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EXPERIMENTAL STARK WIDTH OF THE 581.198 nm C IV SPECTRAL LINE

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1. INTRODUCTION

Spectral lines of multiply ionized emitters, like C IV, were discovered in the spectra of stellar atmospheres of hot stars (Bruhweiler & Kondo 1983 and references therein; Dupree & Raymond 1982; Bruhweiler 1985). Thus, the necessity of knowledge of Stark widths of these lines was imposed. On the basis of Stark width values it is possible to obtain other basic plasma parameters e.g. electron temperature (T) and electron density (N), important in the modeling of the stellar atmospheres.

We have measured Stark FWHM (full-width at half intensity maximum, W) of the C IV 581.198 nm line at an T=24 000 K electron temperature and N = 1.66 10^{23} m^{-3} electron density in the CO_2 plasma. It should be pointed out that the existing experimental W values are obtained at electron temperatures higher than 38 000 K. However, the low temperature region is important for sensitive evaluation of the W values. Namely, various theoretical approximations involve stronger temperature dependence in this temperature region and show mutual discrepancies. Their reliability can be arbitrary with reliable experimental data.

2. EXPERIMENT

The modified version of the linear low pressure pulsed arc (Djeniže et al 1998) has been used as the plasma source. A pulsed discharge was driven in a quartz discharge tube of 5 mm i.d. and has an effective plasma length of 7.2 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 was 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 shot-by-shot 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 exit slit (10μm) of the spectrograph 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. The investigated C IV spectral lines are recorded in the ionization phase of the discharge when the spectral lines from lower ionization states (C II, O II, C III, O III) can not disturb the observed C IV spectral region.

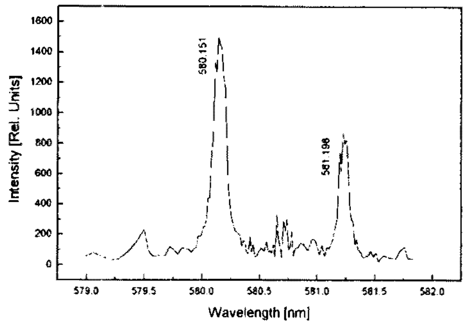

Fig.1.Recorded spectrum at $5^{th}\mu$s after the beginning of the discharge

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 broadenings.

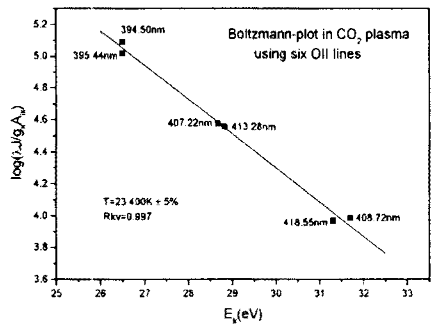

Fig.2. Boltzmann-plot of six O II lines

A standard deconvolution procedure (Davies & Vaughan 1963) was used. The Stark widths were measured with $\pm 12\%$ error at given T and N.

The plasma parameters were determined using standard diagnostics methods. The electron temperature was determined from the Boltzmann-slope 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). At 15.μs after the beginning of the discharge (the moment when the spectral line profiles were analyzed) the found electron temperature was 24 000 K $\pm 5\%$.

For electron density measurement we used the well-known laser interferometry method 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} $\pm 7\%$ (at the 15. μs after the beginning of the discharge).

3. RESULTS

Our experimental result of the measured Stark FWHM value at 24 000 K electron temperature and an $N = 1.66 \cdot 10^{23}$ m^{-3} electron density is 0.103 nm.

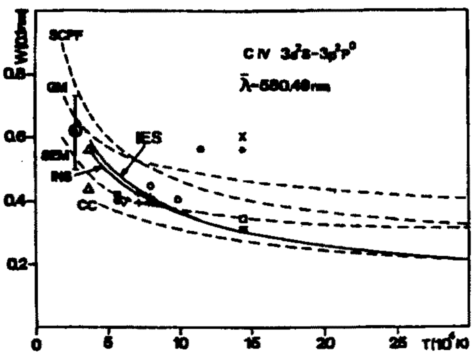

Fig.3. Stark FWHM dependence on the electron temperature at 10^{23} m^{-3} electron density. Measured values: $\odot$, this work; 0, Glenzer et al. (1992); +, Blagojević et al. (1999); Δ, Djeniže et al. ((1988); ∇, Bogen (1972); $\bullet$, Ackermann et al. (1985); $\oplus$, El Farra & Huges (1983); $\star$, Böttcher et al. (1988). Calculated values (see text for explanation): GM, SEM and SCPF, Blagojević et al. (1999); CC, Seaton (1988); x, Baranger (1962); , Hey & Breger (1982) and Hey & Breger (1980). Estimated values: on the basis of the regularities along the isonuclear (INS) and isoelectronic (IES) sequences (Djeniže 1999). Error bar represents 19% uncertainties. $\bar{\lambda}$ is the mean wavelength in the multiplet.

4. DISCUSSION

In order to allow easy comparison between measured and calculated Stark width values, we display in Fig. 3. 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 previous calculation of the Stark width values of the mentioned C IV spectral lines was performed by Dimitrijević & Konjević (1980) on the basis of the simplified semiclassical approximation after Griem (1974) (GM) and of the modified semiempirical formulae (SEM) (Dimitrijević & Konjević). Seaton's calculations, using the close-coupling theory (CC), have been presented in 1988. Böttcher et al. (1988) have calculated the Stark width values of these lines at 145 000 K electron temperature with the impact and classical path approximations (Hey & Breger 1980,1982) and Baranger's (1962) theory for nonhydrogenic ions. Blagojević et al. (1999) have calculated the new values of the Stark widths in a wide range of the electron temperatures (20 000 K - 300 000 K) using the semiclassical perturbation formalism (SCPF) (Sahal-Brechot 1969a, 1969b). This is an extension of the calculations performed by Dimitrijević et al. (1991). INS and IES denote estimated W values (Djeniže 1999) using Stark width regularities along isonuclear and isoelectronic sequences, respectively.

5. CONCLUSION

Our measured W value at 24 000 K electron temperature agree, within experimental accuracy, with GM and SEM theoretical predictions. On the other hand, good agreement was found, also, with the estimated INS and IES Stark FWHM values.

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