Simulations of high-power laser interaction with plasmas using nonlocal transport hydrodynamic model

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The non-locality affects the transport of particles, mostly electrons, as much as it does radiation. The nonlocal theory of the energy transport in radiative plasmas of arbitrary ratio of the characteristic spatial scale length to the photon and electron mean free paths is applied to define the closure relations of hydrodynamic system and is effectively implemented into our nonlocal hydro code PETE. The key feature of the proposed method is a direct solution of the simplified Bhatnagar-Gross-Krook form of the Boltzmann transport equation for both electrons and photons [1], which presents a phase-space (including particle momentum) extension of the general high-order curvilinear finite element approach for solving Lagrangian hydrodynamics [2]. By the means of hydrodynamic simulations, the non-local transport is investigated for the ablated plasma as it is created by the pre-pulse of high-power lasers. Subsequently it is shown how non-locality affects the propagation of a very short and very intense focused laser pulse using particle-in-cell simulations, where the obtained plasma profiles manifestly demonstrate that the classical diffusion electron transport cannot model properly the physics of ablation. This is also the case of the preheat effect, which was observed in the WDM experiment of the plastic foam equation of state measurements at the Omega facility. The shock velocities reaching 80 km/s were measured by a comprehensive diagnostic instruments including SOP and VISAR. It was demonstrated, that such high shock velocities are achieved only when the preheat due to nonlocal electron transport affects the Hugoniot jump condition.

References
