- IFSA2025 –

Low-Mode X-ray Drive Asymmetries in ICF Hohlraums: 3D Rad-MHD Simulations with *Chimera*

Benjamin Duhig[(1)], A. Dearling[(1)], A. Crilly[(1,2)], P. Moloney[(1)], N.Chaturvedi[(1)], N.Joiner[(3)], J.Chittenden[(1)]

[(1)] *Centre for Inertial Fusion Studies, The Blackett Laboratory, Imperial College, London SW7 2AZ, United Kingdom*

[(2)] *I-X Centre for AI In Science, Imperial College London, White City Campus, 84 Wood Lane, London W12 0BZ, United Kingdom*

[(3)] *First Light Fusion Ltd., Unit 10 Oxford Industrial Park, Mead Road, Yarnton, Oxfordshire, OX5 1QU*

Laser beam power imbalances, beam geometry and hohlraum engineering features, such as diagnostic windows, introduce low-mode X-ray drive asymmetries of indirect-drive inertial confinement fusion (ICF) capsules, in both the rz and $r\vartheta$ plane [1-3]. Attenuation of the inner beams by plasma blowoff from outer beam spots produces a time-dependent P_2 asymmetry in the drive. Production of hard X-rays, primarily near outer beam spots, introduces a frequency-dependent component to this asymmetry [4]. These spatial, temporal, and spectral asymmetries are key contributors to reduced implosion performance [5]. In this work, we present the first 3D hohlraum simulations using the radiation-MHD code Chimera [6] that features a fully inline, multi-group, Sn radiation transport (RT) solver. This is compared to variable Eddington factor (VEF) reduced RT models to evaluate their ability to resolve low-mode asymmetries. Performing inline RT calculations would allow for the investigation into the dynamic development of asymmetries throughout the implosion and the study of their integrated effects. A sufficient reduced model would reduce the computational cost of 3D hohlraum simulations allowing for an increase in spatial resolution or the ability to run more simulations with the same computational resources.

1. Young, C. V. et al. View factor estimation of hot spot velocities in inertial confinement fusion implosions at the National Ignition Facility. Physics of Plasmas 27, 082702 (2020).

2. MacGowan, B. J. et al. Trending low mode asymmetries in NIF capsule drive using a simple viewfactor metric *. High Energy Density Physics 40, 100944 (2021).

3. Rinderknecht, Hans G. et al. Azimuthal Drive Asymmetry in Inertial Confinement Fusion Implosions on the National Ignition Facility. Phys. Rev. Lett 124, 145002 (2020).

4. Dewald, E. L. et al. First study of Hohlraum x-ray preheat asymmetry inside an ICF capsule. Physics of Plasmas 27, 122703 (2020).

5. Casey, D. et al. Diagnosing the origin and impact of low-mode asymmetries in ignition experiments at the National Ignition Facility. Phys. Rev. E 108, L053203 (2023).

6. Chittenden, J. P., Appelbe, B. D., Manke, F., McGlinchey, K. & Niasse, N. P. L. Signatures of asymmetry in neutron spectra and images predicted by three-dimensional radiation hydrodynamics simulations of indirect drive implosions. Physics of Plasmas 23, 052708 (2016).

This research was supported by First Light Fusion Ltd.