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ON THE STARK BROADENING AND SHIFT OF TRIPLY IONIZED OXYGEN LINES

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Abstract. Stark broadening parameters of triply ionized oxygen $3s^2S$-$3p^2P^o$ and $3p^2P^o$-$3d^2D$ transitions have been observed experimentally in the plasma of a low pressure pulsed arc, and studied theoretically within the semiclassical perturbation approach. The temperature dependence of the Stark widths and shifts and the influence of forbidden perturbing level, have been considered as well.

1. INTRODUCTION

Temperature dependence of the Stark widths and shifts of the O IV $3s^2S$-$3p^2P^o$ and $3p^2P^o$-$3d^2D$ transitions have been studied theoretically using the impact semiclassical method and experimentally observed in the plasma of a low pressure pulsed arc. Plasma electron densities were determined from the width of the He II P_α line while electron temperatures were measured from the relative line intensities. To estimate influence of different ions on the width and shift of lines, evaluation of plasma composition data was performed and in conjunction with our theoretical results the contribution of ion broadening estimated. Furthermore in our theoretical calculations we included for the first time the influence of forbidden perturbing levels on the width and shift of investigated O IV spectral lines.

2. THEORY

By using the semiclassical-perturbation formalism (Sahal-Bréchot, 1969ab) we have calculated previously (Blagojević *et al.*, 1994) electron-, proton-, and He II-impact broadening parameters for OIV $3s^2S$-$3p^2P^o$ and $3p^2P^o$-$3d^2D$. Energy levels needed for these calculations have been taken from Bashkin and Stoner (1975). Oscillator strengths were calculated by using the method of Bates and Damgaard (1949); (see also tables in Oertel and Shomo, 1968). For higher energy levels the method described in Van Regemorter *et al.* (1979) has been used. Since in the case of the considered transitions, several forbidden transitions may influence significantly, particularly shift values, new calculations with the inclusion of such transitions have been performed here. In order to assure the consistency of the data set, all oscillator strengths (and not only those for added forbidden transitions) have been taken from the TOP base (the complete package of the opacity project (OP) data with the database management system is usually refered to as TOP base) (Butler *et al.*, 1993; Cunto *et al.*, 1993). Besides electron impact line widths and shifts, Stark broadening parameters, due to all relevant ion perturbers, have been calculated as well.

3. EXPERIMENT

Experimental apparatus and procedure are described in Blagojević *et al.* (1994) so only minimum details will be given here. The light source was a low pressure pulsed arc with a quartz discharge tube 10 mm internal diameter. The distance between aluminum electrodes was 161 mm, and 3 mm diameter holes were located at the center of both electrodes to allow end-on plasma observations. All plasma observations are performed with 1-m monochromator with inverse linear dispersion 8.33 Å/mm in the first order of the diffraction grating, equipped with the photomultiplier tube and a stepping motor. The discharge was driven by a 15.2 μF low inductance capacitor charged to 6 kV, peak current I_p = 27 kA, pressure of the gas mixture p = 3 torr, continuous flow of the gas mixture, composition : 1.4% of O_2 in He. The stepping motor and oscilloscope are controlled by a personal computer, which was also used for data acquisition. Recordings of spectral line shapes were performed shot-by-shot. At each wavelength position of the monochromator time evolution and decay of the plasma radiation were recorded by the oscilloscope. Four such signals were averaged at each wavelength. To construct the line profiles these averaged signals, at different wavelengths and at various times of the plasma existence, were used to construct the line profiles. Spectral line profiles were recorded with instrumental half widths of 0.165 Å. To determine the Stark half width from the measured profile, a standard deconvolution procedure for the Lorentzian (Stark) and Gaussian (instrumental+Doppler) profiles was used. For the line-shift measurements we used line profiles at different times of the plasma existence (Purić and Konjević, 1972). For this technique of shift measurements it is necessary to know plasma parameters (electron density and temperature) at the times when both profiles are recorded. Descriptions of electron density and electron temperature measurements are given in Blagojević *et al.* (1994).

4. EXPERIMENTAL RESULTS AND DISCUSSION

The experimental results for Stark widths of O IV lines and comparisons with theoretical results are given in Fig.1 and Fig.2 for O IV $3s^2S$-$3p^2P^o$ and $3p^2P^o$-$3d^2D$ transitions, respectively. In order to evaluate contribution of ion impact widths it was necessary to compute plasma composition data for the conditions of width measurements (electron density and temperature). Measured shifts and comparison with the semiclassical theoretical shifts are given in Table 1.

The inclusion of some perturbing forbidden levels in our semiclassical calculations of O IV line widths and shifts improves the agreement between theory and experiment.

Table 1. Experimental Stark shifts d_m determined as a wavelength shift between two line profiles measured at N_{e1} , T_{e1} and N_{e2} , T_{e2} and normalized to $N = 10^{17}$ cm^{-3}, compared with corresponding theoretical shift d^e_{DSB} for electron impacts.

Transition	N_{e1} (10^{17} cm^{-3})	T_1 (K)	N_e2 (10^{17} cm^{-3})	T_2 (K)	d_m (Å)	d_m/d^e_{DSB}
$3s^2S_{1/2}$–$3p^2P^o_{3/2}$	2.06	62600	5.07	93600	0.03	1.4
$3s^2S_{1/2}$–$3p^2P^o_{1/2}$	2.06	62600	5.07	93600	0.03	1.4
$3p^2$ $P^o_{1/2}$–$3d^2D_{3/2}$	2.06	62600	5.07	93600	0.03	1.5
$3p^2$ $P^o_{3/2}$–$3d^2D_{5/2}$	2.06	62600	5.07	93600	0.03	1.5

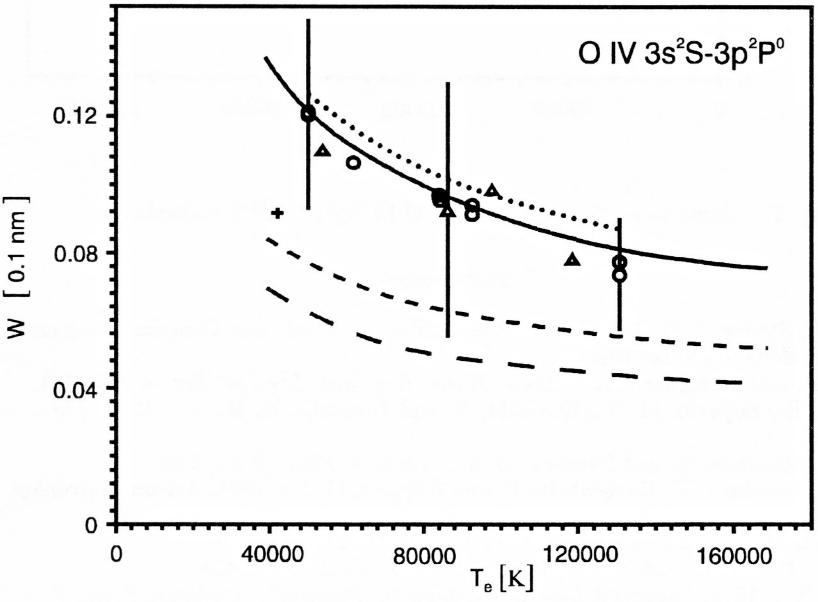

Fig. 1. Full Stark widths (normalized to an electron density of 10^{17} cm^{-3}) for the O IV $3s^2S$ - $3p^2P^o$ multiplet *vs* electron temperature. Theory : ....., semiclassical electron- + ion-impact widths, —, semiclassical, electrons only; - - -, semiclassical approximation (Eq.(526) taken from Griem, 1974); – – –, modified semiempirical formula (Dimitrijević and Konjević, 1980). Experiment : O, this work; +, Purić *et al.*, (1988); Δ, Glenzer *et al.*, (1994).

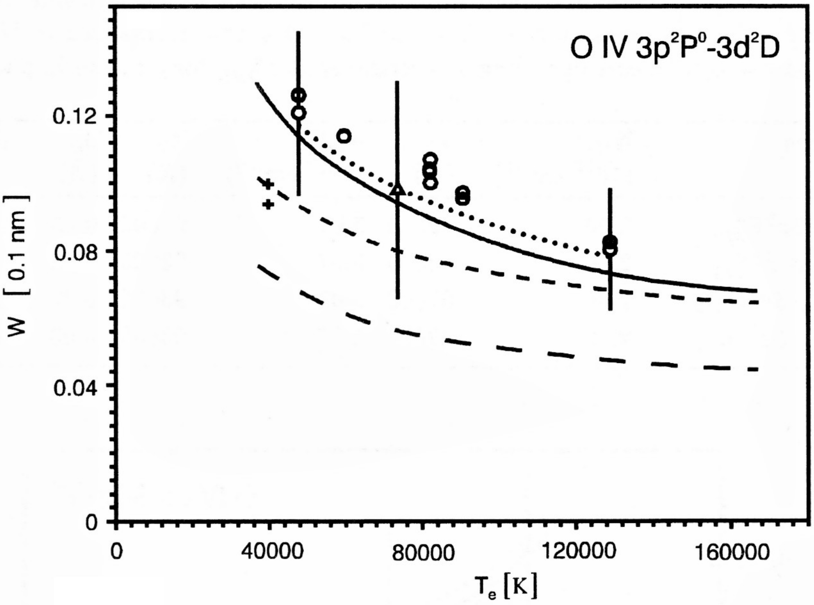

Fig. 2. Same as in Figure 2, but for O IV $3p^2P^o$-$3d^2D$ multiplet.

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