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Experimental Station for Ultrafast Extreme Ultraviolet Spectroscopy for Non-equilibrium Dynamics in Warm Dense Matter

Jong-won Lee[a], Xiaotao Geng[b,c], Jae Hyung Jung[a], Min Sang Cho[a], Seong Hyeok Yang[a], Jawon Jo[b,c], Chang-lyoul Lee[d], Byoung Ick Cho[a,*], Dong-Eon Kim[b,c,†]

[a]*Department of Physics and Photon Science, GIST, Gwangju 61005, South Korea*
[b]*Max Planck POSTECH/Korea Research Initiative (MPK), Pohang 37673, South Korea*
[c]*Department of Physics, Pohang University of Science and Technology, Pohang 37673, South Korea*
[d]*Advanced Photonics Research Institute, GIST, Gwangju 61005, South Korea*

Corresponding authors: [*]bicho@gist.ac.kr, [†]kimd@postech.ac.kr

Abstract

Recent interest in highly excited matter generated by intense femtosecond laser pulses has led to experimental methods that directly investigate ultrafast non-equilibrium electronic and structural dynamics. We present a tabletop experimental station for the extreme ultraviolet (EUV) spectroscopy used to trace *L*-edge dynamics in warm dense aluminum with a temporal resolution of a hundred femtoseconds. The system consists of the EUV probe generation part via a high-order harmonic generation process of femtosecond laser pulses with atomic clusters, a beamline with high-throughput optics and a sample-refreshment system of nano-foils utilizing the full repetition rate of the probe, and a flat-field EUV spectrograph. With the accumulation of an order of a hundred shots, a clear observation of the change in the aluminum *L*-shell absorption was achieved with a temporal resolution of 90 fs in a 600-fs window. The signature of a non-equilibrium electron distribution over a 10-eV range and its evolution to a 1-eV Fermi distribution are observed. This demonstrates the capability of this apparatus to capture the non-equilibrium electron-hole dynamics in highly excited warm dense matter conditions.