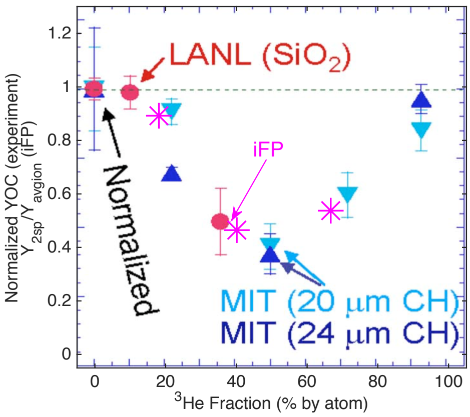
Investigation of ICF Capsule Yield Anomalies via Fully Kinetic Simulations

Luis CHACÓN, William T. TAITANO, Andrei N. SIMAKOV and Brett KEENAN
Los Alamos National Laboratory, Los Alamos, New Mexico, USA
E-mail: chacon@lanl.gov

In the quest towards ICF ignition, plasma kinetic effects such as fuel segregation and kinetic mix are considered by some as prime candidates to explain discrepancies between experiments and radiation-hydrodynamics simulations. To assess their importance, however, a high-fidelity fully kinetic simulation capability of ICF capsule implosions is needed. Owing to the exceedingly multiscale nature of the problem, such a capability has to overcome nontrivial numerical and algorithmic challenges, and very few good options are currently available to the modeler.

Here, we present an initial assessment of the impact of kinetic fuel segregation on anomalous yield degradation using the novel, LANL-developed 1D-2V Vlasov-Fokker-Planck code iFP [1-3] to model the implosion experiments discussed below. iFP is a multiscale code of unprecedented fidelity, featuring unique algorithmic advances such as fully implicit time-stepping, exact mass, momentum, and energy conservation, and optimal grid adaptation in phase space, all critical to ensure long-time numerical accuracy of capsule implosion simulations. iFP has been extensively verified in planar [4] and spherical geometries.

Anomalous yield degradation has been observed in several Omega campaigns, with the so-called "Rygg effect" [5,6] being a prime example. Understanding the physical mechanisms underpinning yield degradation in non-ignition-grade experiments is of great interest, as such experiments are often used for platform and diagnostic development for ignition-grade experiments on NIF. The Rygg effect has been studied numerically before [7], concluding that kinetic effects were not at play. Here, we revisit the issue with iFP. We have modeled Omega implosions of interest [5,6], and we have found (to our knowledge, for the first time) excellent yield-over-clean (YOC) agreement with several LANL and MIT experimental results (see the figure). This validates iFP, and suggests that kinetic fuel segregation is indeed at the root of the observed yield degradation. In this presentation, we introduce iFP, and provide an in-depth analysis of the Rygg-effect simulations and the underlying physics.



References

[1] W. T. Taitano, L. Chacón, A. N. Simakov, K. Molvig, J. Comp. Phys. **297**, 357-380 (2015).
[2] W. T. Taitano, L. Chacón, A. N. Simakov, J. Comp. Phys. **318**, 391-420 (2016).
[3] W. T. Taitano, L. Chacón, A. N. Simakov, J. Comp. Phys. **339**, 453-460 (2017).
[4] L. Yin, B. J. Albright, W. T. Taitano *et al.*, Phys. Plasmas **23**, 112302 (2016).
[5] J. R. Rygg, J. A. Frenje, C. K. Li *et al.*, Phys. Plasmas **13**, 052702 (2006).
[6] H. W. Hermann, J. R. Langenbrunner, J. M. Mack *et al.*, Phys. Plasmas **16**, 052312 (2009).
[7] O. Larroche, Phys. Plasmas **19**, 122706 (2012).