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Exploring the dynamics of kinetic/multi-ion effects and ion-electron equilibration rates in ICF plasmas at OMEGA

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During the last few years, an increasing number of experiments have shown that kinetic and multi-ion-fluid effects do impact the performance of an ICF implosion. Observations include: increasing yield degradation as the implosion becomes more kinetic; thermal decoupling between ion species; anomalous yield scaling for different fuel mixtures; ion diffusion; and fuel stratification. The common theme in these experiments is that the results are based on time-integrated nuclear observables that are affected by an accumulation of effects throughout the implosion, which complicate interpretation of the data. A natural extension of these studies is therefore to conduct time-resolved measurements of multiple nuclear-burn histories to explore the dynamics of kinetic/multi-ion effects in the fuel and their impact on the implosion performance. This was accomplished through simultaneous, high-precision measurements of the relative timing of the onset, bang time and duration of DD, D^3He, DT and T^3He burn from T^3He (with trace D) or D^3He gas-filled implosions using the new Particle X-ray Temporal Diagnostic (PXTD) on OMEGA. As the different reactions have different temperature sensitivities, $T_i(t)$ was determined from the data. Uniquely to the PXTD, several x-ray emission histories (in different energy bands) were also measured, from which a spatially averaged $T_e(t)$ was also determined. The inferred $T_i(t)$ and $T_e(t)$ data have been used to experimentally explore ion-electron equilibration rates and the Coulomb Logarithm for various plasma conditions. Finally, the implementation and use of PXTD, which represents a significant advance at OMEGA, have laid the foundation for implementing a $T_e(t)$ measurement in support of the main cryogenic DT programs at OMEGA and the NIF. This work was supported in part by the US DOE, LLE, LLNL, and DOE NNSA SSGF.