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Enhanced particle acceleration via interaction of an "infinite" array of co-propagating beamlets

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We pay homage to previous work using multiple laser pulses shown to yield widespread benefits in laser driven particle acceleration and radiation generation - and here explore the consequences of scaling the interaction to an "infinite" number of co-propagating beamlets which couple together and form large-gradient, periodic accelerating structures capable of elevated injection for high-charge and high-energy electron acceleration. Taking advantage of fully kinetic particle-in-cell (PIC) simulations with periodic boundary conditions, we demonstrate tailoring the interspacing beamlet distance can lead to a two-order of magnitude increase in accelerated charge per pulse, an order of magnitude increase in the electron cutoff energies, prolonged pulse propagation beyond single pulse depletion, and an overall reduction in the self-injection threshold. Continual reduction of the inter-pulse spacing below a characteristic distance of a half beam waist leads to a plane-wave like acceleration dynamic which collapses the acceleration process into 1D, eliminating transverse focusing fields which may be deleterious for emittance preservation and positron acceleration. It is demonstrated this "infinite" pulse dynamic can be recovered with as few as a dozen co-propagating pulses (in 2D). Using modest laser energies, we propose this work to be a key candidate for scalable kHz, ultrashort fiber arrays for unprecedented electron luminance. Further work proves a similar principle can be extended to solid-target ion acceleration for enhanced cut-off energies, fluxes, and decreased divergence.

Working group

WG1 : Laser-driven plasma wakefield acceleration

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