

Stepwise contraction of the nf Rydberg shells in the $3d$ photoionization of multiply-charged xenon ions

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Synopsis Photoionization of Xe^{3+} , Xe^{4+} and Xe^{5+} ions was measured in the energy range 670–750 eV, including the $3d$ ionization threshold. The cross sections exhibit a progressively larger number of sharp resonances as the ion charge state is increased. This clearly visualizes the re-ordering of the ϵf continuum into a regular series of (bound) Rydberg orbitals as the ionic core becomes more attractive.

Recently, first low-resolution results for $3d$ multiple photoionization of Xe^{q+} ($1 \leq q \leq 5$) from the photon-ion spectrometer PIPE at the Hamburg PETRA III synchrotron light source have been reported [1]. Here, new high-resolution measurements with an experimental energy spread of 160 meV are presented for $3 \leq q \leq 5$ [2] (Fig. 1). Pronounced resonance structures are observed for all ions but with an increasing number of resonances as the charge state of the ions is increased. In contrast to the usually rather complex cross sections for outer shell ionization of atoms and ions, the present inner-shell ionization cross sections can be interpreted straight-forwardly. The strongest resonances are associated with the photoexcitation of a $3d$ electron to an atomic nf subshell ($n = 4, 5, 6, \dots$) and the subsequent multiple autoionization of the associated hole states. The $3d_{3/2}^{-1} - 3d_{5/2}^{-1}$ fine structure splitting (~ 13 eV) of the $3d$ hole leads to two distinct Rydberg series of resonances in each spectrum. For Xe^{3+} , for example, resonances with principal quantum numbers n from 4 to 7 can be clearly discerned. For Xe^{5+} the series of nf resonances could be observed up to $n = 9$. This progression of resonance structure with increasing charge state clearly visualizes the re-ordering of the ϵf continuum into a regular series of (bound) Rydberg orbitals as the ionic core becomes more attractive. The energies and strengths of the resonances are extracted from the experimental data and are further analyzed by relativistic atomic-structure calculations.

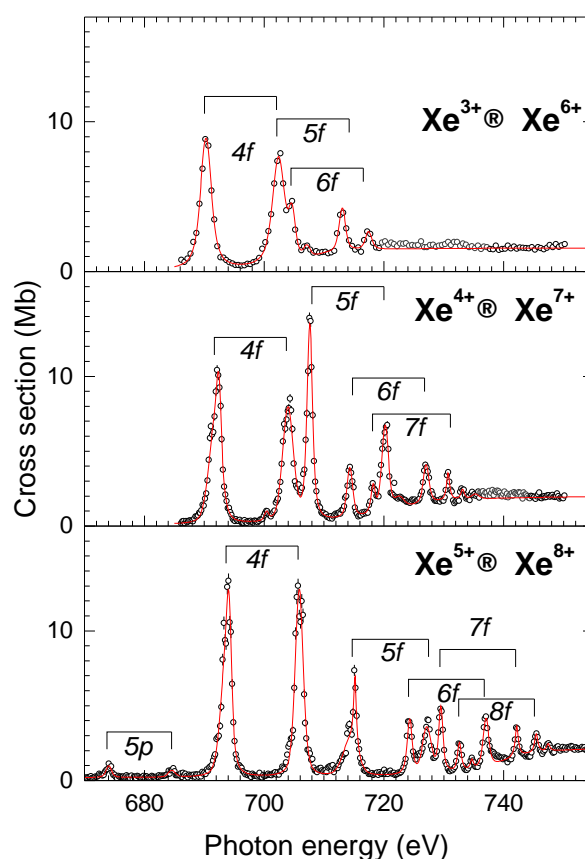


Figure 1. Measured (symbols) and fitted (full lines) absolute cross sections for triple ionization of Xe^{3+} , Xe^{4+} , and Xe^{5+} ions. Resonances are labeled by the $n\ell$ subshell to where the $3d$ electron is excited.

References

- [1] S. Schippers *et al.* 2014 *J. Phys. B* **47** 115602
- [2] S. Schippers *et al.* 2015 *J. Phys. B* in print; [arXiv:1412.3592](https://arxiv.org/abs/1412.3592)

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