STARK BROADENING CALCULATIONS OF NEUTRAL COPPER SPECTRAL LINES AND TEMPERATURE DEPENDENCE

B. Zmerli, N. Ben Nessib, M. S. Dimitrijević and S. Sahal Bréchot

Introduction

In plasmas, Stark broadening of spectral lines is important not only for experimental methods, but also for theoretical understanding.

The neutral copper (CuI) is often used in electrical industry as an electrode material. Therefore, diagnostic techniques for this element are of particular interest in industrial laboratories.

Stark broadening calculation:

1. semi-classical method
2. Impact approximation

SC method

S. Sahal-Bréchot, Astron. Astrophys. **1**, 91 (1969)
S. Sahal-Bréchot, Astron. Astrophys. **2**, 322 (1969)
M.S. Dimitrijević, S. Sahal-Bréchot, Phys. Rev. A **31**, 316 (1985)

In 2008, in order to demonstrate the deviations from the $T^{-1/2}$ dependence for neutral atom lines, we derived the explicit temperature dependence for two particular cases: the simplifiedf ormulae of Freudenstein and Cooper and Dimitrijević *and Konjević :*

Eur. Phys. J. D (2008)
DOI: 10.1140/epjd/e2008-00128-9

THE EUROPEAN PHYSICAL JOURNAL D

Temperature dependence of atomic spectral line widths in a plasma

B. Zmerli[1], N. Ben Nessib[1], and M.S. Dimitrijević[2,a]

[1] Groupe de Recherche en Physique Atomique et Astrophysique, Institut National des Sciences Appliquées et de Technologie, Centre Urbain Nord, BP 676, 1080 Tunis Cedex, Tunisia
[2] Astronomical Observatory, Volgina 7, 11160 Belgrade, Serbia

Received 14 November 2007 / Received in final form 13 February 2008
Published online 25 June 2008 – ©

Abstract. We investigated here temperature dependence of Stark widths for neutral atom spectral lines in order to find a more precise method for scaling with temperature than sometimes used dependence $T^{-1/2}$,

B. Zmerli, N. Ben Nessib and M. S. Dimitrijević, Eur. Phys. J. D. 48 (2008) 389

In this work, we present semiclassical calculations of Stark broadening (W and d en Å) for neutral copper spectral lines:

$$w = N \int_0^\infty v f(v) dv \left(\sum_{i' \neq i} \sigma_{ii'}(v) + \sum_{f' \neq f} \sigma_{ff'}(v) + \sigma_{el} \right),$$

$$\sum_{i' \neq i} \sigma_{ii'}(v) = \frac{1}{2} \pi R_1^2 + \int_{R_1}^{R_D} 2\pi\rho \, d\rho \sum_{i' \neq i} P_{ii'}(\rho, v),$$

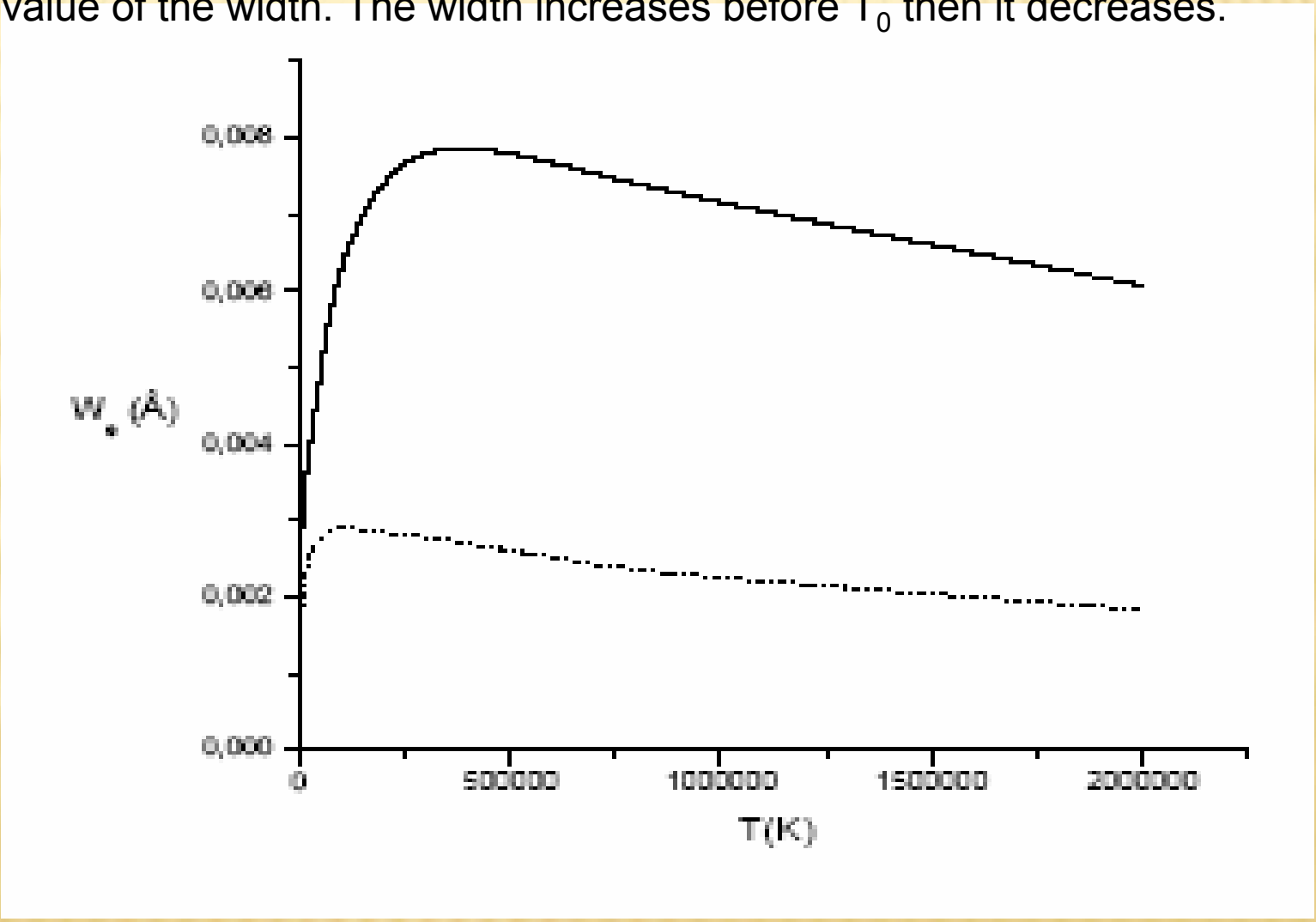
$$\sigma_{el} = 2\pi R_2^2 + \int_{R_2}^{R_D} 8\pi\rho \, d\rho \sin^2\delta, \quad \delta = \left(\phi_p^2 + \phi_q^2\right)^{1/2}.$$

$$d = N \int_0^\infty v f(v) dv \int_{R_3}^{R_D} 2\pi\rho \, d\rho \sin^2\phi_p.$$

$$A = \left(\frac{e F_0^2}{\hbar W_e} \left| \alpha_i - \alpha_f \right| \right)^{\frac{3}{4}},$$

$$F_0 = 2\pi \left(4/15\right)^{\frac{2}{3}} e N^{\frac{2}{3}}, \quad \alpha_i = 4 a_0^3 \sum_{i' \neq i} f_{ii'} \left(\frac{I_H}{\Delta E_{ii'}} \right)^2.$$

In the figure, we show Stark width for the copper resonance spectral line (3247.54 Å): dot line – electron width for 3-level model and solid line - electron width for multi-level model. We calculate the critical temperature T_0 (=361 kK) corresponding to the maximal value of the width. The width increases before T_0 then it decreases.



$$T_0 = \left(\frac{R^2_{jj'} \Delta E_{jj'}}{3 k_B} \right),$$

$$R^2_{jj'} = f_{jj'} \frac{\lambda_{jj'}(\text{Å})}{303.7}$$

λ (Å)	Transition	T_0 (kK)
5105.54	$4s^2\ ^2D[5/2] - 4p\ ^2P^o[3/2]$	292
5700.24	$4s^2\ ^2D[3/2] - 4p\ ^2P^o[3/2]$	370
5782.13	$4s^2\ ^2D[3/2] - 4p\ ^2P^o[1/2]$	301
3273.96	$4s\ ^2S[1/2] - 4p\ ^2P^o[1/2]$	398
3247.54	$4s\ ^2S[1/2] - 4p\ ^2P^o[3/2]$	361

DISCUSSION

An improved agreement is found between our results and the theoretical ones. The ratio (W_e/W_1) is about 78%, $(W_e/W_2)=$ 76%, $(W_e/W_4)=$ 51% and the agreement with Babina results W_3 reaches 95%.
$(d_e/d_1)=$ 84%, $(d_e/d_2)=$ 85% and $(d_e/d_3)=$ 42%.
$(A/A_1)=$ 105%, $(A/A_2)=$ 111% and $(A/A_3)=$ 90%.

For experimental results the agreement is acceptable:
W/W_K =60%, W/W_L =32%, W/W_F =26%, W/W_S =33% and $d/_L$ =20%.
We have a good agreement with Fleurier result d/d_F =151% .

CONCLUSION

This method of Stark width calculation can be widely used in getting more accurate results were extensive set of data are needed.

Thank you