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THE Kr II SPECTRAL LINES STARK WIDTHS

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Abstract. Stark widths of fourteen singly charged (Kr II) krypton ion spectral lines have been measured in the linear, low pressure, pulsed arc at 17 000 K electron temperature and $1.65\mathrm{x}10^{23}$ m^{-3} electron density. The measured width values have been compared to the theoretical data calculated by using the modified semiempirical method.

1. Introduction

Stark widths of Kr II spectral lines have been investigated in a number of references, starting up with the first measurements, presented in Mandel'shtam (1962) and Mazing and Vrublevskaya (1962). For example seven experiments from Brandt et al. (1981), Richou et al. (1983), Pittman and Konjević (1986), Vitel and Skowronek (1987), Uzelac and Konjević (1989) and Lesage et al. (1989) have been performed within the 10 000 K and 17 400 K electron temperature range. These values show mutual scatter up to the factor 3. Moreover, in Popović and Dimitrijević (1998) Stark widths of 37 Kr II lines, that belong to the 5s-5p and 5s′-5p′ transitions, have been calculated within the modified semiempirical approach (Dimitrijević and Konjević 1980).

In this work we present measured and calculated Stark FWHM (full-width at half intensity maximum, W) values of fourteen Kr II spectral lines. Stark FWHM values of two Kr II were not known before. Our calculated Stark widths of the 5p-5d Kr II lines are, also, the first theoretical data.

2. Experiment

The modified version of the linear low pressure pulsed arc (Djeniže et al. 1991, Djeniže et al. 1998, Milosavljević and Djeniže 1998) has been used as a plasma source. A pulsed discharge was driven in a quartz discharge tube of 5 mm inner diameter and effective plasma length of 7.2 cm (Fig. 1 in Djeniže et al. 1991, Djeniže et al. 1998). The tube has end-on quartz window. 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 pure krypton at 130 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 1.5 kV. The line profiles were recorded using a shot-by-shot technique with a photomultiplier (EMI 9789 QB and EMI 9659B) and a grating spectrograph (Zeiss PGS-2, reciprocal linear dispersion 0 .73 nm/mm in first order) system. The complet experimental procedure have been described in our earlier publications.

The plasma parameters were determined using standard diagnostic methods (Rompe and Steenbeck 1967). Thus, the electron temperature was determined from the ratios of the relative intensities of nine Kr II spectral lines (435.547 nm, 457.720 nm, 461.529 nm, 461.915 nm, 463.388 nm, 465.887 nm, 473.900 nm, 476.577 nm, 483.207 nm) to the five Kr I spectral lines (435.136 nm, 436.264 nm, 446.369 nm, 557.028 nm, 587.091 nm) with an estimated error of ±9%, assuming the existence of LTE, according to the criterion from Griem (1974). All the necessary atomic data were taken from Lide (1994) and Striganov and Sventickij (1966). The electron density decay was measured using a well know single laser interferometry technique (Ashby et al. 1965) for the 632.8 nm He-Ne laser wavelength with an estimated error of ±7%.

3. Method of calculation

The Stark widths for 14 Kr II lines have been calculated by using the modified semiempirical approach - SEM (Dimitrijević and Konjević 1980, 1981, 1987, Dimitrijević and Kršljanin 1986, Dimitrijević 1988ab and Popović and Dimitrijević 1996ab)

The needed atomic energy levels have been taken from Sugar and Musgrove (1991). Moreover, we present here the results for Stark widths obtained within the modified semiempirical approach for two lines that belong to the Kr II $5p^4D$-$5d^4F^o$ multiplet. For these lines 5f levels are not in the LS coupling but we took them together within the one electron approximation (see e. g. Griem 1974).

4. Results

The results of the measured Stark FWHM (W_m) values at T=17 000 K electron temperature and 1.65×10^{23} m^{-3} electron density are shown in Table 1. Ratios W_m/W_{th} are also given in the same Table, where W_{th} is the Stark FWHM calculated within the modified semiempirical approach by us and from Popović and Dimitrijević (1998). The astrerisk denotes the W_{th} values taken from Popović and Dimitrijević (1998).

Table 1.

Transition	Multiplet	λ (nm)	W_m (nm)	W_m/W_{th}
5s-5p	$^4P_{5/2}$-$^4P^0_{3/2}$	465.89	0.0399	0.90*
	$^4P_{3/2}$-$^4P^0_{1/2}$	483.21	0.0429	0.84*
	$^4P_{5/2}$-$^4D^0_{7/2}$	435.55	0.0378	0.95*
	$^4P_{5/2}$-$^4D^0_{5/2}$	473.90	0.0338	0.73*
	$^4P_{3/2}$-$^4D^0_{5/2}$	476.57	0.0454	0.92*
	$^2P_{3/2}$-$^2P^0_{1/2}$	484.66	0.0426	0.89*
	$^2P_{3/2}$-$^2P^0_{3/2}$	461.53	0.0454	1.05*
	$^2P_{3/2}$-$^2D^0_{5/2}$	461.91	0.0305	0.74*
5s′-5p′	$^2D_{3/2}$-$^2F^0_{5/2}$	463.39	0.0391	0.64*
	$^2D_{5/2}$-$^2F^0_{5/2}$	457.72	0.0449	1.00*
	$^2D_{5/2}$-$^2P^0_{3/2}$	447.50	0.0512	1.03*
	$^2D_{5/2}$-$^2D^0_{5/2}$	408.83	0.0274	0.79*
5p-5d	$^4D^0_{7/2}$-$^4F_{9/2}$	378.31	0.0879	0.83
	$^4D^0_{5/2}$-$^4F_{7/2}$	377.81	0.0848	0.79

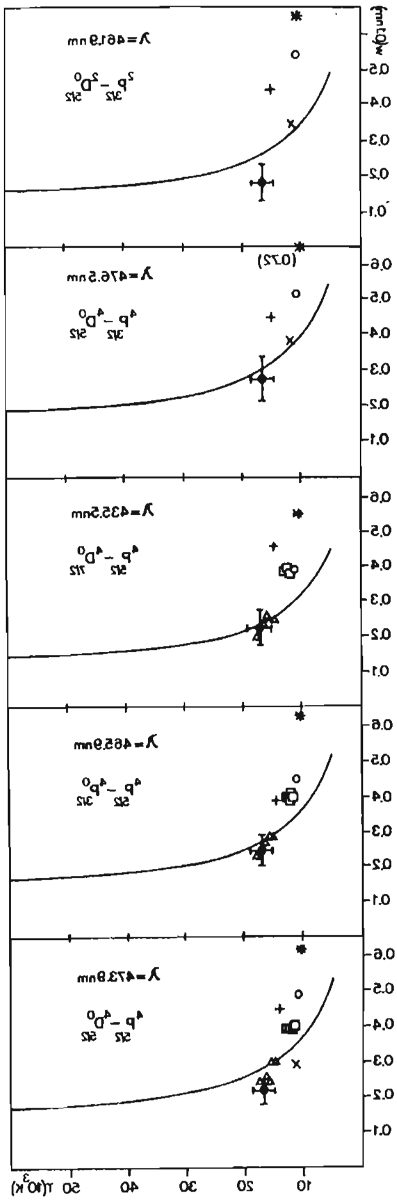

Fig. 1 *Stark FWHM (W) dependence on the electron temperature for the most investigated Kr II spectral lines belonging to the 5s-5p transition at* $1x10^{23}$ m^{-3} *electron density.* —, *calculations by using the modifed semiempirical approach (Popović and Dimitrijević 1998).* • *our experimental results and those of other authors: x, Brandt et al. 1981; *, Richou et al. 1983;* △, *Vitel and Skowronek 1987;* |, *Uzelac and Konjević 1989; o, Lesage et al. 1989 and +, Bertuccelli and Di Rocco 1991. The error bars include the uncertainties of the width, electron density and temperature measurements.*

5. Discussion

In order to make easier the comparison between measured and calculated Stark width values, the theoretical Stark FWHM dependence on the electron temperature together with the values of the other authors and our experimental results at an electron density of 1x10^{23} m^{-3} are presented graphically in Fig.1.

On the basis of the Table 1, and Fig. 1 one can conclude that the comparison between our measured Strak FWHM values of the Kr II lines with the theoretical predictions from Popović and Dimitrijević (1998) show a satisfactory agreement taking into account that the assumed error bars of the modified semiempirical method are ±50 % (Dimitrijević and Konjević 1980). Generally, our W_m values lie below the theoretical up to 13% in average (see W_m/W_{th}, values in Tab. 1). It should be pointed out that our new W_m values at 17 000 K electron temperature agree well with those from Vitel and Skowronek (1987).

6. Conclusion

We have presented in this work experimental Stark widths and shifts for 14 Kr II spectral lines at an electron temperature of 17 000 K and an electron density of 1.65x10^{23} m^{-3}. Moreover we have calculated 2 Kr II Stark line widths within the frame of the modified semiempirical method. Our results have been compared with other experimental and theoretical results. A detailed analysies of our results for Stark widths and shifts for Kr II and Kr III lines will be given elsewhere (Milosavljević et al. 2000).

We hope that the obtained results will be of help for laboratory plasma diagnostics and krypton plasma research and modeling, as well as for astrophysical purposes.

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