3D Simulations Capture the Persistent Low-Mode Asymmetries Evident in Laser-Direct-Drive Implosions on OMEGA

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Laser-direct-drive implosion experiments conducted on the OMEGA laser system have been found to be prone to a systematic flow anomaly at stagnation. This anomaly persists across warm and cryogenic experiments and after elimination of other perturbation sources such as target offset, vibration, stalk and ice nonuniformity. Recently, a proposed explanation for this anomaly has been the polarized Cross Beam Energy Transfer (CBET) interaction in the particular OMEGA beam configuration of the Polarization Smoothing system, on the basis of post-processing with the BeamletCrosser tool developed at LLE.

Here, we present the first polarized CBET model fully coupled to radiative hydrodynamics. The polarized model is implemented in the IFRIIT 3D laser code, coupled to the ASTER 3D radiation hydrodynamics code. The coupled code is used to investigate 4 OMEGA shots considering various sources of low modes: pointing error, balance error, taregt offset, and polarized CBET.

The simulations reproduce bang times and neutron yields - when separately accounting for fuel age and high modes. The magnitude of the flow is well reproduced only when the low mode sources are large, whereas the modeling of stalk is thought to be required to match the flow magnitude in the remaining cases. For the cases explored in more details, polarized CBET - the only known systematic drive asymmetry, brought the results closest to the measured flow vectors, which may help explain the systematic flow orientation evident in the OMEGA implosion database. For typical current levels of beam mispointing, power imbalance, target offset, and asymmetry caused by polarized CBET, low modes degrade the yield by more than 40%. The current strategy of attempting to compensate the mode-1 asymmetry with a preimposed target offset recovers only about 1/3 of the losses caused by the low modes due to the dynamic nature of the multiple asymmetries and the presence of low modes other than l=1. Therefore, addressing the root causes of the drive asymmetries is apt to be more beneficial. To that end, one possible solution to the specific issue of polarized CBET (10 microns DPRs) is shown to work well.