Inverse Compton scattered gamma-rays from an MeV laser plasma electron accelerator and plasma mirror

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Compared to conventional kilometer length accelerators, table top laser plasma accelerators (LPAs) can accelerate electrons to hundreds of MeV within a few millimeters. These accelerators are noted for their impressive beam quality, high brightness, short pulse duration and tunability, generating quasi-monoenergetic electron bunches with hundreds of pC in the FWHM of the peak [1]. Inverse Compton scattered (ICS) x- and γ-rays are generated when relativistic electrons oscillate in the electric field of a counter propagating laser pulse, emitting radiation that is upshifted in energy by a factor of $\sim 4\gamma^2$, where γ is the Lorentz factor of the electrons [2]. Inverse Compton scattering off relativistic electrons from a table-top LPA produces a bright, narrow-bandwidth, ultra-short source of hard x- or γ-rays on a compact system, ideal for accessing a wide range of applications in a University or small lab setting.

There are two leading methods for generating ICS pulses from LPAs. The first method uses a second laser pulse that interacts with the accelerated electron bunch, offering good control over the collision parameters [3] but is difficult to align, expensive and borrows energy from the LPA drive pulse. The second method involves inserting a plasma mirror (PM) at the exit of the accelerator to retro-reflect the drive pulse onto the trailing accelerated electrons [4,5]. This second technique offers a cheap, self-aligning and reproducible method for generating quality γ-ray pulses that uses the expended drive laser pulse.

The complex laser-plasma interactions that take place during the acceleration process can severely modulate the spectrum and intensity of the drive laser. This leads to concerns about the viability of the PM method, resulting in more groups using the first method for significant ICS experiments. However, when operating a LPA within the pump depletion limit the spectral modulations are minimized. We present a comprehensive study on the effect these modulations have on the resultant γ-ray spectra as well as an in-depth characterization of the laser after driving an LPA at the high-power laser facility DRACO at HZDR.

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