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STARK WIDTHS OF SEVERAL Ar III SPECTRAL LINES

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Abstract. The Stark widths of three ArIII spectral lines have been measured at an electron density of 2.0×10^{23} m^{-3} and electron temperature of 31 000 K in a linear pulsed arc plasma discharge containing argon-helium mixture. The measured values were compared to the existing calculated values based on the semiclassical and semiempirical approximations.

1. INTRODUCTION

The knowledge of the ArIII 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. A number of experimental and theoretical papers have dealt with Stark broadening of ArIII spectral lines (Fuhr and Lesage 1993 and references therein).

The aim of this work is to present measured Stark FWHM (full width at half maximum intensity, w) of 3 ArIII spectral lines of $4s'-$ $4p'$ transition at electron temperature of an 31 000 K. The measured values of Stark widths were compared to the existing theoretical predictions based on the semiclassical, semiempirical and modified semiempirical approaches initiated by Dimitrijević and Konjević (1981).

2. EXPERIMENT

The linear pulsed arc, that was used as a plasma source, has been described in detail in our previous publications (Djeniže *et al.* 1990; 1996) so only a few details will be given here. A pulsed discharge occurred in a Pyrex discharge tube of 5 mm i.d. and had an effective plasma length of 5.8 cm. The tube had quartz windows. On the opposite side of the electrodes the glass tube was expanded in order to reduce erosion of the glass wall and also sputtering of the electrode material onto the quartz windows. The working gas was argon-helium (72%+ He28%) mixture at 70 Pa filling pressure in flowing regime. Spectroscopic observation of isolated spectral lines were made end-on along the axis of the discharge tube. A capacitor of 14 μF was charged up to 2.8 kV and supplied discharge current up to 5.4 kA. The line profiles were recorded by a shot-by-shot technique described elsewhere (Djeniže *et al.* 1990). The exit slit of the spectrograph with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps. The photomultiplier signal was digitized using digital scope, interfaced to a computer. Plasma reproducibility was monitored by the ArIII line radiation and also by the discharge current (it was found to be within ±6%).

The measured profiles were of the Voigt type due to the convolution of the Lorentzian Stark and Gaussian profiles caused by Doppler and instrumental broadening. For electron density and temperature obtained in our experiment the Lorentzian fraction in the Voigt profile was dominant (over 80 %). Van der Waals and resonance broadening were estimated to be smaller by more than an order of magnitude in comparison to the Stark, Doppler and instrumental broadening. A standard deconvolution procedure (Davies and Vaughan 1963) was used. The deconvolution procedure was computerized using the least squeres algorithm. Great care was taken to minimize the influence of selfabsorption on Stark width determinations. The opacity was checked by measuring line-intensity ratios within multiplet. The values obtained were compared with calculated ratios of the products of the spontaneous emission probabilities and the corresponding statistical weights of the upper levels of the lines (Wiese *et al.* 1969). It turns out that these ratios differed by less than ±10%.

The plasma parameters were determined using standard diagnostic methods. The electron temperature (T) was determined from the ratios of the relative intensities of the investigated ArIII lines to the 335.09 nm ArII spectral line, assuming the existence of LTE, with an estimated error of ±11%. All the necessary atomic parameters were taken from Wiese *et al.* (1969). The electron density (N) decay was measured using a single wavelength He-Ne laser interferometer for the visible 632.8 nm transition with an estimated error of ±7%.

3. RESULTS AND DISCUSSION

The results of the measured Stark FWHM values (w_m in 10^{-1}nm) at electron temperature of T=31 000 K and electron density of N= 2.0×10^{23} m^{-3} are shown in Table 1.

Table 1.

Transition	Multiplet	λ (nm)	w_m	w_m/w_G	w_m/w_{GM}	w_m/ w_{SEM}	w_m/ w_{SE}
4s′−4p′	$^3D^0 - ^3F$ (3)	333.61	0.308	0.94	1.23	1.23	2.00
		334.47	0.294	0.86	1.13	1.13	1.84
		335.85	0.256	0.75	0.98	0.98	1.59

The w_m values were obtained with ±14% uncertainties. In the same Table are also given ratios w_m/ w_{th} where w_{th} are the Stark FWHM values calculated on the basis of various theoretical approximations initiated by Dimitrijević and Konjević (1981). Thus, w_{SE} and w_{SEM} denote results of the semiempirical and modified semiempirical predictions using Eqs. (4-5) and Eqs. (7-10) respectively, from Dimitrijević and Konjević (1981). w_G and w_{GM} denote 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 Eq. (12) in Dimitrijević and Konjević (1980) for the w_{GM} values. The theoretical Stark FWHM dependence on the electron temperature together with the values of the other authors and our experimental results (symbol - o) at the electron density of N= 1 × 10^{23} m^3 are presented graphically in Fig.1, assuming the domination of the electron impact mechanism to the line broadening.

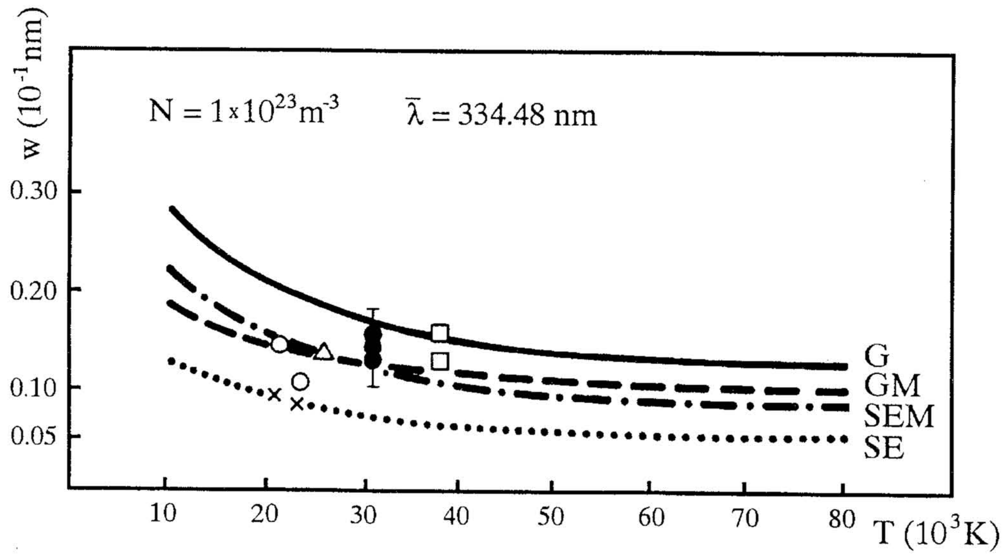

Fig. 1. (See text for details).

The measured Stark width values (symbol - o) in Platiša *et al.* (1975) are given at two close electron temperatures (c.a. 21 000 K and 23 000K). The existing discrepancies between them were discussed by Hey (x, 1977).

On the basis of the w_m/w_{th} values from the Table 1 and Fig.1 we can conclude that, in general, our results, obtained at 31 000 K electron temperature, agree well with theoretical predictions w_G, w_{GM} and w_{SEM} based on the semiclassical and modified semiempirical approximations. Theoretical values w_{SE} lie below our experimental data. The w_{SE} values are lower than our results up to the factor 1.8 (in average). It should be pointed out that the experimental data of other authors (Platiša *et al.* 1975-(symbol - o); Konjević and Pittman 1987 (symbol - △); Djeniže *et al.* 1996 (symbol - □) show, also agreement with the w_G, w_{GM} and w_{SEM} theoretical predictions within the experimental accuracy. In general, all the existing experimental data confirm the predictions based on the semiclassical and modified semiempirical theory over the range of the electron temperature of: 21 000 K - 38 000 K.

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