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Multiphoton induced x-ray fluorescence of Fe atoms

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We report on multiphoton processes involving inner-shell electrons of solid Fe with very intense and ultra-short hard x-ray free-electron laser (XFEL) pulses. The experiment was carried out at the CXI end-station of the Linac Coherent Light Source by means of the high energy resolution x-ray emission technique. The XFEL beam of ˜10ˆ12 photons/pulse and pulse energy in the range of 1-4 mJ was focused on the solid Fe sample. The ultra-focused x-ray beam provided an extreme fluence (˜10ˆ4-10ˆ5 photons/Åˆ2). Moving the sample out of the focus along the beam allowed varying the fluence. For the K x-ray emission spectra measurements the bent crystal von Hamos x-ray spectrometer of PSI [1] installed at CXI and equipped with the CSPAD detector developed at SLAC was employed.

To explore the nonlinear interaction of Fe atoms with high-fluence XFEL radiation the photon beam energies were chosen below the Fe K-shell single- and double-ionization thresholds. The K x-ray emission spectra comprising the Kα (Kˆ{-1}−>Lˆ{-1}) diagram lines and the rich satellite structures due to the multiphoton induced multiple ionization, as well as the Kαˆh hypersatellite (Kˆ{-2}−>Kˆ{-1}Lˆ{-1}) transitions, were measured as a function of the XFEL fluence. The obtained results evince the nonlinear two-photon processes leading to K-shell ionization, and the K-shell hollow atom formation following sequential two-photon absorption.

[1] J. Szlachetko et al., Rev. Sci. Instrum. 83, 2012, 103105.

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