Transverse drift in the laser due to transverse frequency chirp: Variational principle approach

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Abstract

It has already been observed experimentally [Popp et al., Phys. Rev. Lett, 105, 215001 (2010)] that a tilted laser pulse causes optical steering of the injected electron beam. Multi-dimensional particle-in-cell (PIC) simulations using OSIRIS show that the transverse frequency chirp can induce pulse front tilt (PFT) in the laser as it propagates. The PFT leads to transverse inhomogeneities of the electron density at the laser front causing the drift of the laser in the transverse direction. When present, the self-injected electrons also follow the transverse drift imposed by the laser transverse chirp. We investigate the effect of the chirp on the transverse drift by developing an analytical model based on the variational principle approach, and we compare the analytical findings with multi-dimensional simulations. Theory and simulations indicate that the temporal rate of the transverse drift scales linearly with the frequency chirp. Simulations also show an optimal laser intensity and pulse length for which the drift is maximum for constant frequency chirp.