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Enhancing direct laser driven electron acceleration using quasi static transverse sheath electric fields

Laser-driven acceleration of relativistic electron beams has gained significant attention in recent years. Among the primary techniques for electron acceleration are Direct Laser Acceleration (DLA) and Vacuum Laser Acceleration (VLA). While both methods enable electrons to achieve high energies, practical challenges arise due to dephasing between the laser pulse and the electron beam, which limits the overall energy gain. Recent studies utilizing plasma mirrors or ultrathin foils for controlled injection have shown encouraging outcomes. However, these approaches often encounter issues where transient surface sheath fields hinder electron acceleration by disrupting optimal phase injection into the laser pulse.

We propose an innovative approach where the sheath field actively enhances it instead of impeding acceleration. This method leverages two laser pulses: one to generate the sheath field and another to accelerate electrons within this field, leading to improved energy gains.

The Particle-in-Cell (PIC) simulations were performed using the SMILEI code on the high-performance computing cluster at TIFR. SMILEI enables to insert two lasers at different angles of incidence from different faces of the simulation box enabling the geometry to have freedom on the orientation of the box. The entire simulation was carried out in the overdense regime with a hydrogen plasma approximation also taking into account the prepulse scale length of each of the two lasers. Furthermore, a comprehensive analysis of single-particle dynamics was conducted to gain deeper insights into the influence of the sheath field.

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