Groupe De Recherche en Physique Atomique et Astrophysique, Tunisia

6th SCSLSA, Sremski Karlovci, Serbia June 11-15 2007

Quantum-mechanical Calculations of Ne VII Spectral Line Widths

Quantum-mechanical Calculations of Ne VII Spectral Line Widths

Haykel Elabidi[1], Nébil Ben Nessib[2] , Marguerite Cornille[3], Jacques Dubau[3,4] and Sylvie Sahal-Bréchot[5]

[1] Groupe de Recherche en Physique Atomique et Astrophysique, Faculté des Sciences de Bizerte, Tunisia
[2] Groupe de Recherche en Physique Atomique et Astrophysique, INSAT, B.P. 676, 1080, Tunis Cedex, Tunisia
[3]LUTH, UMR 8102 CNRS, Observatoire de Paris-Meudon, F-92195, Meudon Cedex, France
[4]LIXAM, UMR 8642 CNRS, Université Paris-sud, F-91405, Orsay Cedex, France
[5]LERMA, UMR 8112 CNRS, Observatoire de Paris-Meudon, F-92195, Meudon Cedex, France

Quantum-mechanical Calculations of Ne VII Spectral Line Widths

✓ Stellar and laboratory plasma diagnostic, atomic abundances, opacity calculations… have led to a need for knowledge about Stark broadening data.

- The semi-classical and semi-empirical calculations give a good accuracy.
- Quantum calculations underestimate the majority of the measured widths.

New accurate calculations become an important and an urgent task

Griem H R 1974 *Spectral line broadening by plasmas* (New York: New York Academic Press)
Sahal-Bréchot S 1969 *Astron. Astrophys.* **1** 91
Dimitrijević M S and Konjević N 1980 *J. Quant. Spectrosc. Radiat. Transfer* **24** 451
Griem H R 1968 *Phys. Rev.* **165** 258

Ralchenko Yu V, Griem H R, Bray I and Fursa D V 1999 *Phys. Rev.* A **59** 1890
Ralchenko Yu V, Griem H R, Bray I and Fursa D V 2001 *J. Quant. Spectrosc. Radiat. Transfer* **71** 591
Ralchenko Yu V, Griem H R and Bray I 2003 *J. Quant. Spectrosc. Radiat. Transfer* **81** 371

Quantum-mechanical Calculations of Ne VII Spectral Line Widths

✓ A quantum-mechanical expression for calculating electron-impact widths was obtained for intermediate couplingtaking into account fine structure effects of the emitter.

$$w = \pi \left(\frac{\hbar}{m}\right)^2 N_e \sum_{J_i^T J_f^T l l' K_i K_f K_{i'} K_{f'}} (-1)^{2J_i+K_i+K_{i'}+K_f+K_{f'}+2J_f^T+l+l'+1}$$
$$\times [K_i, K_f, K_{i'}, K_{f'}]^{\frac{1}{2}} \frac{[J_f^T, J_i^T]}{2} \left\{ \begin{array}{c} J_i K_i l \\ K_f J_f 1 \end{array} \right\} \left\{ \begin{array}{c} J_i K_{i'} l' \\ K_{f'} J_f 1 \end{array} \right\}$$
$$\times \left\{ \begin{array}{c} K_i J_i^T s \\ J_f^T K_f 1 \end{array} \right\} \left\{ \begin{array}{c} K_{i'} J_i^T s \\ J_f^T K_{f'} 1 \end{array} \right\} \int_0^\infty \frac{f(v)}{v} dv \left\{ \delta_{l'l} \delta_{K_{i'} K_i} \delta_{K_{f'} K_f} \right.$$
$$- \Re \left[S_F^{*IC}(\Delta_{f'} J_f l' K_{f'} s J_f^T; \Delta_f J_f l K_f s J_f^T) \right.$$
$$\left. \left. \times\ S_I^{IC}(\Delta_{i'} J_i l' K_{i'} s J_i^T; \Delta_i J_i l K_i s J_i^T) \right] \right\},$$

$$\vec{J}_i = \vec{L}_i + \vec{S}_i, \vec{K}_i = \vec{J}_i + \vec{l} \text{ and } \vec{J}_i^T = \vec{K}_i + \vec{s}$$

Neglecting elastic scattering with l≠l'

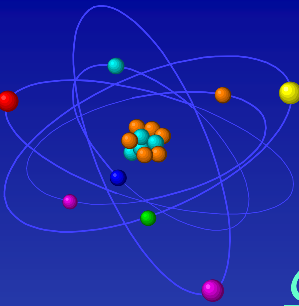
$$\vec{K}_i = \vec{K}_{i'} \text{ and } \vec{K}_f = \vec{K}_{f'}$$

$$W = 2N_e \left(\frac{\hbar}{m}\right)^2 \left(\frac{2m\pi}{k_B T}\right)^{\frac{1}{2}} \int_0^\infty \Gamma_w(E) \exp\left(-\frac{E}{k_B T_e}\right) d\left(\frac{E}{k_B T_e}\right)$$

$$\Gamma_w(E) = \sum_{J_i^T J_f^T l K_i K_f} \frac{[K_i, K_f, J_f^T, J_i^T]}{2} \left\{ \begin{array}{c} J_i K_i l \\ K_f J_f 1 \end{array} \right\}^2 \left\{ \begin{array}{c} K_i J_i^T s \\ J_f^T K_f 1 \end{array} \right\}^2$$
$$\times \left[1 - (\Re S_I^{IC} \Re S_F^{*IC} - \Im S_I^{IC} \Im S_F^{*IC})\right].$$

Elabidi H, Ben Nessib N and Sahal-Bréchot S 2004 *J. Phys. B.: At. Mol. Phys.* **37** 63

Elabidi H and Dubau J *unpublished results*



Groupe De Recherche en Physique Atomique et Astrophysique, Tunisia

6th SCSLSA, Sremski Karlovci, Serbia June 11-15 2007

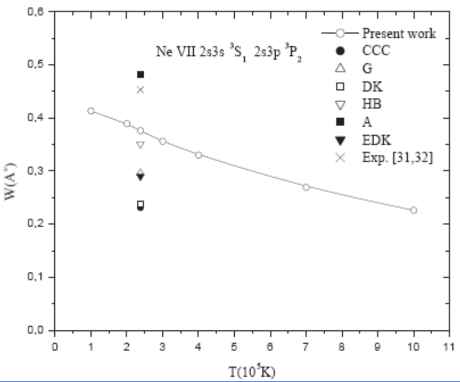
Quantum-mechanical Calculations of Ne VII Spectral Line Widths

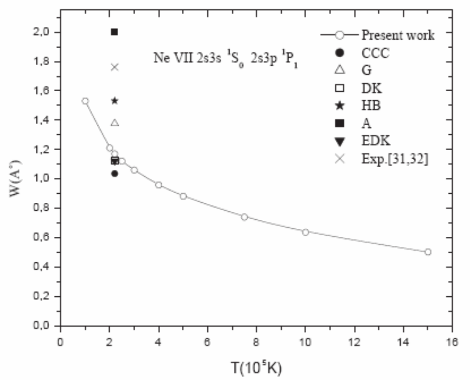
In this work, we have applied our quantum-mechanical calculations to the Ne VII singlet and triplet transitions.

This is ***the first time that we find a good agreement between quantum and experimental line widths*** of highly charged ions.

TABLE 1. Stark widths for Ne VII 2s3s–2s3p transitions ($N_e = 3\times10^{18} cm^{-3}$ for the triplet and $N_e = 3.5\times10^{18} cm^{-3}$ for the singlet transition). Present quantum calculations W and other theoretical results (CCC: quantum calculations [5], DSB: semi-classical calculations, G: simplified semi-classical approach [1], DK: modified semi-empirical formula [3] evaluated in [13], EDK: modified semi-empirical calculations [15], HB: quasi-classical Gaunt factor approximation [16, 17] and A: Alexiou 1995, 1997 [18, 19]; the number in brackets concerns Ref. [19]) are compared with experimental widths W_m [13, 14] ([14] is only for $^3S_1-^3P_2$).

Transition	T_e (10^5K)	W (Å)	$\frac{W_m}{W}$	$\frac{W_m}{W_{CCC}}$	$\frac{W_m}{W_{DSB}}$	$\frac{W_m}{W_G}$	$\frac{W_m}{W_{DK}}$	$\frac{W_m}{W_{EDK}}$	$\frac{W_m}{W_{HB}}$	$\frac{W_m}{W_A}$
$^3S_1-^3P_2$ 1981.97Å	2.380	0.378	**1.19**	1.96	1.60	1.53	1.91	1.55	1.29	0.94(0.82)
$^3S_1-^3P_1$ 1992.06Å	2.380	0.383	**1.17**	1.58						
$^3S_1-^3P_0$ 1997.35Å	2.38	0.391	**1.15**	1.58						
$^1S_0-^1P_1$ 3643.60Å	2.205	1.17	**1.50**	1.70	1.48	1.28	1.57	1.57	1.15	0.88(0.77)





22% is the difference between our quantum-mechanical widths and the measured ones.

This difference is about 83% for the quantum-mechanical widths of Ralchenko *et al.* (Convergent Close Coupling).

THANK YOU FOR YOUR ATTENTION