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Extreme manifestations of phase- and polarization-dependent electron in the ultra-relativistic regime of LWFA

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When an ultra-intense laser pulse propagates through a dense plasma, the front of the laser can be locally "etched" by the nonlinear laser-plasma interaction, forming an optical shock. The laser front edge becomes extremely sharp, reaching relativistic amplitude over a sub-wavelength scale. This gives rise to the Carrier-Envelope-Phase (CEP) effect in laser wakefield accelerators (LWFA), whereby an Expanding and Periodically Undulating Bubble (EPUB) is generated. The EPUB undergoes simultaneous expansion and periodic undulation according to the laser CEP and polarization. Particle-In-Cell simulations and analytic theory shows that EPUB gives rise to a phase and polarization dependent (PPD) plasma electron self-injection and acceleration, giving rise to spatiotemporally structured ultrashort (fs) high-charge (nC) high-current (tens to hundreds of kA) electron bunch. We discuss observables for this PPD process including electron and X-ray spectra and angular distribution. Experimental conditions necessary to observe these PPD processes in high-power laser facilities will be discussed, including plasma length and profile as well as laser power and duration. Methods to improve beam quality via magnets and apertures will be discussed, and specific examples relevant to the 100TW ultrashort laser facility in ELI-NP will be provided. This new regime of LWFA will provide a promising path to generating high-charge high-quality electron beams in many high-power laser facilities.

Working group

WG1 : Laser-driven plasma wakefield acceleration

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