Publ. Astron. Obs. Belgrade No. 65 (1999), 59 - 62

MEASURED, CALCULATED AND ESTIMATED STARK WIDTHS OF THE 580.133 nm AND 581.198 nm C IV SPECTRAL LINES

S. DJENIŽE

Faculty of Physics, University of Belgrade
P.O.B. 368, 11000 Belgrade, Serbia, Yugoslavia

1. INTRODUCTION

Spectral lines of multiply ionized emitters,like C IV ,were discovered in the spectra of stellar atmospheres of hot stars (Bruhweiler and Kondo 1983 and references therein; Dupree and Raymond 1982; Bruhweiler 1985). Thus, the necessity of knowledge of Stark widths of these lines was imposed. On the basis of Stark HWHM (half-width at half intensity maximum, w) 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 (Lesage 1994).It is of interest to find spectral lines with well-known Stark width values,convenient in a plasma diagnostics.In that respect, the 580.133 nm and 581.198 nm C IV spectral lines, that belong to the $3s^2S - 3p^2P^0$ transition, would be recommended for a plasma diagnostics. Namely, the existing measured, calculated and estimated Stark width values of these lines show mutual agreement in a wide range of the electron temperatures.

2. MEASUREMENTS

Seven experiments deal with the Stark HWHM investigation of the 580.133nm and 581.198 nm C IV spectral lines (Bogen 1972; El Farra and Hughes 1983; Ackermann *et al.* 1985; Djeniže *et al.* 1988; Böttcher *et al.* 1988; Glenzer *et al.* 1992; Blagojević *et al.* 1999), to the knowledge of the author (Lesage and Fuhr 1998, and references therein). Measurements were realized in the electron temperature range between 38 000 K and 145 000 K.

3. CALCULATIONS

The previous calculation of the Stark width values of the mentioned C IV spectral lines was performed by Dimitrijević and Konjević (1980) on the basis of the simplified semiclassical approximation after Griem (1974) (GM) and of the modified semiempirical formulae (SEM) (Dimitrijević and Konjević 1980). 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 which the impact and classical path approximations (Hey and 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) in the semiclassical perturbation formalism (SCPF) (Sahal-Brechot 1969a, 1969b). This is an extension of the calculations performed by Dimitrijević *et al.* (1991).

4. ESTIMATIONS

The simplest way to estimate the value of a Stark HWHM is to use established regularities of w along the isonuclear or isoelectronic sequences for given type of quantum transition. It was found (Djeniže *et al.* 1988 ; Purić *et al.* 1988) that a simple analytical relationship may, for same transition, exist between w and the corresponding upper-level ionization potential (I) of a particular spectral line. The found relationship, normalized to a $N = 10^{23}$ m^{-3} electron density, is of the form:

$$w(\mathrm{rad/s}) = az^2T^{-1/2}I^{-b}. \qquad (1)$$

The upper-level ionization potential I (in eV) and net core charge z (z=1,2,3,4,... for neutral, singly, doubly, triply,... ionized atoms, respectively) specifies the emitting ion, while the electron temperature T (in K) characterizes the assembly. The coefficients a and b are independent of I and T. In the case of the lithium-like isoelectronic sequence (IES) (Li I, Be II, B III, C IV, N V, O VI, F VII, Ne VIII,...),for the 3s - 3p transition, this dependence is expressed (Purić *et al.* 1988) as:

$$w(\mathrm{rad/s}) = 5.31\ 10^{14}z^2T^{-1/2}I^{-1.74} \qquad .(2)$$

In the case of the carbon isonuclear sequence (INS) (C I,C II,C III,C IV,...), for the 3s - 3p transition the following form was found (Djeniže *et al.* 1988; Djeniže and Labat 1996):

$$w(\mathrm{rad/s}) = 1.42\ 10^{14}z^2T^{-1/2}I^{-1.34}. \qquad (3)$$

Table 1. Estimated Stark width values (2w) on the basis of the regularities along an isonuclear (INS) and isoelectronic (IES) sequences at various electron temperatures and 10^{23} m^{-3} electron density.

$T(10^3K)$	INS	IES.	$T(10^3K)$	INS.	IES
40	0.0550	0.0559	110	0.0332	0.0343
50	0.0492	0.0509	120	0.0317	0.0329
60	0.0449	0.0465	130	0.0305	0.0316
70	0.0416	0.0430	140	0.0294	0.0304
80	0.0389	0.0403	150	0.0284	0.0294
90	0.0367	0.0380	200	0.0250	0.0254
100	0.0348	0.0360	300	0.0201	0.0208

The Eqs.(2-3) allow to predict the Stark width values for:z = 1,2,3,4,5,6,7 at various electron temperatures. The estimated Stark FWHM (2w) values of the 580.49 nm C IV spectral line (mean wavelength in the multiplet), for z = 4, are presented in Table 1. The necessary atomic data were taken from Wiese *et al.* (1966).

5. DISCUSSION

In order to allow easy comparison among measured, calculated and estimated Stark width values,in Fig.1, the dependence of 2w (FWHM) values on the electron temperatures is given at N = 10^{23} m^{-3} electron density.Theoretical values (dashed lines) present electron contribution to the Stark width,only.

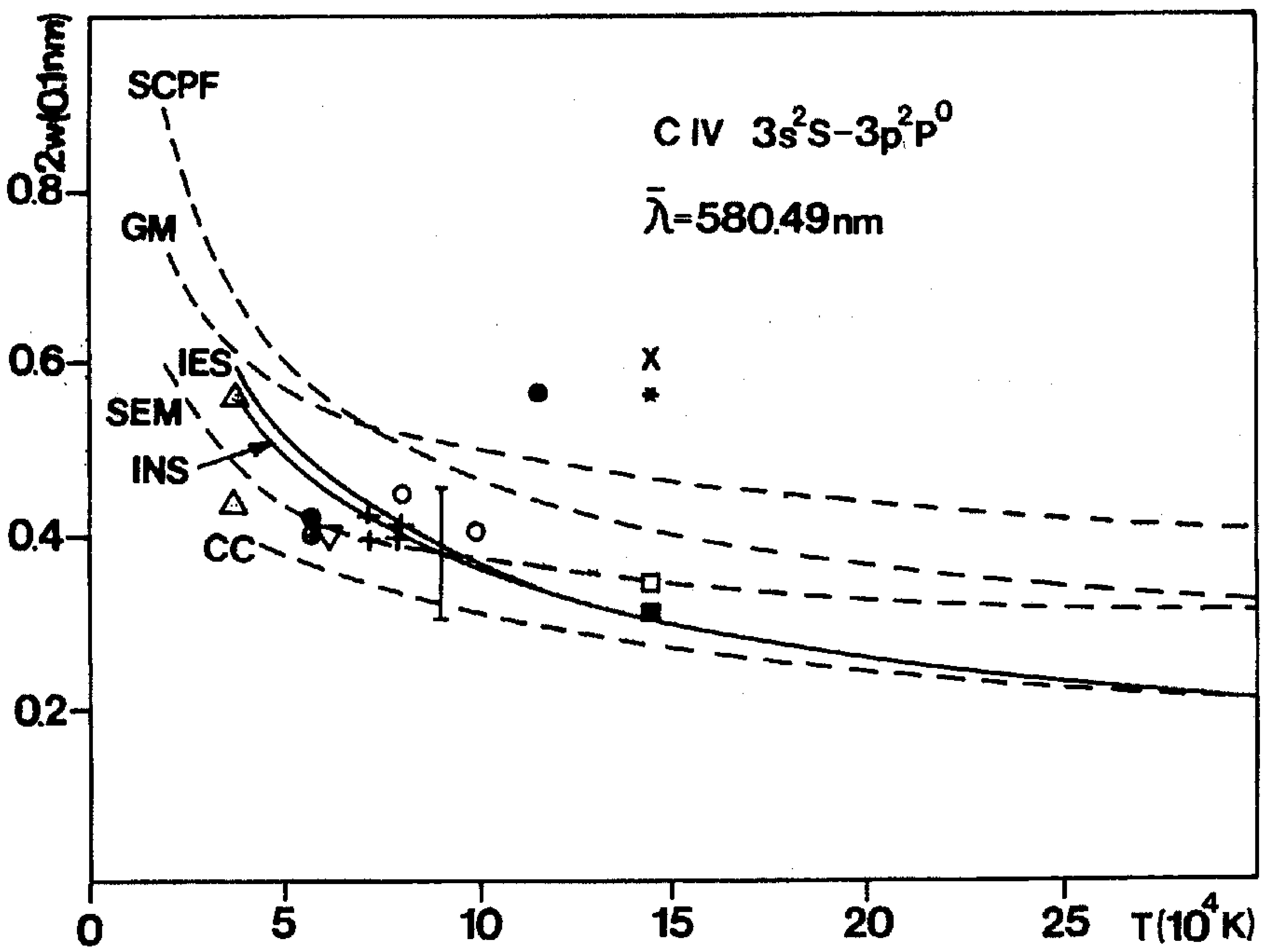

Fig. 1. Stark FWHM dependence on the electron temperature at 10^{23} m^{-3} electron density. Measured values: 0, Glenzer *et al.* (1992); +, Blagojević *et al.* (1999); Δ, Djeniže *et al.* (1988); ∇, Bogen (1972); •, Ackermann *et al.* (1985); $\oplus$, El Farra and Hughes (1983); *, Böttcher *et al.* (1988). Calculated values (see text for explanation): GM, SEM and SCPF, Blagojević *et al.* (1999); CC, Seaton (1988); x, Baranger (1962); , Hey and Breger (1982) and ■, Hey and Breger (1980). Estimated values: on the basis of the regularities along an isonuclear (INS) and isoelectronic (IES) sequences. Error bar represents 20% uncertainties.

The new experimental data (Glenzer *et al.* 1992; Blagojević *et al.* 1999) agree, within 10% accuracies, with the estimated values based on the INS and IES regularities.The earlier experimental results (Bogen 1972; El Farra and Hughes 1983; Djeniže *et al.* 1988) shows similar agreement, also (see Fig.1). Only exception makes experimental data from Ackermann *et al.* (1985) and Böttcher *et al.* (1988). These lies above the all existing theoretical predictions. In general, existing theoretical (GM, SEM, SCPF, CC, ■ and), experimental and estimated (INS, IES) Stark width values shows mutually agreement, within 25% uncertainties, in a wide range of the electron temperatures.

6. CONCLUSION

In general, we noticed a very good agreement among a measured, calculated and estimated Stark width values of the 580.133 nm and 581.198 nm C IV spectral lines. This allows us to recommend their use for plasma spectroscopy. Existing Stark width values of these spectral lines: INS and IES values in the Table 1, in this work, and theoretical values: SEM, CC, and ■ (within 15% uncertainties) present convenient atomic data in the plasma diagnostics up to 300 000 K electron temperature.

Acknowledgements

This research is a part of the project "Plasma Spectroscopy" supported by Ministry of Science and Technology of the Republic of Serbia.

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