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Understanding Yield Anomalies in ICF Implosions via Fully Kinetic Simulations[1]

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In the quest towards ICF ignition, plasma kinetic effects are among prime candidates for explaining some significant discrepancies between experimental observations and rad-hydro simulations. To assess their importance, high-fidelity fully kinetic simulations of ICF capsule implosions are needed. Owing to the extremely multi-scale nature of the problem, kinetic codes have to overcome nontrivial numerical and algorithmic challenges, and very few options are currently available. Here, we present resolutions of some long-standing yield discrepancy conundrums using a novel, LANL-developed, 1D-2V Vlasov-Fokker-Planck code iFP. iFP possesses an unprecedented fidelity and features fully implicit time-stepping, exact mass, momentum, and energy conservation, and optimal grid adaptation in phase space, all of which are critically important for ensuring long-time numerical accuracy of the implosion simulations. Specifically, we concentrate on several anomalous yield degradation instances observed in Omega campaigns, with the so-called Rygg effect [1], or an anomalous yield scaling with the fuel composition, being a prime example. Understanding the physical mechanisms responsible for such degradations in non-ignition-grade Omega experiments is of great interest, as such experiments are often used for platform and diagnostic development, which are then used in ignition-grade experiments on NIF. In the case of Ryggs experiments, effects of a kinetic stratification of fuel ions on the yield have been previously proposed as the anomaly explanation, studied with a kinetic code FPION, and found unimportant. We have revisited this issue with iFP and obtained excellent yield-over-clean agreement with the original Rygg results, and several subsequent experiments. This validates iFP and confirms that the kinetic fuel stratification is indeed at the root of the observed yield degradation.

[1] J.R. Rygg et al., Phys. Plasmas, 13, 052702 (2006).

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