of neutral argon spectral lines has been extensive during the last three decades (Konjević and Roberts, 1976; Konjević et al., 1984), since argon is a widely available inert atomic gas which produce variety of favorable conditions for stable discharges. The determinations of quantitative spectroscopic data for argon, such as Stark broadening parameters (spectral line widths and shifts), are favorite subjects of plasma spectroscopists. In spite of these widely spread investigations, the convergence of the obtained results wasn't achieved. Namely, the different plasma sources and measurement techniques (which are sometimes quite complicated and laborious) showed, that the accuracy of 10% or better, hardly can be achieved. Moreover, even in the cases of similar experimental set-ups and methods, reported results of different authors may deviate by factors of two. In order to establish an experimental consistency within reported measurement techniques and among different experiments, obtained results are often compared with the most comprehensive theoretical predictions provided by (Griem, 1974). The several problems have been found as critical for all emission experiments, which are:

- 1) *Reliability of plasma source.* Ideally, the plasma source should be stationary and homogeneous. The most of the high-precision studies have been performed with stabilized arcs, as continuous plasma sources. In the case of the repetitive pulsed sources, significant reproducibility have to be provided. When the arc channel is observed side-on, reliable Abel inversion of recorded profiles should be used (see for example: Djurović, 1998).
- 2) *Reliable plasma diagnostic approach.* The experimental conditions have to be chosen so that the plasma is approximately in a state of local thermodynamic equilibrium (LTE) and the checks for the existence of LTE have to be made repeatedly.
- 3) *Line intensity measurements.* The experimental techniques for spectral intensity recordings have been strongly developed during last decade with significant improvements of reliability and definition of recorded profiles (Djurović et al., 1997).
- 4) *Self-absorption* of spectral lines must be checked and eliminated if possible, otherwise recorded profiles must be corrected to this effect.
- 5) *Properly performed deconvolution* of experimental profiles. It is very important that all relevant broadening mechanisms are taken into account and represented in the form of mutually folded profiles. Parameter adjustments of such spectral line model should be performed by least-square fitting procedure (Nikolić et al., 1998).

If any of these problems is not properly handled in emission spectroscopy studies, noticeable uncertainties in the results may be introduced, which may lead to the considerable differences among reported results of various authors, as shown in Fig. 1. and Fig. 2. In these figures, experimental widths and shifts, for 12 neutral argon lines investigated in this work, are compared with theory (Griem, 1974) and other available experimental results. We suppose that all authors compared their result with the theoretical ones in the same manner. Noticeable scattering (for more than 200% in some cases) introduces confusion in this field and opens possibilities for new refined measurements of Stark broadening parameters of neutral argon lines in order to overcome problems listed above. In this experimental study we tried to solve these problems and to give new, more reliable results. The extended material is compiled in (Nikolić, 1998) and is available in limited number of copies.

2. RESULTS AND DISCUSSION

Theoretical Stark parameters for two of the investigated lines (419.10 nm, and 433.36 nm) do not exist, so they are not shown at Figs. 1 and 2. However, Ar I 419.10 nm spectral line is also experimentally investigated by Chapelle et al., 1967; some of the experimental papers deal with width and shift of Ar I 433.36 nm line: Musielok, 1994; Bues et al., 1969; Chapelle et al., 1967 and Gericke, 1961. There is no rule about overall agreement between any of the experiments. In some cases agreement is good, but in other cases disagreement is large. For example, the results of (Kusz and Mazur, 1996), are not shown on Figs.1 and 2, since the investigated ratios are larger than 3.00. The measured widths and shifts were corrected (up to 10%) on Van der Waals broadening effect as well as theoretical shifts (negligible for widths) on Debye shielding effect (from 11% to 19%).

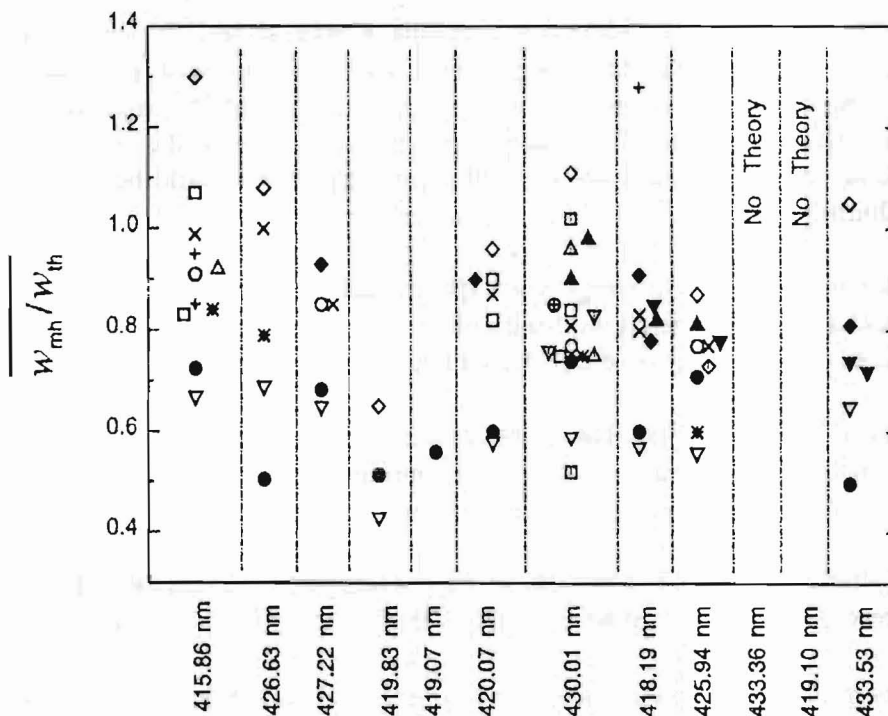


Fig. 1. The averaged ranges of compared measured (w_{mh}) and theoretical (w_{th}) Stark widths

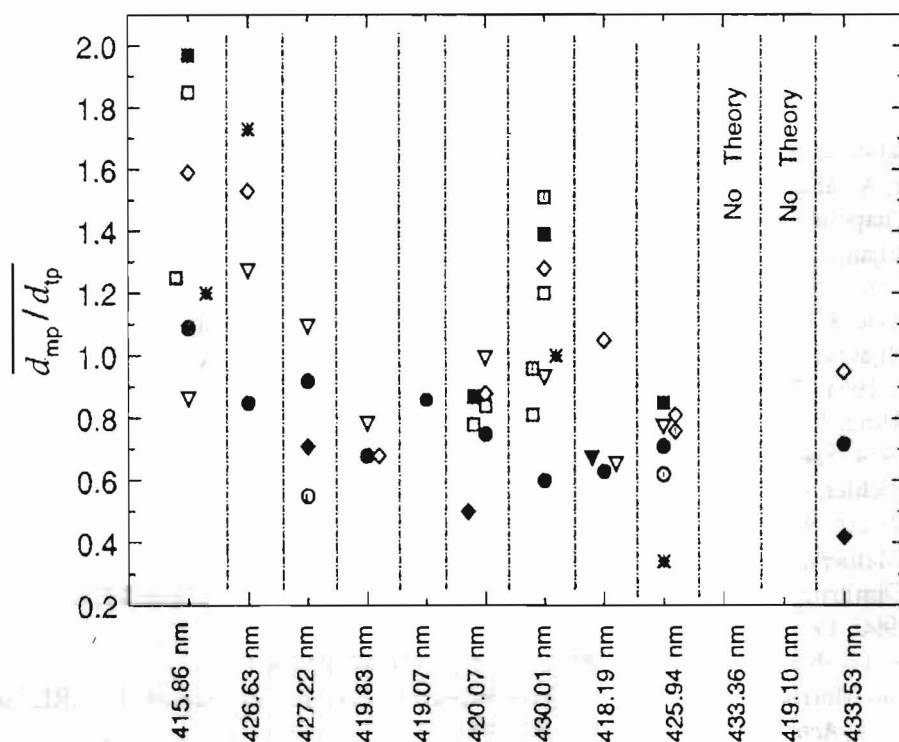


Fig. 2. The averaged ranges of compared measured (d_{mp}) and theoretical (d_{tp}) Stark shifts

The symbols, which make an appearance at given figures, represent various references used for comparing purposes and are listed below:

- (●) This work;
- (○) Jones et al., 1986;
- (△) Jones et al., 1987;
- (×) Musielok, 1994;
- (*) Powel, 1966;
- (◇) Gericke, 1961;
- (■) Morris and Morris, 1970;
- (□) Griem, 1962;
- (▽) Bues et al., 1969;
- (+) Musielok et al., 1976;
- (▽) Chernichowski and Chapelle, 1983;
- (⊙) Djeniže et al., 1995;
- (◆) Chapelle et al., 1967;
- (△) Abbas et al., 1988;
- (⊕) de Izarra et al., 1993;
- (□) Queffelec and Girault, 1971;
- (▲) Klein and Meiners, 1977;
- (▼) Schulz and Wende, 1968;
- (◇) Djurović et al., 1997;

The aim of this paper is to give new and reliable experimental data of Stark broadening parameters of Ar I lines and to point at necessity for new more reliable measurements. Attention was paid on precise spectral intensity recordings, wavelength measurements and procession of obtained data. The comparisons done in this work showed disagreement between other authors results as well as between experiments and theoretical predictions. Without numerous measurements of high precision, meaningful conclusions are not possible.

References

- Abbas, A., Basha, T. S., and Abdel-Aal, Z. A.: 1988, *Jap. J. Appl. Phys.* **27**, 801
- Bues, I., Haag, T., and Richter, J.: 1969, *Astron. & Astrophys.* **2**, 249
- Chapelle, J., Cabonne, Sy. A., Cabannes, F., and Blandin, J.: 1967, *J. Q. S. R. T.* **8**, 1201
- Chernichowski, A., and Chapelle, J.: 1983, *Acta Phys. Pol. A* **63**, 67
- de Izarra, C., Chapelle, J., Chernichowski, A., and Vallee, O.: 1993, *J. Q. S. R. T.* **49**, 433
- Djeniže, S., Skuljan, Lj., and Konjević, R.: 1995, *J. Q. S. R. T.* **54**, 581
- Djurović, S.: 1998, *Contributed papers of 19th SPIG*, 329 (Ed. Konjević, N., Čuk, M., and Videnović, I. R.), Faculty of Physics, University of Belgrade, Belgrade, Yugoslavia
- Djurović, S., Mijatović, Z., Kobilarov, R., and Konjević, N.: 1997, *J. Q. S. R. T.* **57**, 695
- Gericke, W. E.: 1961, *Z. Astrophys.* **53**, 68
- Griem, H. R.: 1962, *Phys. Rev.* **128**, 515
- Griem, H. R.: 1974, *Spectral Line Broadening by Plasmas*, Academic Press
- Jones, D. W., Pichler, G., and Wiese, W. L.: 1987, *Phys. Rev. A* **35**, 2585
- Jones, D. W., Wiese, W. L., and Woltz, L. A.: 1986, *Phys. Rev. A* **34**, 450
- Klein, P., and Meiners, D.: 1977, *J. Q. S. R. T.* **17**, 197
- Konjević, N., Dimitrijević, M. S., and Wiese, W. L.: 1984, *J. Phys. Chem. Ref. Data* **13**, 619; also: 1990, **19**, 1307
- Konjević, N., and Roberts, J. R.: 1976, *J. Phys. Chem. Ref. Data* **5**, 209
- Morris, J. C., and Morris, R. U.: 1970, *Aerospace Research Laboratories*, Report No. ARL 70-0038
- Musielok, J.: 1994, *Acta Physica Polonica A* **86**, 315
- Musielok, B., Musielok, J., and Wujec, T.: 1976, *Zesz. Nauk. Wyzsz. Szk. Pedag. Opolu, Fiz.* **17**, 63
- Nikolić, D.: 1998, *MSc Thesis*, University of Belgrade, Belgrade (in Serbian)
- Nikolić, D., Mijatović, Z., Kobilarov, R., Djurović, S., and Konjević, N.: 1998, *Contributed papers of 19th SPIG*, 191 Belgrade, Yugoslavia
- Popenoe, C. H., and Shumaker Jr., J. B.: 1965, *J. of Research of NBS, Phys. and Chem.* **A 69**, 495
- Powell, W. R.: 1966, *Ph. D. Thesis*, The John Hopkins University
- Queffelec, J. L., and Girault, M.: 1971, *Rev. Phys. Appl.* **6**, 401
- Schulz, P., and Wende, B.: 1968, *Zeitschrift für Physik* **208**, 116