Tailoring beam performance with interfering intense laser beamlets

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The advent of multi-kJ, Peta-Watt class laser systems such as LFEX laser at Institute of Laser Engineering opens a new vista on intense laser-plasma interaction with pulses characterized by longer (multi-ps) duration and multi-beamlet interaction with energies exceeding the kJ level. LFEX laser is composed by four beamlets, each carrying currently up to 500 J of laser energy at maximum compression (1.5 ps) that can be spatially and temporally overlapped onto a 60 mm spot, or arranged in temporal sequence resulting in a single, flat-top laser pulse, as well as a pulse train.
By temporally and spatially overlapping the LFEX beamlet at maximum compression (~1.5 ps) we demonstrate, experimentally and through 2D particle-in-cell simulations, that the combining beamlets with a small angle, hence having interference patterns at the overlapping point, improves the laser absorption and the conversion efficiency from laser to hot electrons, compared to results with only one beam with same laser energy and intensity [2]. This effect is significant even for high contrast laser pulses. 2D PIC simulations support the experimental results, showing that the beamlets interference pattern on target is responsible for the periodical shaping of the critical density and the formation of large surface magnetic fields localized around the interference maxima, as in a mosaic structure. The shaping of the critical surface increases the average laser incidence angle on target as well as the effective area where the interaction takes place, resulting in higher absorption into fast electrons. The large surface B-fields efficiently de-phase and de-couple the oscillating electrons from the laser field. Both effects contribute to the increase of the laser energy absorption into fast electrons by factors.

These results are of great interest for laser-generated proton beam application to High Energy Density (HED) Physics with multi-kJ, multi-ps and multi-beamlet petawatt laser systems and are applicable to other existing laser facilities.

[1] N. Miyanaga et al, J. Phys. IV 133, 81 (2006).
[2] A. Morace et al., to be submitted.