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

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Synopsis: 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 are compared to experimental correction factors directly determined from Auger spectra produced by 1s ionization in collisions of 6.6 MeV C^{2+} ($1s^22s^2\ ^1S$, $1s^22s2p\ ^3P$) mixed state ion beams with H_2 targets. Excellent agreement between simulation and measurement is found.

A persistent problem in high resolution Auger projectile spectroscopy is the determination of the contribution from metastable states due to their inherent long lifetime. As an example we refer to the accurate evaluation of the $1s2s2p\ ^4P/^2P$ ratio of K-Auger cross sections, whose observed non-statistical production by electron capture into He-like ions, is a field of differing interpretations, awaiting further investigation [1-3].

Here, we present SIMION Monte Carlo type simulations of the response function and detection solid angle of two analyzers: A single stage hemispherical spectrograph with injection lens and position sensitive detector [4], and a two-stage parallel plate analyzer [5], both used extensively in zero-degree Auger projectile electron spectroscopy. At 0^0 observation the spectrometers lie in the direct path of the ion with the excited metastable projectile states (lifetimes ~1-10^3 ns) Auger decaying all along its path towards the spectrometer (and even inside the spectrometer). Thus, the overall detection solid angle of the electron emission varies due to the moving source position, resulting in a considerable correction to the measured electron yield [4]. These effects, particular for Auger emission from fast moving projectile ions, are also included in our simulations.

Our SIMION model calculations are also checked experimentally utilizing collisions of Be-like carbon beams produced in mixed $(1s^22s^2\ ^1S,\ 1s^22s2p\ ^3P)$ states which also give rise to $1s2s2p\ ^4P$ states, but free of cascade repopulation effects since they are formed by needle ionization of the *1s* electron of the $1s^22s2p\ ^3P$ state [5]. A typical spectrum obtained recently with our hemispherical spectrograph is shown in Fig. 1. The necessary determination of the metastable beam fraction is obtained from the spectrum of Fig. 1 utilizing the prompt $1s2s^2\ ^2S$ and $1s(2s2p^3P)\ ^2P_-$ lines whose ratio is *known* [5]. The effective solid angle correction factor for the hemispherical spectrograph is then obtained via the determination of the also *known* 1s2s2p $^4P/^2P_-$ ratio of K-Auger electron yields [5]. Our simulations are in excellent agreement with experimental results, thus providing an empirical consistency check for future determinations of these correction factors in other spectrographs and geometries.

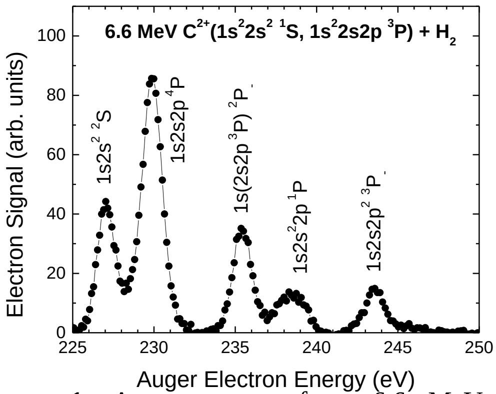

Figure 1. Auger spectra from 6.6 MeV C^{2+} collisions with H_2 targets. C^{2+} beam is delivered in the mixed $1s^22s^2\ ^1S$ ground and $1s^22s2p\ ^3P$ metastable states. The dominant Auger lines are depicted in the figure.

References

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