K-Shell X-Ray Diagnosis Of Hot Electron Generation In Laser-Irradiated Cu Foils

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Production of moderate-energy fast electrons due to laser-matter interaction at intensities 10^{15} - 10^{16} W/cm^2 and their transport through dense material is a subject of fundamental research directed studies in the field of high-energy density physics and one of key issues in a shock ignition approach to ICF. Overall understanding of the role of suprathermal electrons in near-solid density materials requires application of complex diagnostic methods. We report on new experimental results obtained at laser-irradiated Cu foils using a combination of high-resolution K-shell spectroscopy and monochromatic x-ray imaging. Their interpretation is based on hydrodynamic MULTI2D modelling of environmental plasma parameters post-processed by collisional-radiative code FLYCHK assuming variable fractions of hot electrons.

The experiment was carried out with the first and third harmonics of the PALS iodine laser (1.315 μm, 0.3 ns, 400 J, $I\lambda^2 \leq 2\times10^{16}$ W μm^2/cm^2) focused on thin-foil Cu targets. The 2D-resolved monochromatic images of the Cu Kα emission were recorded at quasi-normal incidence of x rays on spherically bent crystal of quartz (422). The 1D spatially resolved, time integrated Cu K-shell spectra covering the photon energy range of 7.5-8.5 keV (i.e., Cu Kα to He-like transitions) were observed by focusing spectrometer equipped with the quartz (223) crystal. Based on results of modelling, the recorded spectra were interpreted with respect to the hot electron presence in early phases of the target irradiation. The found intensity distribution of spectral lines close to Kα emission, particularly $2p\rightarrow1s$ transitions in Ne-like to He-like Cu ions, is of primary importance for rigorous evaluation of fluorescence cross-sections decisive for quantitative interpretation of 2D images. Benefiting from this approach, we provide more precise estimates on conversion efficiency of the laser energy into hot electrons.

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