Effective solid angle correction factors for long-lived Auger states populated in low-Z ion collisions with gas targets

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Abstract

Effective solid angle correction factors for two high resolution electrostatic spectrometers - a hemispherical and a tandem parallel plate - are determined using SIMION Monte Carlo simulations. Results for the hemispherical spectrograph are compared to experimental correction factors directly determined from Auger spectra produced by 1s ionization in collisions of 17.5 MeV O^{4+} and 6.6 MeV C^{2+} ($1s^22s^2\ ^1S$, $1s^22s2p\ ^3P$) mixed state Be-like ion beams with H_2 targets. Satisfactory agreement between simulation and measurement is found.

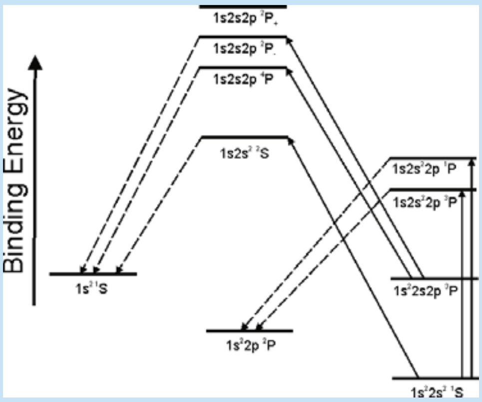

Fig. 1. Schematic energy level diagram showing the production and de-excitation of the 1s2s2l' and $1s2s^22p$ states formed from the $1s^22s^2\ ^1S$ ground and $1s^22s2p\ ^3P$ metastable states, respectively.

Table I. Experimental and SIMION simulations results for the effective angle correction factors G_τ for both PPA and HDA spectrometers. Measurements of the metastable fractions of the mixed ionic beams f_m are also included. Experimental results from Lee *et al* [5] have been used for the PPA entries. We assume that for K ionization $\sigma_K(1s^22s^2) = \sigma_K(1s^22s2p\ ^3P)$ resulting in the ratios $\sigma(^2S):\sigma(^4P):\sigma(^2P_-)$ being 3:2:1.

Spectro meter	State	E_p (MeV)	$f_m=\left[1+\frac{3}{8}\frac{Z(^2S)}{Z(^2P_-)}\right]^{-1}$	$G_\tau=\frac{1}{2}\frac{Z(^4P)}{Z(^2P_-)}$	G_τ (SIMION)	G_τ (PPA formula)
PPA	C^{2+}	7.0	0.66 ± 0.05	1.5 ± 0.3	1.08ᵃ - 1.11ᵇ	0.83ᵃ - 0.80ᵇ
HDA	C^{2+}	6.6	0.70 ± 0.05	2.3 ± 0.3	1.92ᵃ - 2.41ᵇ	
PPA	O^{4+}	17.5	0.59 ± 0.05	1.65 ± 0.3	1.21ᵃ - 1.29ᵇ	0.94ᵃ - 0.97ᵇ
HDA	O^{4+} (F=4)	17.5	0.65 ± 0.05	1.9 ± 0.3	2.47ᵃ - 2.80ᵇ	
HDA	O^{4+} (F=8)	17.5	0.67 ± 0.05	1.6 ± 0.3	2.08ᵃ - 2.33ᵇ	

ᵃ ^4P_J Lifetimes from Benis et al. [6] ᵇ ^4P_J Lifetimes from Chen et al. [7]

References

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Hemispherical Deflector Analyser | Tandem Parallel Plate Analyser

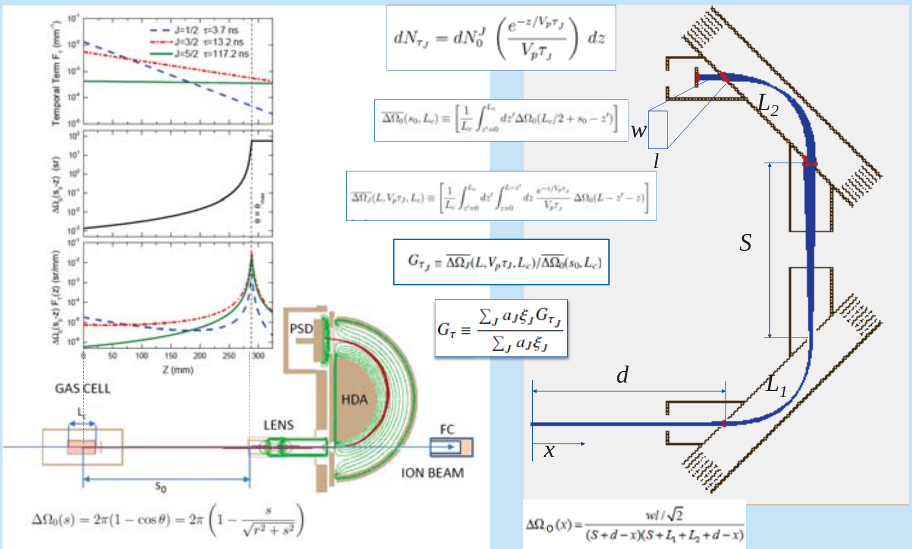

Fig. 2. z-dependence along the ion trajectory for the probability decay density (top), the point source solid angle $\Delta\Omega_o(z)$ (middle) and their product (bottom) as calculated for the 1s2s2p ^4P_J states in the case of a 12.0 MeV C^{4+} ionic beam. At the very bottom drawn to scale is the experimental geometry showing the gas cell, the lens and the HDA.

Fig. 3. Diagram of the tandem parallel-plate spectrometer indicating the geometrical parameters used to analytically determine the detector solid angle.

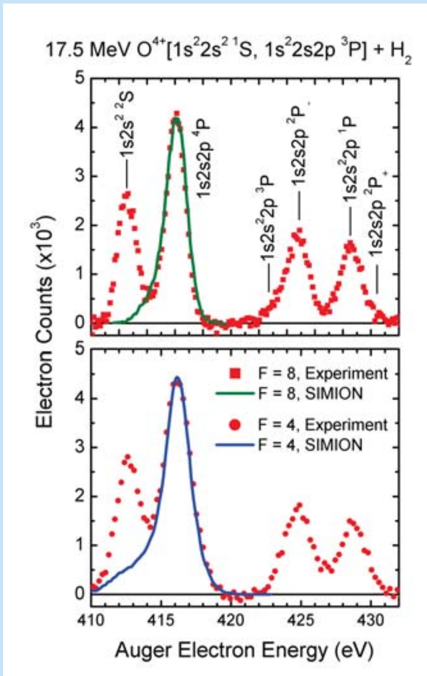

Fig. 4. Experimental data (points) obtained with the HDA spectrograph for: [Top] F=8 and [Bottom] F=4 deceleration conditions. (Line) SIMION simulations for the ^4P state are seen to well reproduce the peak including its asymmetry.

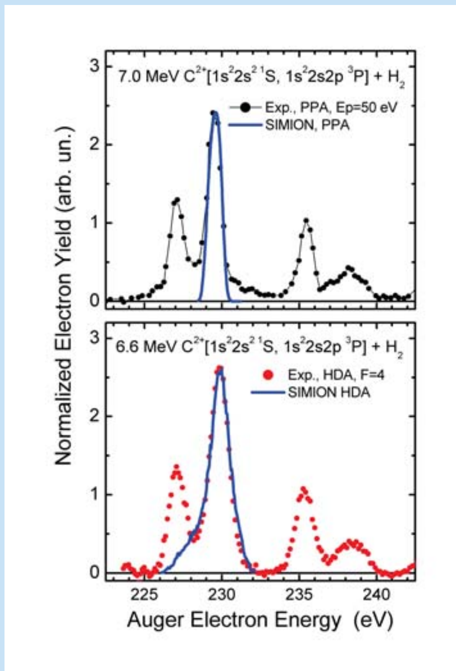

Fig. 5. Experimental data (points) obtained with: [Top] the tandem PPA spectrometer [5] and [Bottom] the HDA spectrograph [4], for similar experimental conditions. Note that the ^4P peak differs in the two spectra due to the different effective solid angle of the two spectrometers in good agreement with SIMION simulations (line).

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