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Synergistic Direct/Wakefield Acceleration of Plasma Electrons In the Plasma Bubble Regime Using Tailored Laser Pulses

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The integration of direct laser acceleration (DLA) and laser wakefield acceleration (LWFA) is a new approach to plasma-based acceleration that confers several benefits over both schemes taken separately. Such integration requires a significant portion [1] of the laser energy (e.g., a separate laser pulse [2,3]) to trail the main bubble-producing laser pulse, and resonantly interact with the trapped accelerated electrons undergoing betatron motion inside the plasma bubble. I will demonstrate how electron dephasing from the accelerating wakefield, which is one of the key limitations of LWFA, is reduced by their growing undulating motion. Moreover, the distinct energy gains from wake and the laser pulse are compounding, thereby increasing the total energy gain. Even more significant increases of the overall acceleration can be obtained by moving away from single-frequency laser format toward combining mid-infrared laser pulses for plasma bubble generation with short-wavelength trailing pulses for DLA. Various injection mechanisms, such as ionization injection, external injection, self-injection, and their advantages will also be discussed. Translating these new concepts into specific experiments will take advantage of recent technological advances in synchronizing laser and electron beams, and using multiple beamlines for producing sophisticated laser pulse formats.

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[3] X. Zhang, V. N. Khudik, A. Pukhov, and G. Shvets, Plasma Phys. Cont. Fusion **58,** 034011 (2016).