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Comparing Envelope and Full-Fluid Models of Intense Laser-Plasma Interactions

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Abstract

Full-fluid models (wherein the only approximation is the assumption of hydrodynamics) can be computationally intensive in the parameter regimes relevant to advanced accelerator concepts, thus there is interest in evaluating the physics content of less intensive models. Recently we have begun exploration of a variety of envelope models to compliment our full-fluid models. We present detailed comparisons of the predictions of these models for the case of long propagation of a resonant laser pulse in a channel. This configuration is important as it is the primary candidate for a multi-GeV accelerator stage and is the subject of active experimental investigation by a number of groups. Accurate handling of the laser propagation over long distances (order of a thousand plasma oscillations) is essential to assessing the performance of a putative accelerator module. We examine the differences in physics content of these models in regard to laser energy transport and generation of plasma waves as well as various numerical considerations such as resolution, convergence, dissipation, dispersion and computational resource requirements. We also examine the role of the wave action adiabatic invariant and the consequences of the numerical handling of this invariant in the different models.