Tailoring beam performance by interfering laser beamlets.

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ABSTRACT.

In this work we describe a method to enhance the laser energy absorption into fast electrons without significant improvement of the laser beam specificatons through for example energy and intensity upgrades. We find that the combining beamlets with a small angle, hence having the interference patterns at the overlapping point, improves the laser absorption and the conversion efficiency from laser to hot electrons, much better than those with only one beam with same laser energy and intensity.

Experimental results demonstrate that interfering laser pulses can effectively improve laser energy absorption and conversion efficiency to electrons and proton beams compared to single beam interaction, keeping constant the energy, pulse duration and average intensity on target. The experiment was performed at LFEX-GXII laser facility at the Institute of Laser Engineering, Osaka University. The four LFEX laser beamlets were focused on a 5 um Al foil followed by a single beamlet focused on the same type of target in different shots. The total energy was kept constant except for the shot-to-shot fluctuation (<10%). A significantly larger hot electron temperature and proton peak energy, as well as laser-to-electron/proton energy conversion efficiency was measured in case of the four interfering beamlets.

2D PIC simulations support the experimental results, showing that the beamlets interference pattern on target is responsible for the shaping of the critical density and the formation of large azimuthal magnetic fields localized around the interference maxima as in a mosaic structure. Radiation pressure-induced shaping of the critical surface enhances laser energy absorption by increasing the average incidence angle of the laser pulse as well as increasing the interaction surface area. The strong azimuthal magnetic fields de-phase and de-couple the oscillating electrons from the laser field thus improving the absorption into fast electrons and protons. The interference technique is easily applicable to existing laser facilities, improving the laser performances without expensive and lengthy laser upgrades and is of direct interest for the latest generation of multi-kJ, PetaWatt-class laser systems such as LFEX and NIF-ARC.