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LINE PROFILE PARAMETERS FOR Li-LIKE IONS

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Résumé - A l'aide du formalisme semi-classique-perturbation dans l'approximation des impacts pour l'élargissement Stark des raies spectrales, nous avons calculé les largeurs et les déplacements d'un certain nombre de raies de la séquence isoélectronique du lithium. Les résultats obtenus sont comparés aux calculs quantiques et aux résultats expérimentaux disponibles.

Abstract - Using a semiclassical perturbational approach in the impact approximation, Stark broadening parameters along the lithium isoelectronic sequence have been calculated. The otained results have been compared with quantum mechanical calculations and with available experimental results.

Several papers have been published recently dealing with the investigation of Stark broadening parameters along isoelectronic sequences [1,2], for astrophysical purposes (opacities) and also in order to enable interpolation of measured and calculated Stark widths. Within the frame of the semi-classical perturbation impact theory [3,4] we have performed calculations of Stark widths and shifts for ionic spectral lines along the lithium isoelectronic sequence. Calculations have been performed using line strengths from Ref. 1. Resonances effects, which were not included in [3,4,5] have been added as in [6] by means of the semi-classical limit of the Gailitis formula. That effect is important.

As an example of obtained results, Stark broadening parameters for C IV, N V and O VI $2s$-$2p$ lines are given in Table 1 as a function of temperature. Thermally averaged collision strengths for the C IV $2s$-$2p$ line profile are compared in Table 2 with quantum mechanical (close coupling) calculations (1). One can see that (especially in the case of the shift) results agree slightly better for higher temperatures. The different experimental and theoretical results have been compared with our calculations for $2s$-$2p$ C IV multiplet in Fig. 1 and for $3s$-$3p$ C IV line (λ=5801.3 Å) in Table 3.

One can see that the agreement between semi-classical and quantum close coupling calculations which was correct but not perfect for some singly charged ions ([10], p.93) is there not very good : yet it is better for higher temperatures and in the case of the $3s$-$3p$ transitions. This can be explained by the fact that the distances between the perturbing levels and the initial and final levels are larger for multicharged ions than in the case of singly charged ions. Therefore elastic collisions are more important than inelastic ones, and elastic collisions are due to close interactions which are not well treated by the perturbation theory. At high temperatures or for excited levels inelastic collisions become important ; they are due to more distant interactions and the perturbation theory may give correct results. It can be noticed that quantum close coupling calculations become difficult to perform for high levels, owing to the number of involved channels. Therefore we can conclude that the two methods are complementary : at low temperatures and for lines between low levels quantum close coupling calculations are necessary if one needs a good accuracy ; the semi-classical approximation cannot give better than a factor of two. At high temperatures or for lines originating from high levels the semi-classical approximation can give correct results when close coupling calculations become unoperative.

Table 1

Stark broadening parameters : full widths at half intensity (FWHM) (w) and shifts (d) for C IV, N V and 0 VI $2s$-$2p$ lines. The electron density is equal to 10^{17} cm^{-3}.

Transition	T(K)	w(Å)	d(Å)
C IV	45000	0.725-2	-0.270-3
$2s^2$S-$2p^2$P^o	90000	0.505-2	-0.259-3
	180000	0.364-2	0.299-3
	360000	0.273-2	-0.300-3
N V	80000	0.297-2	-0.783-4
$2s^2$S-$2p^2$P^o	160000	0.210-2	-0.754-4
	320000	0.152-2	-0.915-4
	640000	0.114-2	-0.879-4
O VI	125000	0.134-2	-0.340-4
$2s^2$S-$2p^2$P^o	250000	0.959-3	-0.326-4
	500000	0.697-3	-0.392-4
	1000000	0.524-3	-0.357-4

Table 2

Thermally-averaged collision strengths for C IV line profiles. (t=$10^{-4}T/Z^2$; Z=ionization stage)

Transition	t	Our present results		Seaton (1988)	
C IV $2s^2S$-$2p^2P^o$	0.5	14.2	-1.04 i	8.1	-2.9 i
	1.0	14.8	-1.41 i	8.1	-3.1 i
	2.0	14.1	-2.31 i	8.4	-3.1 i
	4.0	14.9	-3.28 i	9.3	-3.2 i

Table 3

Experimental (w_{exp}) and calculated (w_{th}) Stark widths (FWHM) of the transition C IV, $3s^2S_{1/2}$-$3p^2P^o_{3/2}$ (λ=5801.3Å) at an electron density of 1.8 10^{18} cm^{-3}.

$w$exp (Å)	wth (Å)	Reference
10.0		[2]
	7.38	present results
	7.98	[10]
	6.01	[7]
	5.45	[11]
	6.09	[12]
	10.80	[13]
	5.32	[1]

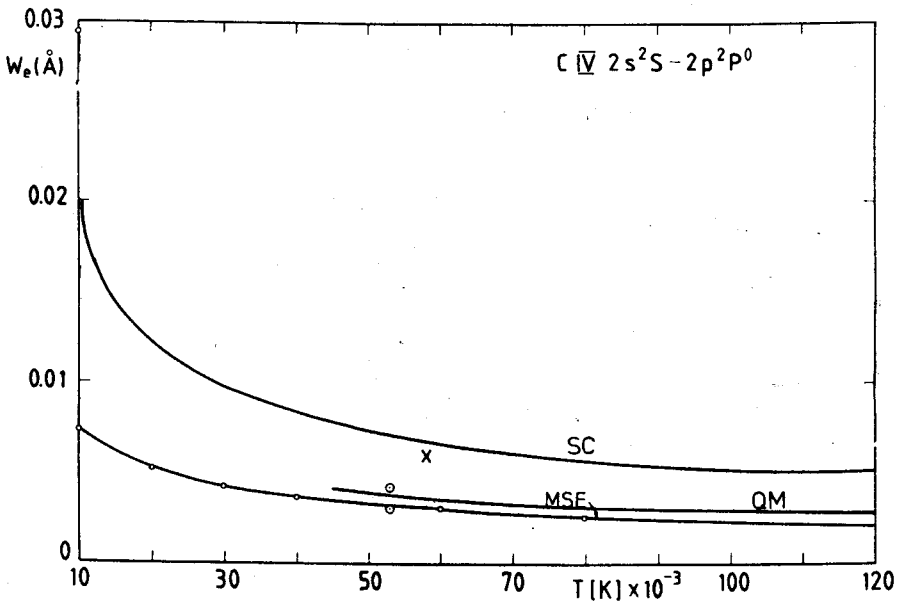

Figure 1

Theoretical and experimental Stark widths (FWHM) for C IV $2s^2S$-$2p^2P^o$ multiplet as function of temperature : SC : our semiclassical calculations ; QM: Seaton (1988) [1] ; MSE : modified semiclassical [7] ; Experimental data : X : Bogen (1972) [8] ; ⊙ : El-Farra and Hughes (1983) [9].

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