Thermal Effects in Intense Laser-Plasma Interactions

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Abstract

Intense laser-plasma interaction experiments access a unique physical regime wherein the plasma electrons experience highly relativistic motion while the temperature (or more correctly, momentum spread) is quite small and the plasma is effectively collisionless. To study this regime, we have recently developed a "warm" fluid model where the width of the distribution function is treated asymptotically. Unlike the collisional case, in this regime the plasma is not in local thermodynamic equilibrium and the pressure tensor can be strongly anisotropic. Using this model, we examine various experimentally relevant configurations, comparing the results of our new model with results of the traditional cold fluid approximation. A case of particular interest which we study in detail is that of a short-pulse pulse propagating in an underdense thermal plasma, where the initial plasma temperature is on the order of 20 eV. Within the quasi-static approximation, the warm-fluid equations for the momentum spread can be solved analytically. We find there is no significant heating of the plasma and that the anisotropy of both the pressure tensor and the distribution function is large. We compare these analytical results to numerical results from both warm and cold fluid models.