

Decay of a 2p inner-shell hole in an Ar^+ ion

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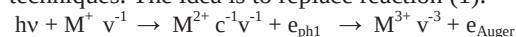
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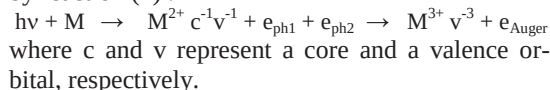
Synopsis: Direct measurements of the photoelectrons or Auger electrons associated with inner shell ionization of positively charged ions are extremely difficult and rarely realized. We use here an alternative method to simulate such measurements, based on core-valence double photoionization of the neutral species. As an example, we obtain the spectroscopy, lifetimes and Auger decays of the states arising from 2p inner shell ionization of an Ar^+ ion. Observations compare well with theoretical predictions obtained with multiconfigurational Dirac-Fock formalism.

The experiment was performed at the U56/2 PGM1 beam line of the BESSY-II synchrotron and uses the HERMES magnetic bottle time of flight spectrometer [1] developed at LCP-MR. Its characteristics is to detect very efficiently (>50%) all electrons emitted in multi-ionization events and to measure their energies with good resolution, making it a perfect tool for multi coincidence studies.

The method to obtain photoelectron and Auger electron spectroscopy of positively charged ions, is based on single photon multi-ionisation of the corresponding neutral species and on coincidence techniques. The idea is to replace reaction (1):



by reaction (2):



The information on the spectroscopy of the $M^{2+} c^{-1} v^{-1}$ species that would result from a core ionization of the $M^+ v^{-1}$ ion is retrieved from the coincidence spectra between the two photoelectrons emitted in reaction (2). Coincidences enable us also to extract the Auger spectrum resulting from the decay of each M^{2+} intermediate state. This is illustrated in Figure 1 which shows as an example the simulation of the 2p inner shell ionization of Ar^+ ions. All Auger spectra display a maximum at ~190eV whatever the initial v^{-1} valence hole. Calculations show that this is because the v^{-1} hole remains spectator during the Auger decay. Another important result is that the lifetime of $\text{Ar}^{2+} 2p^{-1}3p^{-1}$ states depends on the coupling between the angular momentum of the two holes and can vary by an order of magnitude. [2]

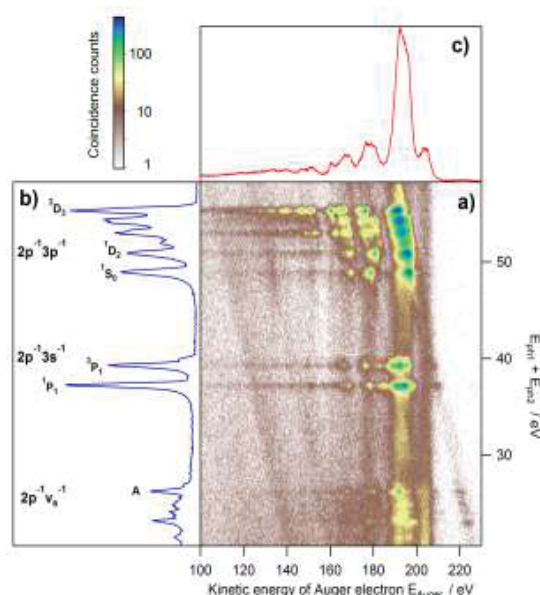


Figure 1. Simulation of the 2p inner-shell ionization of the Ar^+ ion. a) shows the two-dimensional coincidence map between the 3 electrons emitted in reaction (2): the two photoelectrons, with their energy sum plotted in b) and the Auger electron, plotted in c). Peaks in b) reveal the $\text{Ar}^{2+} 2p^{-1}v^{-1}$ states as if created upon inner-shell ionization of $\text{Ar}^+ v^{-1}$ ions. The Auger spectra associated with the decay of each state is given by the corresponding coincidence line in a).

References

- [1] F Penent *et al* 2011 *Phys. Rev. Lett.* **106** 103002 and references included
- [2] S Huttula *et al* 2013 *Phys. Rev. Lett.* **110** 113002

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