Publ. Astron. Obs. Belgrade No. 68 (2000), 77 – 80

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

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

1. INTRODUCTION

Knowledge of the doubly ionized argon (Ar III) 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 the 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 researched Ar III spectral lines in the 4s-4p and $4s' - 4p'$ transitions (Multiplets: No.1, No. 2 and No 3). Namely, from the eventual agreement between them, their recommendation for the plasma diagnostics purpose can be followed as a spectral lines with convenient Stark width data. These comparisons give, also, possibility of the critical analyzing of the existing experimental and theoretical Stark width values (Djeniže 2000a,b).

2. MEASUREMENTS

Five experiments deal with Stark FWHM (full-width at half intensity maximum, W) investigation of mentioned spectral lines (Platiša et al. 1975; Konjević & Pittman 1987; Kobilarov & Konjević 1990 and Djeniže et al. 1996, 2000). Measurements were realized in the electron temperature range between 21 000 K and 80 000 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 semiemperical 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) one the right-hand side of equation (12) in Dimitrijević & Konjević (1980) for the GM values. Mentioned calculations are performed only for five multiplets. Beside, theoretical Stark width values, calculated on the basis of the classical-path approximation by Hey (1977), are also presented, but only for the plasma parameters observed in experiment by Platiša et al. (1975).

Transition	Multiplet	$\overline{\lambda}$ (nm)	$WT^{1/2}$ $(nm\ K^{1/2})$	Eq.
4s - 4p	$^5S^0 - ^5P$ (1)	329.66	1.88	2
$4s' - 4p'$	$^3D^0 - ^3D$ (2)	349.21	2.20	3
	$^3D^0 - ^3F$ (3)	334.48	2.06	3

Table 1. Estimated (INS) Stark FWHM values dependence on the electron temperature (T in K) at $N = 10^{23}$ m^{-3} electron density, calculated using Eq. (2) and (3). $\overline{\lambda}$ denote the mean wavelength in multiplet. The width of each multiplet component can be easily evaluated if one takes into account that the line width is proportional to λ^2.

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 et al.1988; 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:

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

The upper level ionization potential I (in eV) and net core charge $z(z = 1, 2, 3, 4, \ldots$ for neutral, singly, doubly, triply,... ionized atoms, respectively) specifies 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):

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

The 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 (INS) Stark FWHM values of the mentioned Ar III spectral lines (for $z = 3$,) are presented in Table 1. The necessary atomic data were taken from Wiese at al. (1969).

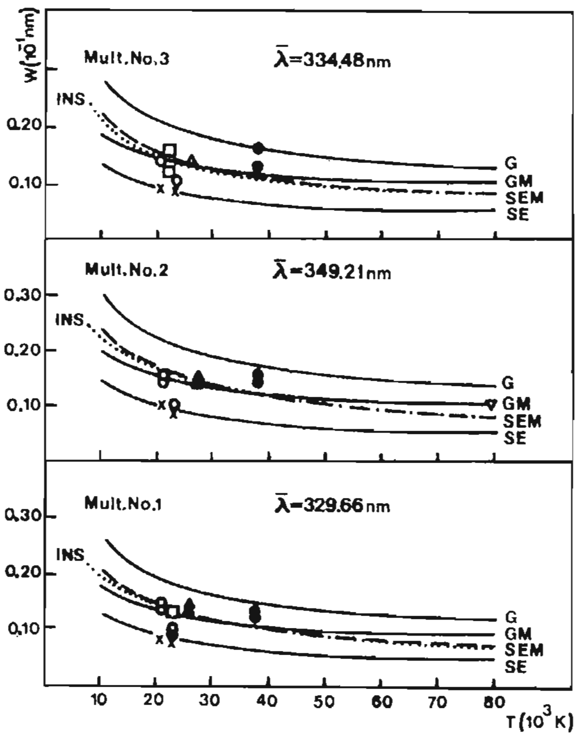

Fig. 1. Stark FWHM (W) dependence on the electron temperature for the most investigated Ar III multiplets belonging to the 4s-4p and $4s'-4p'$ transitions at 10^{23} m^{-3} electron density. •, Djeniže et al. 1996; □ Djeniže et al. 2000; ○, Platiša et al. (1975); △, Konjević & Pittman (1987) and ▽, Kobilarov & 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 semiemperical approximations, respectively. All these calculations were performed by Dimitrijević & Konjević (1981). x, theoretical predictions by Hey (1977) calculated at plasma parameters obtained by Platiša et al. (1975). INS (....) represent our estimated values taken from Tab. 1.

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. It should be pointed out that the experimental Stark width values around 23 000 K electron temperature (Konjević & Pittman 1987, Djeniže et al. 2000) show mutual agreement and agree, also, with values from Platiša et al. (1975) given at 21 000 K. Hey's calculation give Stark FWHM values that agree with SE predictions and both lie below the all others calculated and measured values.It must be turns out that the INS and SEM values show excellent mutual agreement in a wide electron temperature range, between 10 000 K and 80 000 K in the case of the all three researched multiplets.

6. CONCLUSION

In general, we noticed a good agreement among a measured, calculated and estimated Stark width values of the Ar III spectral lines that belong to the multiplet 1 (328.585 nm, 330.188 nm, 331.125 nm) in the 4s - 4p and multiplets 2 (348.055 nm, 350.358 nm, 349.967 nm) and 3 (333.613 nm, 334.472 nm, 335.844 nm) in the $4s' - 4p'$ transition, especially between INS, GM, SEM and all experimental values except those from Platiša et al. (1975) at about 23 000 K electron temperature. This allows us to recommend their use for plasma spectroscopy. Existing Stark width values of these spectral lines: INS values in the Tab.1, in this work, and theoretical values GM and SEM in Dimitrijević & Konjević (1981), within 10% uncertainties present convenient atomic data in the plasma diagnostic up to 80 000 K electron temperature.

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