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Sequential multiphoton multiple ionization of Ar and Xe by X-ray free electron laser pulses at SACLA

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Synopsis We have investigated multiphoton multiple ionization of Ar and Xe atoms irradiated by intense X-ray pulses using the new X-ray free electron laser facility SACLA. The experimental results are compared with theoretical results.

Multiphoton processes in the optical regime are well-known phenomena investigated for decades. The advent of extreme ultraviolet (EUV) and X-ray free-electron lasers (FELs), with femtosecond pulse widths, has led to renewed interest in multiphoton processes in the EUV to X-ray spectral region. Recently, a new X-ray free electron laser facility, the SPring-8 Ångstrom Compact free electron LAser (SACLA) [1] started user operation in Japan. We have investigated multiphoton multiple ionization dynamics of Ar and Xe atoms by 5 and 5.5 keV XFEL pulses provided by SACLA. The absolute fluence of the XFEL pulse has been determined using two-photon processes in the Ar atoms with the help of calculations.

Figure 1 shows the charge state distribution of Xe at the photon energy of 5.5 keV [2]. The peak fluence determined via the calibration using Ar was 70 μJ/μm^2. We have identified that highly charged Xe ions with the charge states of up to +26 are produced. The theoretical charge state distribution is also shown in Fig. 1. The experimental and the theoretical results are in reasonable agreement. The observed high charge states of +24 and above are produced via five-photon absorption, evidencing the occurrence of multiphoton absorption involving deep inner shells. Our theoretical results explain the complex pathways of sequential electronic decay cascades accessible in heavy atoms.

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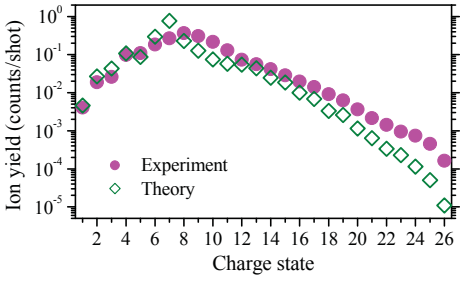

Figure 1. Experimental and theoretical charge state distribution of Xe at the photon energy of 5.5 keV.

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