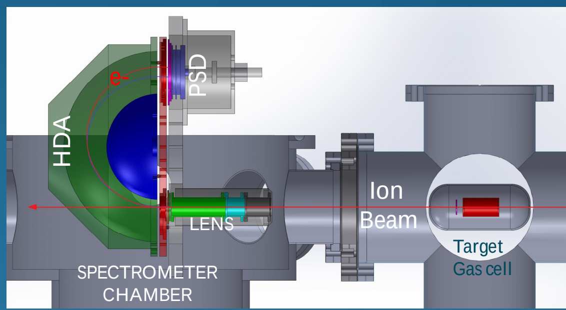
MONTE CARLO CALCULATIONS OF THE DETECTION SOLID ANGLE OF ELECTRONS EMITTED FROM SLOWLY DECAYING PROJECTILE ION AUGER STATES

S. Doukas[1], N. Angelinos[2], A. Kanellakopoulos[3], I. Madesis[2,4], A. Dimitriou[2,4], E.P. Benis[5], and T.J.M. Zouros[2,4]

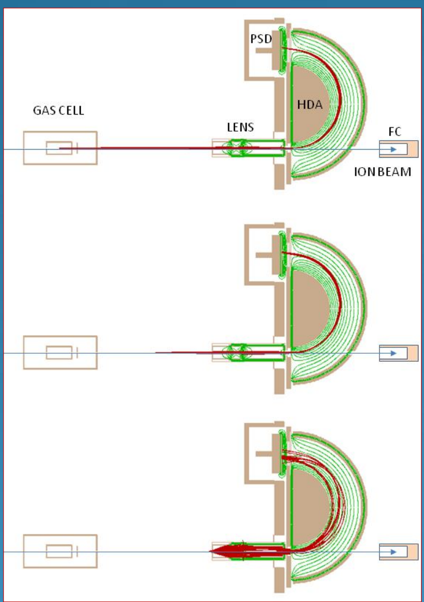
[1]Department of Material Science and Engineering, University of Ioannina, GR 45110 Ioannina, Greece.
[2]Department of Physics, University of Crete, P.O Box 2208, GR 71003 Heraklion, Greece.
[3]Department of Physics, University of Athens, Zografou Campus, GR 15784 Athens, Greece.
[4]Tandem Accelerator Laboratory, INP, NCSR Demokritos, GR 15310 Ag Paraskevi, Greece.
[5]Department of Physics, University of Ioannina, GR 45110 Ioannina, Greece.

Abstract

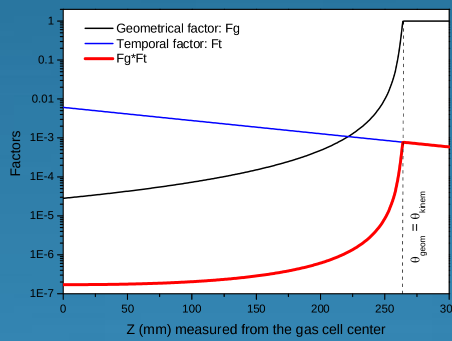
The long life times of the 1s2s2p ^4P metastable states (in the 10^{-6}-10^{-9} s range) of ions formed in energetic ion-atom collisions permits these to Auger decay well after their excitation in the target making it hard to determine their effective detection solid angle. Our goal is to investigate the formation mechanisms of these states through the study of their Auger decay and the determination of this solid angle is therefore of vital importance. Here, we have used the SIMION 8.1 package to treat the problem in an effective Monte Carlo type calculation. The experimental setup geometry consisting of a hemispherical deflector analyzer (HDA) with injection lens and position sensitive detector (PSD) was accurately simulated and the electrostatic potentials were determined. Random electron distributions in energy and emission angles were created simulating the metastable Auger electron decay along the path of the projectile ions, while the trajectories of the emitted electrons were traced through the HDA and counted at the PSD. A systematic study based on the above simulation procedure allowed for the accurate determination of the relevant solid angle.



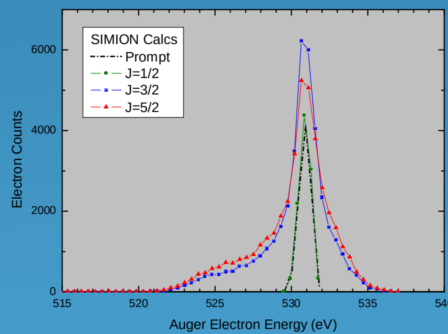
Double Differential pumped target gas cell, along with Paracentric Hemispherical Deflector Analyser (HDA) with 4-element input lens and 2-D Position Sensitive Detector (PSD). Each color denotes a different voltage.



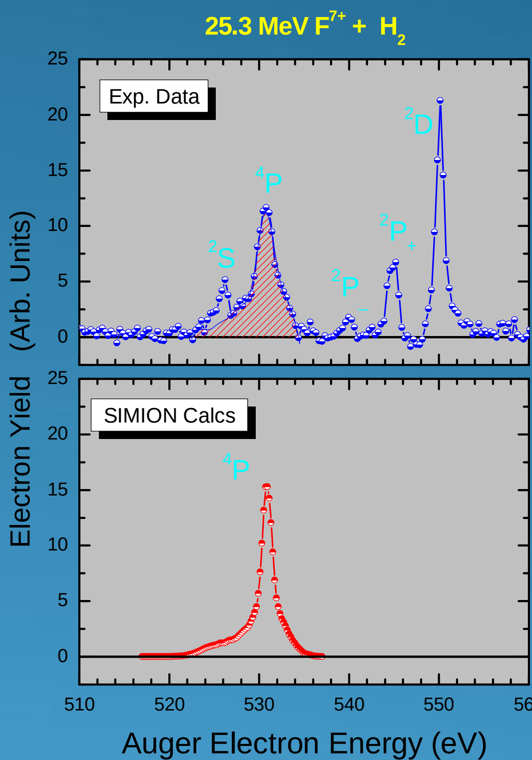
A two-dimensional view of the experimental setup. The ionic projectile beam interacts with the atoms at the gas cell, populating excited ionic states whose Auger decay occurs along the ion's path all along to and through the spectrometer. Electrons emitted from the excited ions are focused by the lens at the entry of the HDA to be detected at the PSD at the exit of the HDA. The ions continue through the spectrometer and are collected in a Faraday cup (FC). Three different cases of the ionic states Auger de-excitation are illustrated: [*Top*] At the center of the gas cell. [*Middle*] At the mid-distance between the center of the gas cell and the lens entry. [*Bottom*] At the neighborhood of lens entry where the solid angle effects become considerable.



Normalized contributions of the geometrical and temporal factors Fg and Ft (case of 25.3 MeV F^{7+} ion beam), respectively, to the effective solid subtended by the spectrograph. Notice that Fg reaches its maximum value at $\theta_{geom} = \theta_{kinem}$ due to kinematic considerations.



Contributions of the three J-components of the metastable ^4P_J state yield (case of 25.3 MeV F^{7+} ion beam). A prompt state is also shown in dash-dotted line for comparison.



[Top] Experimental data depicting the metastable ^4P state having different shape as opposed to the other states due to the effective solid angle effect. [Bottom] Reproduction of the effect in SIMION calculations.

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* E-mail: mbenis@uoi.gr

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