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Absolute measurements of short-pulse, long-pulse, and capsule-implosion backlighter sources at x-ray energies greater than 10 keV

BRIAN MADDOX, Lawrence Livermore National Laboratory

Laser-generated x-ray backlighters with x-ray energies > 10 keV are becoming essential diagnostic tools for many high energy density experiments. Examples include studies of high areal density cores for ignition designs, mid- to high-Z capsule implosion experiments, absolute equation of state experiments, dynamic diffraction under extreme pressures, and the study of material strength. Significant progress has been made recently using short pulse lasers, coupled to metal foil targets [1], and imploding capsules for producing high energy backlighters. Measuring the absolute x-ray flux and spectra from these sources is required for quantitative analysis of experimental data and for the design and planning of future experiments. We have performed an extensive series of experiments to measure the absolute x-ray flux and spectra on the Titan, Omega, Omega-EP, and NIF laser systems, employing single-photon-counting detectors, crystal spectrometers, and multichannel differential filtering (Ross-pair) and filter stack bremsstrahlung spectrometers. Calibrations were performed on these instruments [2] enabling absolute measurements of backlighter spectra to be made from 10 keV to 1 MeV. Various backlighter techniques that generate either quasi-monochromatic sources or broadband continuum sources will be presented and compared. For Molybdenum Kα backlighters at x-ray energy of $\sim$17 keV we measure conversion efficiencies of 1.3x10^{-4} using 1 μm wavelength short-pulse lasers at an intensity of $\sim$1x10^{17} W/cm^2. This is a factor of $\sim$2 high than using 0.3 μm wavelength long-pulse lasers at an intensity of $\sim$1x10^{16} W/cm^2. Other types of backlighter targets include capsule implosion backlighters that can generate a very bright "white-light" continuum x-ray source and high-Z gas filled capsules that generate a quasi-line-source of x rays. We will present and compare the absolute laser energy to x-ray conversion efficiencies for these different backlighter techniques and give examples of the science experiments that they enable. Lawrence Livermore National Laboratory is operated by Lawrence Livermore National Security, LLC, for the U.S. Department of Energy, National Nuclear Security Administration under Contract DE-AC52-07NA27344.

[1] H-S. Park, PoP, 15, 072705 (2008).
[2] B. R. Maddox, RSI, submitted (2010).