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High-Intensity-Laser–Solid Interactions in the Refluxing Limit

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Small mass targets are of interest in high-intensity-laser–solid interactions due to their unique fast-electron transport properties.[1,2] Electron refluxing in solid-density matter by the Debye sheath fields that are set up at the target surfaces provide a unique environment for the determination of the conversion efficiency of laser energy into fast electrons.[3] Previous measurements of the absolute K_α yield from copper foils as a function of laser intensity demonstrate excellent agreement with electron refluxing models.[3,4]In particular, fast-electron conversion efficiencies of around 10% to 20% have been inferred by fitting the absolute K_α yields to semi-analytical modeling. It is well known that ionization of the M shell during volumetric heating within such small mass copper targets can cause a deviation in the ratio of the number of emitted K_β and K_α photons below the cold material limit.[4] This is a direct consequence of bulk target heating due to fast-electron energy loss. Such a deviation could provide a useful code benchmarking parameter on the energy content of the fast electrons and a consistency check on the laser-electron conversion efficiency. This consistency check, however, has proven elusive experimentally. We demonstrate here for the first time the consistency between the fast-electron conversion efficiencies predicted by these two methods using small mass targets. It is demonstrated that a 3.5× reduction in the ratio of the number of emitted K_β and $K_\alpha$photons is achievable below the cold material limit using $20 \times 20 \times 2$ μm copper targets at laser intensities of 2×10^{19} W cm^{-2}. These results provide a comparison in preparation for the higher energy-density environments that will be accessible using the future OMEGA EP Laser Facility.[5] This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreements DE-FC52-92SF19460 and DE-FC02-04ER54789. Contributors: W. Theobald, J. Myatt, M. Storm, O.V. Gotchev, C. Mileham, C. Stoeckl, R. Betti,* D.D. Meyerhofer,* and T.C. Sangster. *Also at the Fusion Science Center for Extreme States of Matter and Fast Ignition.

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