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MEASURED, CALCULATED AND ESTIMATED STARK WIDTHS OF SEVERAL Ar IV SPECTRAL LINES

S. DJENIŽE
Faculty of Physics, University of Belgrade
P.O.B.368, 11000 Belgrade, Serbia, Yugoslavia
E-mail: steva@rudjer.ff.bg.ac.yu

Abstract. Comparison between existing measured, calculated and estimated Stark width values was performed for the most researched Ar IV spectral lines belonging to the 4s-4p and $4s' - 4p'$ transitions. On the basis of the found agreement between these values four spectral lines have been recommended as lines with convenient Stark width data needed in plasma spectroscopy.

1. INTRODUCTION

Knowledge of the triply ionized argon (Ar IV) spectral lines characteristics is important for the determination of chemical abundances of elements and, also, for the estimation of the radiative transfer through stellar plasmas, as well as for opacity calculations (Inglesias et al. 1990). Thus, the necessity of knowledge of Stark widths of these lines was imposed. On the basis of Stark width values it is possible to obtain other basic plasma parameters e.g. electron temperature (T) and electron density (N), important in the modeling of various plasmas. The aim of this work is the comparison between existing measured, calculated and estimated Stark width values of most investigated Ar IV spectral lines (264.03, 275.79, 278.89, 280.94 and 292.63 nm) in the 4s-4p and $4s' - 4p'$ transitions. Namely, from the eventual agreement between them, their recommendation for the plasma diagnostics purpose can follow as spectral lines with convenient Stark width data. These comparisons give, also, possibility of the critical analyzing of the experimental results.

2. MEASUREMENTS

Five experiments deal with Stark FWHM (full-width at half intensity maximum, W) investigation of mentioned spectral lines (Platiša et al. 1975; Purić et al. 1988 a; Kobilarov & Konjević 1990; Hey et al. 1990 and Djeniže et al. 1999, 2000). Measurements were realized in the electron temperature range between 21 000 K and 110 000 K (see Lesage & Fuhr 1998 and references therein).

3. CALCULATIONS

Theoretical W values (G,GM,SEM, SE) are calculated on the basis of various approximations initiated by Dimitrijević & Konjević (1981). Thus, SE and SEM denote the results of semiempirical and modified semiempirical predictions using equations (4), (5) and equations (7) - (10), respectively, from Dimitrijević & Konjević (1981). G and GM denote w values obtained on the basis of the semiclassical approximation (Griem 1974 and references therein) with 1.4 instead of 5-(4.5/z) on the right-hand side of equation (12) in Dimitrijević & Konjević (1980) for the GM values. Mentioned calculations are performed only for four multiplets. Besides, in Hey et al. (1990) theoretical Stark width values, calculated on the basis of the impact and classical-path approximations (Hey & Breger 1982), are also presented, but only for the plasma parameters observed in experiments: Platiša et al. (1975), Purić et al. (1988a) and Hey et al. (1990).

4. ESTIMATIONS

The simplest way to estimate the value of a Stark FWHM is to use established regularities of W along the isonuclear or isoelectronic sequences for given type of quantum transition. It was found (Djeniže & Srećković 1998; Purić et al. 1988a,b) that a simple analytical relationship may, for same transition, exist between W and the corresponding upper-level ionization potential (I) of a particular spectral line. The found relationship, normalized to a $N = 10^{23}$ m^{-3} electron density, is of the form:

$$W(\mathrm{rad/s}) = a z^2 T^{-1/2} I^{-b}. \tag{1}$$

The upper level ionization potential I (in eV) and net core charge $z(z = 1, 2, 3, 4,...$for neutral, singly, doubly, triply,... ionized atoms, respectively) specify the emitting ion, while the electron temperature T (in K) characterizes the assembly. The coefficients a and b are independent of I and T. In the case of the argon isonuclear (INS) sequence (Ar I - Ar VIII) for the 4s - 4p transition this dependence is expressed (Purić et al. 1988a,b; Djeniže & Srećković 1998) as:

$$W(\mathrm{rad/s}) = 1.18\ 10^{14} z^2 T^{-1/2} I^{-1.27}. \tag{2}$$

In the case of the $4s'-4p'$ transition the following form was found (Djeniže & Srećković 1998; Purić et al. 1988a)

$$W(\mathrm{rad/s}) = 1.12\ 10^{14} z^2 T^{-1/2} I^{-1.32}. \tag{3}$$

Eqs. (2-3) allow to predict the Stark width values for: $z = 1, 2, 3, 4, 5, 6, 7$ at various electron temperatures. The estimated Stark FWHM values of the mentioned Ar IV spectral lines (for $z = 4$) are presented in Table 1. The necessary atomic data were taken from Wiese at al. (1969).

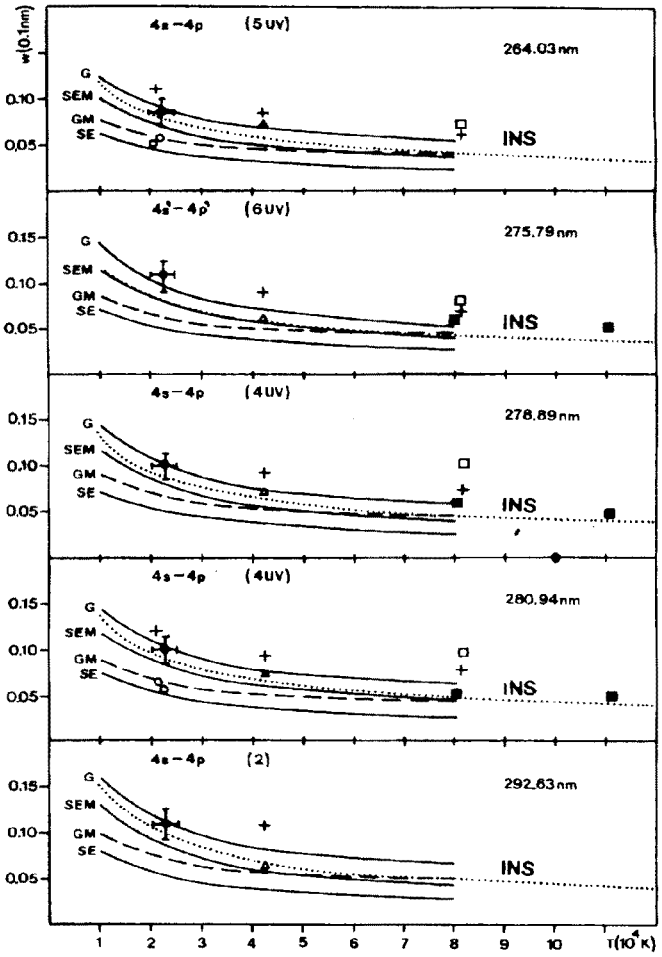

Fig. 1. Stark FWHM (W) dependence on the electron temperature for the most investigated Ar IV lines belonging to the 4s-4p and 4s′−4p′ transitions at 10^{23} m^{-3} electron density. •, Djeniže et al. (1999, 2000); ○, Platiša et al. (1975); △, Purić et al. (1988a); , Hey et al. (1990) and , Kobilarov & Konjević (1990). G and GM denote values obtained on the basis of the semiclassical (Griem 1974) approximation, both SEM and SE denote values obtained on the basis of the modified semiempirical and semiempirical approximations, respectively. All these calculations were performed by Dimitrijević & Konjević (1981). +, theoretical predictions by Hey et al. (1990) calculated plasma parameters obtained by Platiša et al. (1975), Purić et al. (1988a) and Hey et al. (1990). INS represent our estimated values taken from Table 1.

Table 1. Estimated (INS) Stark FWHM values dependence on the electron temperature (T in K) at $N = 1 \cdot 10^{23}$ m^{-3} electron density, calculated using Eq. (2) and (3).

λ (nm)	$W\ T^{1/2}$ (nm K$^{1/2}$)	Eq.
264.03	1.243	2
275.79	1.217	3
278.89	1.360	2
280.94	1.387	2
292.63	1.532	2

5. DISCUSSION

In order to allow easy comparison among measured, calculated and estimated Stark width values, in Fig.1 the dependence of Stark FWHM values on the electron temperatures is given at $N = 10^{23}$ m^{-3} electron density.

6. CONCLUSION

In general, we noticed a good matching between measured, calculated and estimated Stark width values of the 264.03 nm, 275.74 nm, 278.89 nm and 280.94 nm Ar IV spectral lines. This allows us to recommend their use for plasma spectroscopy. Existing Stark width values of these spectral lines: INS values in Table 1, in this work, and theoretical values G and SEM in Dimitrijević & Konjević (1981), within 20% uncertainties present convenient atomic data in the plasma diagnostic up to 120 000 K electron temperature (Djeniže et al. 2000). It should be pointed out that Hey's (1990) experimental W values at 80 000 K electron temperature lie about all existing measured, calculated and estimated values, especially in the case of the 278.89 nm and 280.94 nm lines. New measurements in these plasma conditions would be helpful.

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