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STARK WIDTHS IN THE C II 3s ^{2}S - 3p ^{2}P^0 TRANSITION

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1. INTRODUCTION

Carbon is one of the most present element in the various cosmic emitters. Beside,as impurities is, also, present in laboratorical light sources. So, spectral lines of singly ionized carbon (C II) can be taken for plasma diagnostics purpose. Thus, the necessity of knowledge of Stark widths of C II lines was imposed. Namely, on the basis of Stark width values it is possible to obtain the other basic plasma parameters e.g. electron temperature (T) and electron density (N) important in the modeling of the stellar atmospheres and, also, in the calculations the cinetics of the thermo-ionization, chemo-recombination , etc.... processes in various plasmas.

Five experiments (Hughes & El-Farra 1983; Djeniže et al. 1988; Perez et al. 1991; Sarandaev & Salakhov 1995; Blagojević et al. 1999) deal with the Stark FWHM (full-width at half intensity maximum, W) investigations of the $3s^2S - 3p^2P^0$ transition in the electron temperature range between 17 000 K and 32 000 K. Existing theoretical W values, calculated on the basis of the semiclassical (SC) (Griem 1974) and modified semiempirical (SEM) (Dimitrijević & Konjević 1980; Blagojević et al. 1999) approaches mutual differ up to 70% in the mentioned electron temperature interval.

The aim of this work is contribution to the knowledge of the Stark FWHM values at about 19 000 k electron temperature who the experimental W values obtained by Blagojević et al. (1999) and Sarandaev & Salakhov lie between theoretical SC and SEM values.

We have measured Stark FWHM values of the 657.803 nm and 658.285 nm C II spectral lines that belong to the 3s - 3p transition at 19 000 K electron temperature and 1.66 10^{23} electron density. Our W data have been compared to the SC, SEM theoretical and INS estimated Stark width values.

2. EXPERIMENT

The modified version of the linear low pressure pulsed arc (Djeniže et al 1998) has been used as a plasma source. A pulsed discharge was driven in a quartz discharge tube of 5 mm i.d. and has an effective plasma length of 6.3 cm. The tube has end-on quartz windows. On the opposite sides of the carbon electrodes the glass tube was expanded in order to reduce sputtering of the electrode material onto the quartz windows. The working gas was CO_2 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 14μF was charged up to 2.8 kV. The line profiles were recorded by a step-by-step technique using a photomultiplier (EMI 9789 QB , EMI 9659 B) and a grating spectrograph (Zeiss PGS-2, reciprocal linear dispersion 0.73 nm/mm in the first order) system. The spectrograph exit slit (10μm) with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps (0.0073 nm). The photomultiplier signal was digitized using oscilloscope, interfaced to a computer. A sample output, as example, is shown in Fig.1 and Fig.2. These figures show the researched C II lines in the early ionization and recombination phases of the discharge, respectively.

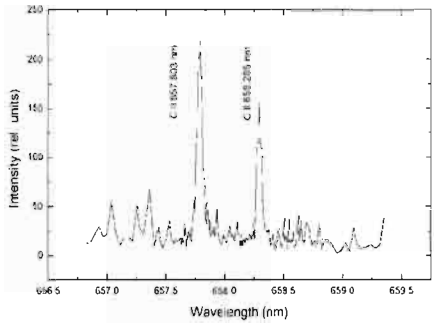

Fig.1.Recorded spectrum at $3^{th}\mu$s after the beginning of the discharge

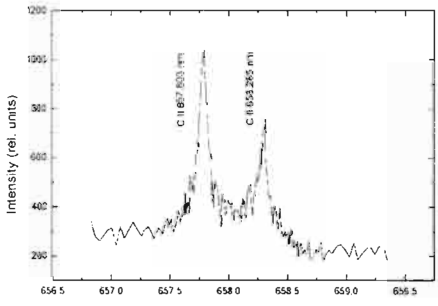

Fig.2. Recorded spectrum at $15^{th}\mu$s after the beginning of the discharge

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. 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 & Vaughan 1963) was used. The Stark widths were measured with ±12% error at given T and N.

The plasma parameters were determined using standard diagnostics methods. The electron temperature was determined from the Boltzmann-plot of six O II lines (394.50, 395.44, 407.22, 408.72, 413.28 and 418.55 nm) with a corresponding upper-level energy interval of 5.2 eV. The necessary atomic data were taken from Wiese et al. (1966).

For electron density measurement the well-known laser interferometry method has been used and, also, the convenient Stark widths of the mentioned O II spectral lines. The obtained value was $N = 1.66 \cdot 10^{23}$ m^{-3} $\pm 7\%$ (in the 15. μs after the beginning of the discharge). The observed electron density decay is presented in Fig.3.

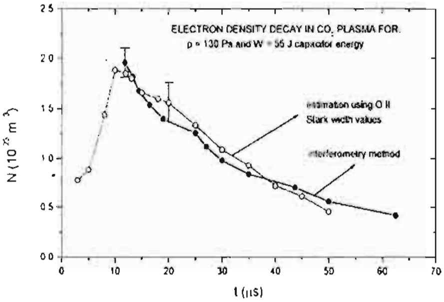

Fig.3. Electron density decay

3. RESULTS

Our experimental results of the measured Stark FWHM values at 19 000 K electron temperature and an $N = 1.66 \cdot 10^{23}$ m^{-3} electron density are 0.146 nm on 0.141 nm for the 657.803 nm and 658.285 nm C II lines, respectively.

4. DISCUSSION

In order to allow easy comparison among measured and calculated Stark width values, we report in Fig.4 variations of W (FWHM) with the electron temperatures for a given electron density equal to 10^{23} m^{-3}. Theoretical predictions, (dashed lines) present electron contribution to the Stark width, only. The Stark width values of the mentioned C II spectral lines was calculated on the basis of the semiclassical approximation by Griem (1974) (SC) and on the basis of the modified semiempirical formulae (SEM) (Dimitrijević & Konjević). INS denote estimated W values (Djeniže et al. 1988) using the obtained Stark width regularities along the carbon isonuclear sequence.

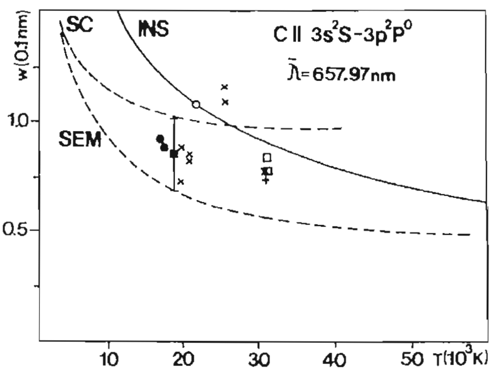

Fig.4. Stark FWHM dependence on the electron temperature at an 10^{23} m^{-3} electron density. Measured values: ■, this work; 0, Perez et al. (1991); •, Blagojević et al. (1999); + Djeniže et al. (1988); □, Hughes & El Farra (1983); ×, Sarandaev & Salakhov (1995). Calculated values: SC, Griem (1974); SEM Blagojević et al. (1999); Estimated values: on the basis of the regularities along the carbon isonuclear (INS) sequence (Djeniže 1988). Error bar represents 19% uncertainties. $\bar{\lambda}$ is the mean wavelength in the multiplet.

5. CONCLUSION

Our measured W values at 19 000 K electron temperature agree, within experimental accuracy, with those from Blagojević et al. (1999) and lie between SC and SEM theoretical predictions confirmed earlier experimental W data (Hughes & El Farra 1983; Djeniže et al. 1988; Sarandaev & Salakhov 1995 and Blagojević et al. 1999).

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