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STARK BROADENING OF S III AND S IV SPECTRAL LINES

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Abstract. Stark widths of three S III spectral lines belonging to 4p - 5s transitions have been measured and calculated. Measurements have been performed in the low pressure linear pulsed arc at 2.1 10^{23} m^{-3} electron density and 40 000 K electron temperature. Calculations for S III lines were performed by using the modified semiempirical approach. For S IV $4s^2S$ - $4p^2P^o$ multiplet, calculations were performed within the semiclassical perturbation formalism. The obtained results were compared with the other theoretical and experimental data.

1. INTRODUCTION

The experimental study of the Stark broadening of spectral lines within S III 4p - 5s transitions has been performed The experimental results will be compared with the theoretical results calculated by using the modified semiempirical approach (Dimitrijević and Konjević, 1980), the approximate semiclassical approach (Griem, 1974, Eq. 526) and its modification (Dimitrijević and Konjević, 1980). Since for S IV, the new atomic energy level data enabling the ful semiclassical perturbation calculation (Sahal - Bréchot, 1969ab) become available, the S IV lines will be considered here as well.

2. APPARATUS AND PROCEDURE

Details of the experimental apparatus were described elsewhere (Djeniže *et al.* 1990). A pulsed discharge occured in a Pyrex discharge tube of 5 mm i.d. and had an effective plasma length of 7.4 cm. The tube had end on quartz windows. The working gas was SO_2 at an initial filling pressure of 400 Pa. A capacitor of 0.3μF was charged up to 14.6 kV and supplied discharge currents up to 6.0 kA. The discharge period was 3.7 μs.

Spectroscopic observations of isolated spectral lines were made end-on along the axis of the discharge tube. Great care was taken to minimize the influence of the selfabsorption on Stark FWHM (fullwidth at half intensity maximum) determination. In order to find existence of selfabsorption of lines, one has to check wheather the ratio of their intensities (I) is the same as the ratio of products of spontaneous transition

Table 1. Stark full widths of S III spectral lines for an electron density of 2.1 10^{17} cm^{-3} and T = 40,000 K. With W_m is denoted experimental width. Present theoretical results : W_{MSE} - by using the modified semiempirical approach [4]; W_{GM} - by using the modified version [4] of the symplified semiclassical approach [12, eq. 526]; W_G - by using the Griem's symplified semiclassical approach [12, eq. 526].

	Transition	$\lambda[\AA]$	$W_m[\AA]$	$W_{MSE}[\AA]$	$W_{GM}[\AA]$	$W_G[\AA]$
S III	$4p^3D$-$5s^3P^o$	2508.15	0.402	0.483	0.466	0.623
	(17 UV)	2499.08	0.360	0.483	0.466	0.623
S III	$4p^3S$-$5s^3P^o$	2785.49	0.380	0.569	0.552	0.752
	(20 UV)					

probabilities (A) and statistical weights (g) of their upper level, *i.e.* : $I_1 : I_2 = A_1g_1 : A_2g_2$. In the case of the spectral lines from the 17UV multiplet this ratio were found to be the same within the experimental error, proving that no significant selfabsorption exists.

The spectral line profiles were recorded by the step by step method, described elsewhere (Djeniže *et al.* 1990), using spectrograph - photomultiplier combination. The electron density was measured using a single wavelength He - Ne laser interferometer for the visible 6328. *Å* transition with an estimated error of : ±7%. Peak electron density was found to be 2.4 10^{23} m^{-3}. The electron temperature was deduced from the relative intensity ratios of 4333.7 *Å* S III and S II 5646.9 *Å* lines, assuming the existence of the LTE. It was found to be 40 000 K ±14% at 5μs after the begining of the discharge and decayed slowly during the first 20 μs.

3. RESULTS AND DISCUSSION

In Dimitrijević and Konjević (1980) it is emphasized that "for S III, data on the 4f and 5p levels are unavailable which may affect the results for the multiplets 15 UV - 18 UV". This statement concerns as well to the multiplet 19 UV (Dimitrijević, 1988). In spite of the fact that a new comprehensive investigation of S III spectrum (Johansson *et al.* 1992) exists, as well as a new review of critically selected atomic energy level data (Martin *et al.* 1990), the reliable data on 4f and 5p energy level positions are still missing. Since the experimental results obtained here for S III 17 UV multiplet are (in average) around 3 times larger than calculated (Dimitrijević, 1988), we recalculated them with the inclusion of the new energy values for 4d levels (Johansson *et al.* 1992) and of the estimated (Breger, 1980) positions of $5p^3P$ level (220419 cm^{-1}) and of $5p^3D$ level (219184 cm^{-1}). The present experimental results for line widths within S III $4p^3D$ - $5s^3P^o$ (17 UV) and $4p^3S$ - $5s^3P^o$ (20 UV) multiplets are compared in Table 1 with the present calculations by using the modified semiempirical approach (Dimitrijević and Konjević, 1980), the symplified semiclassical approach (Griem 1974, eq. 526) and its modification (Dimitrijević and Konjević, 1980). One can see that the results obtained by using the modification (Dimitrijević

and Konjević, 1980) of the symplified semiclassical approach (Griem, 1974, eq. 526) and the modified semiempirical approach (Dimitrijević and Konjević, 1980), agree better with the present experimental results than with the symplified semiclassical approach (Griem, 1974, eq. 526). If one takes into account that the error bars of the approximate approaches are within 50 per cents (Griem, 1974) and that the positions of 5p levels are approximate, the agreement with experiment is within the error bars of theoretical uncertainties.

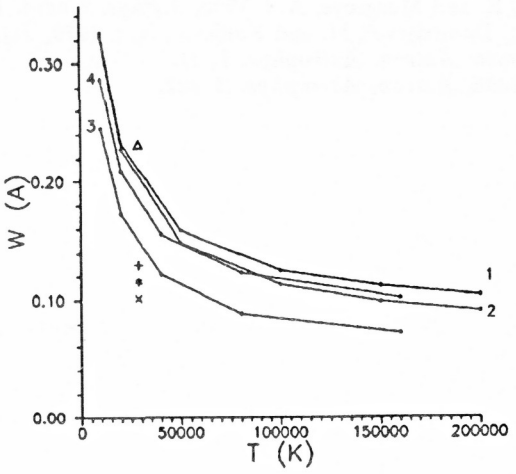

Fig. 1. Full Stark widths for S IV $4s^2S$ - $4p^2P^o$ multiplet as a function of temperature for an electron density of 10^{17} cm^{-3} Experiment : * - Platiša *et al.* (1979). Theory : 1 - present semiclassical results with the ion broadening contribution included; 2 - present semiclassical results, electrons broadening only; 3 - modified semiempirical formula (Dimitrijević and Konjević, 1980); 4 - calculations of Dimitrijević and Konjević (1980) by using the semiclassical approximation (Eq.(526) taken from Griem, 1974); x - Hey and Breger (1980), the method I; + - Hey and Breger (1980), the method II; Δ - semiclassical calculations of Dimitrijević and Konjević (1982).

Needed energy levels for S IV have been taken from Martin *et al.* (1980). In Fig. 1, our results for S IV $4s^2S$ - $4p^2P^o$ multiplet Stark broadening parameters, are compared with experimental results (Platiša *et al.* 1979) and other theoretical calculations, *i.e.* with results obtained by using the modified semiempirical formula (Dimitrijević and Konjević, 1980); calculations of Dimitrijević and Konjević (1980) by using the semiclassical approximation (Eq.(526) taken from Griem, 1974); approximate approaches of Hey and Breger (1980) and with the semiclassical calculations of Dimitrijević and Konjević (1982). Experimental results (Platiša *et al.* 1979) compare better with the approximate approaches of Hey and Breger (1980) and Dimitrijević and Konjević (1980) than with more sophysticated semiclassical calculations. More experimental data will be of use for a better investigation of these discrepancies.

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