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Polarization and CEP Dependence of the Transverse Phase-Space in Laser-Driven Accelerators

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We have conducted experiments at the JeTi-200 laser facility ($\lambda_0 = 800nm$, spotsize $w_0 = 22\mu m$, pulse length $\tau = 23fs$, $a_0 = 2.4$) to investigate the contribution of laser polarization and carrier envelop phase (CEP) -fluctuations on the electron beam pointing jitter in laser wakefield accelerators(LWFAs). Furthermore, we developed a theory describing the transverse dynamics of the trapped electrons inside the resonantly oscillating wakefield bubble.
LWFAs were studied extensively and many advances were made in important beam parameters such as bunch energy, charge, and emittance. However, with the emergence of QED and beam colliding experiments requiring very precise positioning of the electron beam the beam jitter and its control become very important. Until now, electron beam jitter was generally contributed to imperfections in the plasma target reproducibility. Here we report on a polarization and CEP-dependent
mechanism that is intrinsic to LWFAs. The ponderomotive force of the laser pushes electrons aside and creates the well-known bubble structure. However, with few-cycle laser pulses or self-steepened longer pulses due to etching at the front the electron density in the trailing bubble can become asymmetric. The difference in phase and group velocity of the laser leads to an oscillation of the bubble centroid which couples to the trailing electron bunch. We measured the electron beam pointing in experiments with ionization and self-injection showing an increased beam-pointing jitter in the polarization direction regardless of the injection mechanism. In 2D PIC simulations we found countrolling the CEP phase of the laser within $500mrad$ constrains the polarization-induced jitter to below $50\mu rad$.

Acknowledgments

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