Ar 2s Auger spectrum observed in coincidence with the 2s photoelectron in the sub-natural linewidth regime

Yasumasa Hikosaka[1], Tomohiro Aoto[1], Richard Hall[2], Francis Penent[2], Pascal Lablanquie[3], Matjas Žitnik[4], Kenji Ito[1]

[1] IMSS-KEK, Tsukuba, Ibaraki 305-0801, Japan
[2] DIAM, Université P. & M. Curie, 75252 Paris Cedex 05, France
[3] LURE, Centre Universitaire Paris-Sud, Bâtiment 209D, BP 34, 91898 Orsay, France
[4] J. Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia

Introduction

The 2s hole in Argon is extremely short lived, due to its fast decay involving the 2p shell (Coster-Kronig decay). As a consequence, the resulting Auger spectrum is broadened by 2.25 eV. This prevents the observation of the detailed spectroscopy of the final Ar^{++} states produced, as well as their relative intensities. Previous measurements of the Ar 2s Auger spectrum produced by electron impact [1] or more recently by photon impact [2] were faced with this 2.25 eV limit and hardly resolved the 2 groups of states corresponding to the Ar^{++} $2p^{-1}3p^{-1}$ states and the Ar^{++} $2p^{-1}3s^{-1}$ states, respectively.

Our approach to overcome this limit uses photoionization with synchrotron radiation and consists in measuring the Ar 2s Auger spectrum in coincidence with the associated 2s photoelectron. Energy conservation shows then that the final state is defined with a precision that depends only on the combined resolutions of the photons and of both electron detectors. The limitation associated with the hole lifetime is thus removed, as was shown by revealing, for the first time, the structure of the Ar^{++} $2p^{-1}3p^{-1}$ states [3]. This situation is referred to as the "sub-natural linewidth regime" [4].

The present experiment

Our experiment [5] uses here a high luminosity threshold electron spectrometer, dedicated to the detection of the photoelectron, and a hemispherical electrostatic analyzer, equipped with a two dimension position sensitive detector for the detection of the Auger electron. These measurements on Argon were made on the BL16B beam line at the Photon Factory.

The complete coincident Auger spectrum reveals the spectroscopy of the Ar^{++} dication with a hole located in the 2p innershell. The Ar^{++} $2p^{-1}3p^{-1}$ states were observed with better statistics and resolution than previously [3], as shown in the figure. Population of the Ar^{++} $2p^{-1}3p^{-1}$ (^1S) is now demonstrated by the peak at 40.5 eV that was obscured previously by the large error bars.

Furthermore, we located the Ar^{++} $2p^{-1}3s^{-1}$ states and revealed satellite lines, predicted to be of Ar^{++} $2p^{-1}3p^{-2}nl$ configurations [6]. Special care was taken to obtain relative intensities of the different Auger transitions. Work is now in progress to accomplish an accurate theoretical description of the observed processes.

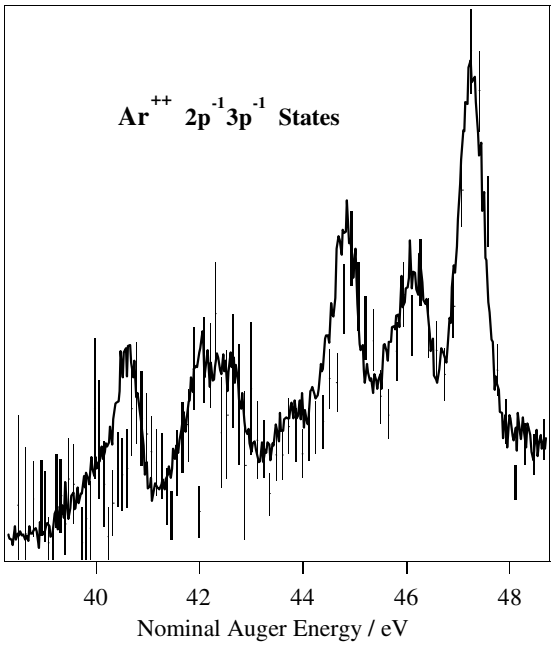

Figure: Ar $L_1L_{2,3}M_{2,3}$ Auger lines observed in coincidence with the 2s photoelectron, revealing the Ar^{++} $2p^{-1}3p^{-1}$ final states. Solid line gives the present measurement, error bars are those from reference [3].

References

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* Hikosaka@post.kek.jp