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STARK BROADENING OF THE F V $3s^2S$-$3p^2P^O$ AND $3p^2P$-$3d^2D^O$ TRANSITIONS

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Abstract. The Stark widths of several fourthly ionized fluorine lines have been calculated and measured in the plasma of a pulsed arc. Electron density $2.54\times10^{17}cm^{-3}$ was determined from the width of the HeII P_α line while electron temperature of 71200 K is measured from the relative intensities of F IV lines. Our experimental FV widths agree well with our semiclassical theoretical results. The results of another experiment for 3p-3d transition is in a good agreement with our theoretical and experimental data while the discrepancy for 3s-3p transition is rather large. The results of two simple theoretical methods for evaluation of Stark widths are in reasonable agreement with experiment.

1. INTRODUCTION

Broadening and shift of spectral lines in plasmas were the subject of numerous experimental studies (see e.g. Konjević and Wiese 1990. and references therein). Unfortunately, most of the reported data are for the lower ionization stages. The lack of the experimental data makes a detailed test of the Stark broadening theoretical calculations incomplete. The aim of this paper is to supply the theoretical and experimental data for the widths of prominent fourthly ionized fluorine lines for a large electron temperature range. The reported experimental results together with other experimental data will be used for the testing of semiclassical and other theoretical calculations.

2. THEORY

By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969) we have calculated electron- and ion-impact line widths for FV $3s^2S$-$3p^2P^o$ and $3p^2P^o$-$3d^2D$ multiplets. A summary of the formalism is given in Dimitrijević et al 1991. For the comparison with experiment theoretical widths are also evaluated from simplified semiclassical formula (Eq.526, Griem 1974) and modified semiempirical formula (Dimitrijević and Konjević 1980). All necessary data for these calculations are taken from Bashkin and Stonner 1975.

3. EXPERIMENT

Experimental apparatus and procedure are described elsewhere (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 16.1 cm, 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 4.8 kV (peak current 15.8 kA, critically dumped current pulse duration 8.3 μs, pressure of the gas mixture 0.8 torr, continuous flow of the gas mixture 1.4% of SF_6 in He) and fired by ignitron. 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 are 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. Spectral line profiles were recorded with instrumental half widths of 0.192 Å. To determine the Stark half widths from the measured profile, a standard deconvolution procedure for the Lorentzian (Stark) and Gaussian (instrumental+Doppler) profiles (Davies and Vaughan 1963) was used. For the electron density measurements we used the width of the HeII P_α 4686 Å line (Pittman and Fleurier 1986). The axial electron temperatures were determined from intensities of the 2635.37-, 2820.74-, 2823.84- and 2826.13-Å F IV lines. The spectral response of the photomultiplier-monochromator system is calibrated against standard coiled-coil quartz iodine lamp.

4. RESULTS

Comparison of the experimental and theoretical results for the lines belonging to 3s-3p and 3p-3d transitions are given in Figures 1 and 2 respectively. In these Figures theoretical widths are denoted in the following way : electrons only; •, electrons+ions for our experimental conditions : Δ, electrons +ions for the conditions of the experiment by Glenzer et al 1994; — simplified semiclassical approach after Griem 1974; — — —, modified semiempirical formula, after Dimitrijević and Konjević 1980 : o, this experiment, and D, experimental results by Glenzer et al 1994. Our experimental results compare very well with our theoretical results (electrons+ions) see Figs.1 and 2. Same conclusion one may draw for 3p-3d line of Glenzer et al 1994. However, one may not draw same conclusion for the high temperature result the 3s-3p line, see Fig.1. Although the results of simple formulas, (see Figs.1 and 2) are systematically lower than the experimental results, both simplified approaches agree with experiment within the estimated uncertainties of about 50%.

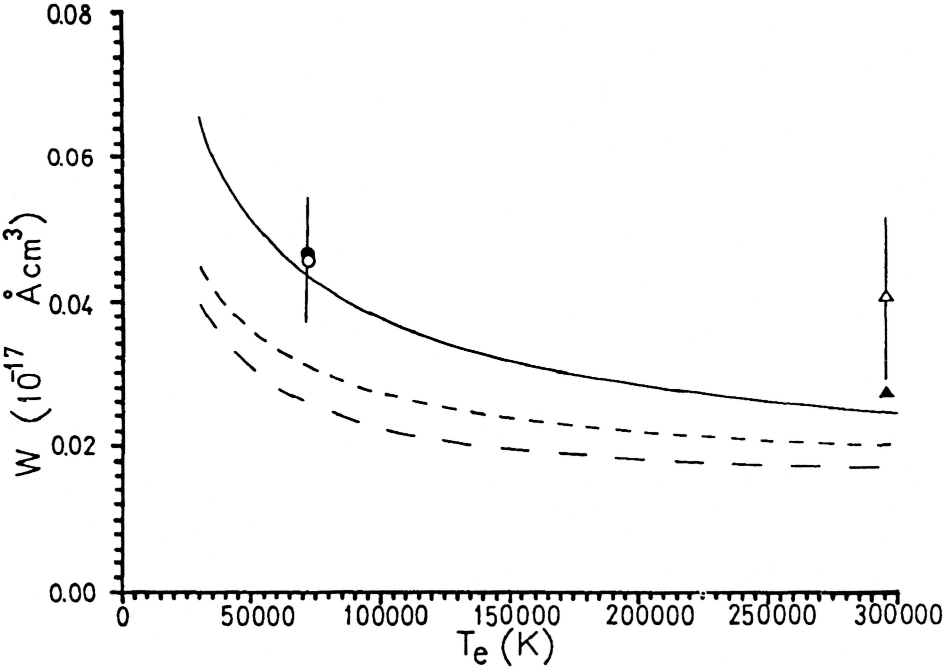

Fig. 1. 3s-3p transition

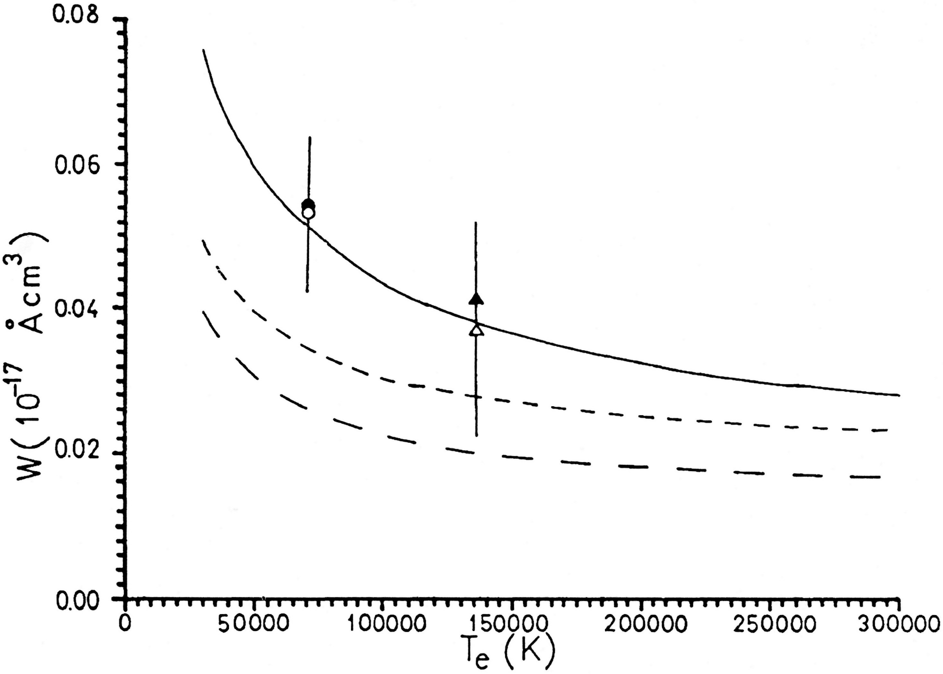

Fig. 2. 3p-3d transition

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