STUDIES OF ION KINETIC EFFECTS USING EXPLODING-PUSHER IMPLOSIONS ON OMEGA AND THE NATIONAL IGNITION FACILITY

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Ion kinetic effects arise in inertial confinement fusion (ICF) implosions when the mean free path for ion–ion collisions approaches the size of the hot-fuel region. Such conditions are likely to be prevalent immediately after shock convergence in a variety of ICF implosions, including ignition-relevant designs. To investigate these kinetic effects in an isolated setting independent from the effects of fuel–shell mix, experimental studies of ion kinetic effects in ICF implosions have been performed using shock-driven, D_2- and D^3He-filled exploding pushers on OMEGA [1,2] and the National Ignition Facility (NIF) [3]. Across this set of experiments, the Knudsen number—the ratio of fuel ion–ion mean free path to the minimum radius of the shell containing the fuel ($N_K = \lambda_{ii}/R_{shell}$)—was varied to assess the breakdown of hydrodynamic models as a result of ion kinetic effects [1–3]. Under hydrodynamic-like conditions ($N_K \sim 0.01$), hydrodynamic models are largely able to reproduce experimental conditions [3,4]. However, under strongly kinetic conditions ($N_K > 1$), significant deviations from hydrocode predictions are observed, including the fusion yields [1] and the shape of fusion emission spatial profiles [2]. A strong trend of decreasing DD and D^3He fusion yields relative to the predictions of hydrodynamic models is observed with increasing Knudsen number for $0.1 < N_K < 10$ as the yield over clean decreases from 1 to 0.01. 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 yield and burn-profile results [5]. A goal of ongoing and future work is to investigate how ion kinetic effects that are likely present during the shock-convergence phase may impact hot-spot formation and the subsequent compression and burn phase of ignition-relevant implosions.

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