High-energy X/Gamma ray source from Compton scattering and Bremsstrahlung in a self-modulated Laser Wakefield Accelerator

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Understanding material properties under extreme conditions of temperature, pressure, and density is essential for different fields of physics such as astrophysics, High Energy Density Science (HEDS) and Inertial Confinement Fusion. The development of directional, low-divergence, and short-duration (ps and sub-ps) x-ray probes with energies of tens of keV is desirable for these applications. Such high-energy x-ray probe beam could be used to radiograph the imploding inertially-confined fusion capsule at the National Ignition Facility [1] or warmdense matter created using lasers or Z-pinches via absorption spectroscopy or scattering techniques. It was recently shown that using the kJ-class, short lasers present in most HEDS facilities, Self-Modulated Laser Wakefield Acceleration (SMLWFA) [2,3] can generate a directional short-duration x-ray source with high-brightness and critical energies up to 20 keV.

In this work, we generate an even more energetic source of x/Gamma-rays using the high charge relativistic electron beam from a SMLWFA exploring two different mechanisms: Bremsstrahlung [5] and inverse Compton scattering [6]. We focused the Titan short laser pulse (150J, 1ps) beam into a gas jet to produce a low divergence electron beam with energies up to 300 MeV and 6 nCs of charge. The electron beam and the remaining laser pulse then exited the gas jet and collided with a foil that was placed after the gas jet. When using a low Z foil the laser collision with the foil created a plasma mirror that reflected the laser beam back to interact with the accelerated electron beam and generated a bright, multi-keV x-ray beam via inverse Compton scattering. When using a high-Z material foil, the electron beam generated a bright Gamma-ray beam through Bremsstrahlung. This x-ray beam is an ideal probe and backlighter for time-resolved spectroscopy, imaging, and Compton radiography. Experimental characterization of these two x/Gamma ray sources will be presented.

References

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This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under the contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC