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Beam Energy Deposition in Plasma Electrons during Wakefield Acceleration by Long Drivers

In this work, we investigate the energy transfer from a long proton bunch driver to the plasma in the context of the AWAKE experiment, using particle-in-cell simulations with OSIRIS. As the driver propagates through the plasma, it excites wakefields by displacing plasma electrons, which gain kinetic energy. This energy can dissipate through several mechanisms, including electromagnetic radiation. We analyse the correlation between the kinetic energy of plasma electrons and the longitudinal accelerating field. Initially, a linear relationship is observed; however, as the wake evolves, phase slippage (dephasing) introduces curvature into the wake structure. Multiple wake phases then contribute to the energy of individual plasma electron slices, breaking the simple linear scaling. We characterise this transition and quantify how dephasing affects the distribution of deposited energy.

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