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Quantitative studies of kinetic effects in direct- and indirect-drive Inertial Confinement Fusion implosions

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A comprehensive set of experiments using shock-driven implosions has been conducted to quantitatively study kinetic effects by exploring deviations from hydrodynamic behavior in plasmas relevant to inertial confinement fusion (ICF). Two types of targets were imploded at OMEGA to create ~10 keV, $\sim 10^{22}$ cm^{-3} plasmas with conditions comparable to the incipient hotspot in ignition designs: thin-glass targets filled with mixtures of D_2 and ^{3}He gas; and thin deuterated-plastic shells filled with ^{3}He. In the thin-glass experiments, the gas pressure was varied from 1 to 25 atm to scan the ion-mean-free path in the plasma at shock burn. The observed nuclear yields and temperatures deviated more strongly from hydrodynamic predictions as the ion-mean-free path increased to the order of the plasma size. This result provides the first direct experimental evidence how kinetic effects impact yields and ion temperature. The ratio of D to ^{3}He was also varied while maintaining the fuel mass density. As the D fraction was reduced, the DD and D^{3}He fusion products displayed an anomalous yield reduction. Separation of the D and ^{3}He ion species across the strong (Mach ~10) shock-front will be discussed as the likely cause of this result. Finally, thin-CD shells filled with ^{3}He produced significantly more D^{3}He-protons when imploded than is explained by hydrodynamic mix models. This result suggests a kinetic form of mix dominates at the strongly-shocked shell-gas interface.

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