Multiple Ionization of Argon following Core-Level Excitation

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INTRODUCTION

In the present work we are interested in near threshold photoionization experiments involving post-collision interaction (PCI)[1-3] and pre-edge inner shell ionization effects related to the Auger decay of a vacancy of a 1s electron in argon.[4,5]

EXPERIMENTAL

Measurements of the various photoion spectra produced by the Auger decay of an argon $1s^{-1}$ core-hole were performed on beamline 9.3.1 at Lawrence Berkeley National Laboratory's Advanced Light Source. The photon Flux provided was typically 5×10^{10} photons/sec with a resolution near 0.5 eV at 3500 eV. The measurements required three different experimental endstations. The first, shown in Fig. 1, a magnetic mass analyzer was used during multi-bunch operation to identify the various degrees of ionization produced with photon energy scans covering the range 3190 to 3230 eV. A current gathered from a thin aluminum window was used to normalize each spectra for the changing photon flux. Gas pressure was monitored with a 10 torr pressure manometer. The second experimental endstation required was an ion Time-of-Flight (TOF) mass spectrometer. This instrument was used during two-bunch operations to determine the branching ratios between the various charge states, thus allowing us to normalize one photoion spectrum gathered with the magnetic mass analyzer to another. The third endstation used was a gas cell separated from the beamline by a Kapton window. It provided the total ion yield spectrum, which serves as a check to the other measurements since it should be linearly related to the sum of all the various normalized photoion spectra.

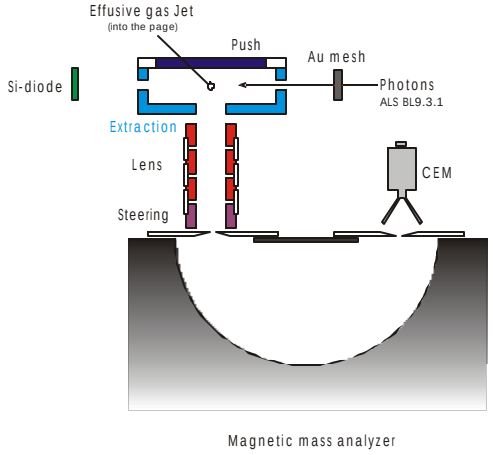

Fig.1 Schematic drawing of the magnetic mass analyzer experimental endstation

SUMMARY OF RESULTS

The argon photoion yields for Ar^{+} through Ar^{7+} are presented in Fig. 2. The primary resonance for all spectra, located at 3203.5 eV, is due to excitation of a 1s electron to the 4p shell, noted as [1s]4p. The broad peak located just above this resonance is due to an overlap of all the remaining [1s]np transitions. Just above the ionization limit (~3206eV) PCI begins to change the shapes of the various ion yields. In addition the most likely charge state is Ar^{4+}. This can be seen in Fig. 3, a plot of the average ionic charge versus photon energy. These results compare favorably with the previous results of Morgan *et al*.[5], although our maximum value is 3.4 whereas their maximum is near 3.8. Post-Collision interaction is most evident in our results when comparing Ar^{+} and Ar^{2+}, and again when comparing $Ar^{3+}$and Ar^{4+}.

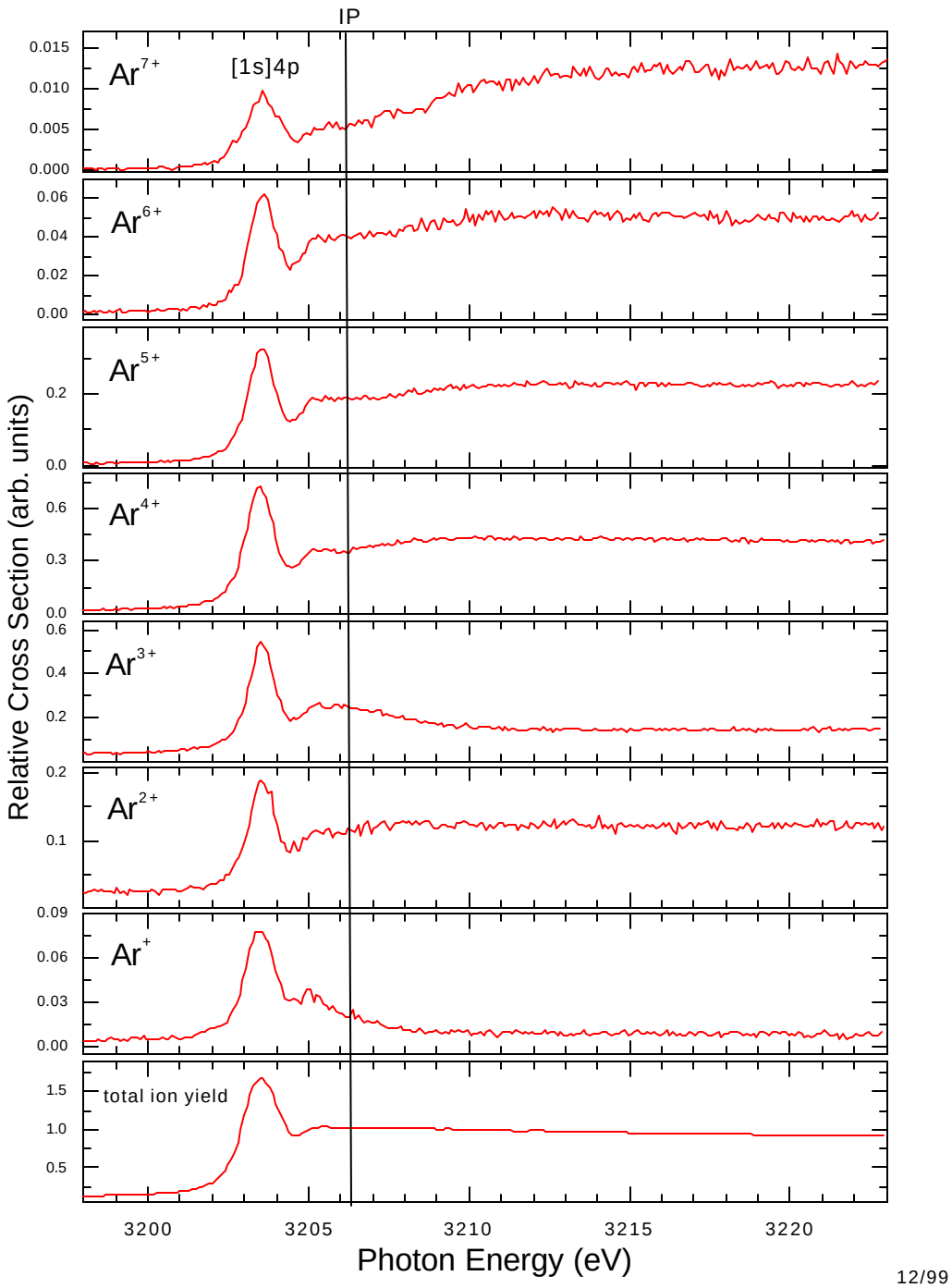

Fig. 2 Photoion yields of Ar^{+} through Ar^{7+} and the total ion yield all of which are produced by the decay of an 1s hole in argon. Energy calibration performed using the [1s]4p transition at 3203.5 eV[5].

Briefly, PCI is the recapture of a slow-moving photoelectron due to the change in potential caused when the decay of the inner-shell vacancy emits a fast Auger electron. In the case of Ar^{4+}/Ar^{3+}, there is a high

probability of recapture of the emitted photoelectron which causes an increase in the Ar^{3+} yield for the first few electron volts above threshold. This is observed as the exponential type decay just above threshold in the Ar^{3+} yield; in addition, there is a corresponding decrease in the Ar^{4+} yield at threshold with a gradual increase with increasing photon energy. This also occurs between Ar^{2+} and Ar^{+} case but is slightly less visible due to the lower signal rate.

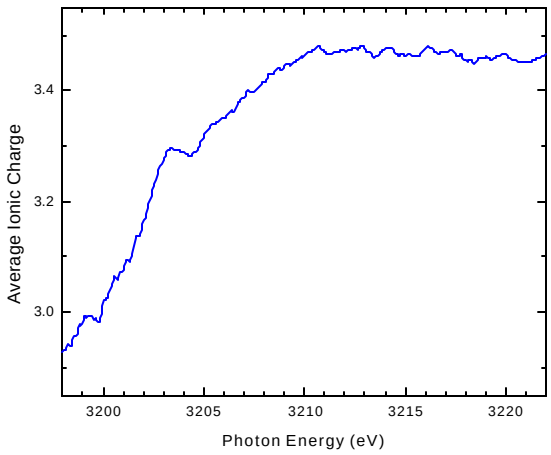

Fig. 3 Average ionic charge verses photon energy near the Ar K-edge.

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