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Optimizing Direct Laser Acceleration[1]

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For high-intensity, sustained laser-plasma interactions, the laser pulse will ponderomotively expel nearly all of the electrons within its focal volume, creating a positively charged plasma channel. This channel is slowly evolving relative to the timescale of electron motion. Electrons that become trapped in this channel can gain longitudinal momentum from the laser field through the $v \times B$ force in the Lorentz force equation. This process is known as Direct Laser Acceleration (DLA). Experiments performed at the OMEGA EP laser facility have demonstrated DLA of electrons up to 600 MeV from a low-density plasma target using a high-energy, picosecond duration pulse at an optimal plasma density. High energy electrons beams with nearly 100 nC charge were also produced. Two-dimensional particle-in-cell (PIC) simulations conducted using the EPOCH code confirm DLA as the dominant acceleration mechanism and elucidate that dynamic role of quasi-static channel fields on electron energy enhancement. PIC simulations also indicate that longer pulse duration could be used to produce higher charge electron beams by DLA. Particle tracking shows considerable acceleration and deceleration of electrons and indicates that this process could be an efficient source of hard X-rays with the capability to be accurately synchronized to short pulse laser-initiated events.

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