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Demonstration of Ion Kinetic Effects in Inertial Confinement Fusion Implosions and Investigation of Magnetic Reconnection Using Laser-Produced Plasmas

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Shock-driven laser inertial confinement fusion (ICF) implosions have demonstrated the presence of ion kinetic effects in ICF implosions and also have been used as a proton source to probe the strongly driven reconnection of MG magnetic fields in laser-generated plasmas. Ion kinetic effects arise during the shock-convergence phase of ICF implosions when the mean free path for ion–ion collisions (λ_{ii}) approaches the size of the hot-fuel region (R_{fuel}) and may impact hot-spot formation and the possibility of ignition. To isolate and study ion kinetic effects, the ratio of $N_{\text{K}} = \lambda_{\text{ii}}/R_{\text{fuel}}$ was varied in D^3He-filled, shock-driven implosions at the Omega Laser Facility and the National Ignition Facility, from hydrodynamic-like conditions $(N_{\text{K}} \sim 0.01)$ to strongly kinetic conditions $(N_{\text{K}} \sim 10)$. A strong trend of decreasing fusion yields relative to the predictions of hydrodynamic models is observed as N_{K} increases from ~ 0.1 to 10. Hydrodynamics simulations that include basic models of the kinetic effects that are likely to be present in these experiments—namely, ion diffusion and Knudsen-layer reduction of the fusion reactivity—are better able to capture the experimental results. This type of implosion has also been used as a source of monoenergetic 15-MeV protons to image magnetic fields driven to reconnect in laser-produced plasmas at conditions similar to those encountered at the Earth's magnetopause. These experiments demonstrate that for both symmetric and asymmetric magnetic-reconnection configurations, when plasma flows are much stronger than the nominal Alfvén speed, the rate of magnetic-flux annihilation is determined by the flow velocity and is largely insensitive to initial plasma conditions.
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