Attosecond time delays in the valence photoionization of xenon and iodine at energies degenerate with core emissions

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Synopsis We perform time-dependent local density functional calculations of the quantum phase and Wigner-Smith time delays in the valence photoionization of Xe versus I atoms at higher energies where coupling with the core emission becomes important. Results for the 5*s* emission are presented.

Study of photoemission dynamics in real time using coherent pump-probe experiments is a key for exploring electron correlations in matter. Such experiments may involve the conventional streaking or the standard reconstruction of attosecond beating by interference of two-photon transitions (RABITT) measurements. Since the additional delay introduced by the probe pulse from the Coulomb-laser coupling can be estimated independently and subtracted from the measured result, the RABITT approach is consistent with the Wigner-Smith (WS) route to determine emission time that involves energy differential of the photoamplitude phase [1].

We compute these quantum phases and resulting WS delays in the photoionization of valence electrons of Xe and I atoms, using a scheme of time-dependent local density approximation (TDLDA) [2]. Analysis of the results with the goal to temporally access details of electron correlations has been carried out.

To identify two spectral features in the valence emission as induced due to its dynamical correlation with the degenerate core (4*d*) channel, we plot the 5*s* cross sections of Xe and I in the top panel of Figure 1. Note these features in each of the curves as (i) a strong shape resonance at lower energies and (ii) a Cooper minimum (CM) at higher energies.

The bottom panel shows the 5*s* time delays for the atoms in the same energy range. Strong negative delays near the resonance indicate accelerated emissions of the electron for both Xe and I. This corroborates to the general expectation of a collective-type resonance environment in which electrons feel transient repulsion as the emission process becomes favored [3]. In contrast, an opposite temporal trend is displayed near the CM region where the delays appear positive. This slower emergence near CM dovetails with the time-behavior earlier seen in the Ar emission near a spectral minimum [2]. Also note that for Xe our result closely agrees with the streaking measurement for the delay of 4*d* relative to 5*s* [4].

The work presents first results for an open-shell atom like I, although modeled in a spherical frame. Robust similarities between Xe and I, we hope, will encourage attosecond measurements on these atoms.

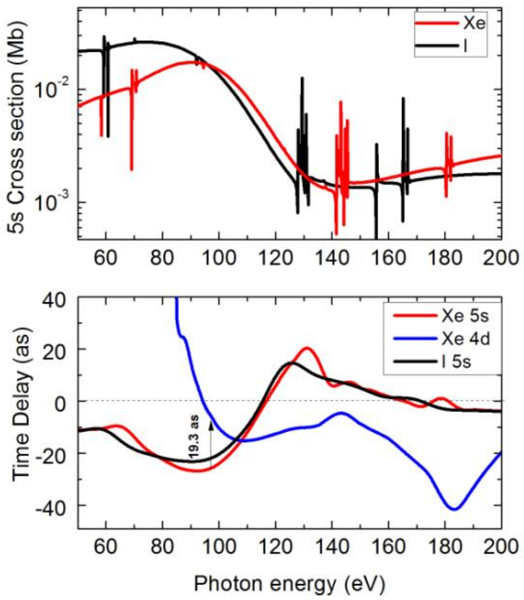

Figure 1. Xe and I 5*s* cross sections (top). WS time delays for Xe and I 5*s*, and Xe 4*d* (bottom). The arrow indicates the measurement from [4].

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References

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