Accelerating Piston Action and Plasma Heating in High-Energy Density Laser Plasma Interactions

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Abstract

The strong light pressure associated with ultraintense short pulse laser beams of $I > 10^{18} W/cm^2$ is a central component to many high-energy density (HED) applications. In this presentation, a more realistic treatment of the laser 'hole boring' process is developed through analytical modeling and particle-in-cell simulations. Key novel aspects of the dynamics are elucidated for the first time, including a self-consistent treatment of the target-front plasma volumetric heating and expansion. The further inclusion of a realistic laser pulse profile is shown to play an essential role, qualitatively modifying the particle phase space, and attenuating the axial depth of the hole boring channel by $\sim \pmod ?$ for many common configurations. In a broad sense, our results show that the ponderomotive hole boring of a realistic laser pulse gives rise to richer particle dynamics, though ultimately represents a less robust 'pressure source' than previously thought. Implications of these results for astrophysically-relevant HED applications, such as the ability to drive collisionless shocks into the overdense target, are highlighted. These considerations are germane to shocks in jets of active galactic nuclei and gamma-ray bursts.