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The X-target: a high-gain and robust target design for HIF

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A new inertial-fusion target configuration, the X-target, using one-sided axial illumination has been explored [1]. This class of target uses annular and solid-profile heavy ion beams to compress and ignite deuterium-tritium (DT) fuel that fills the interior of metal cases that have side-view cross sections in the shape of an "X" . X-targets that incorporate inside the case a propellant (plastic) and a pusher (aluminum) surrounding the DT fuel are capable of assembling higher fuel areal densities ~2 g/cm2 using two MJ-scale annular beams to implode quasi-spherically the target to peak DT densities ~100 g/cm3. A 3MJ fast-ignition solid ion beam heats the high-density fuel to thermonuclear temperatures in ~200 ps to start the burn propagation, obtaining gains of ~300. These targets have been modeled using the radiation-hydrodynamics code HYDRA [2] in two- and three- dimensions to study the properties of the implosion as well as the ignition and burn propagation phases. The main concern for the X-target is the amount of high-Z atomic mixing at the ignition zone produced by hydro-instabilities, which, if large enough, could cool the fuel during the ignition process and prevent the propagation of the fusion burn. At typical Eulerian mesh resolutions of a few microns, the aluminum-DT interface shows negligible Rayleigh–Taylor (RT) and Richtmyer–Meshkov (RM) instability growth; also, the shear flow of the DT fuel as it slides along the metal X-target walls, which drives the Rayleigh–Taylor (RT) and Kelvin Helmholtz (KH) instabilities, does not have a major effect on the burning rate. An analytic estimate of the RT instability process at the Al-DT interface shows that the aluminum spikes generated during the pusher deceleration phase would not reach the ignition zone in time to affect the burning process. Also, preliminary HYDRA calculations, using a higher resolution mesh to study the shear flow of the DT fuel along the X-target walls, indicate that metal-mixed fuel produced near the walls would not be transferred to the DT ignition zone (maximum ρR) located at the vertex of the X-target. These preliminary studies need to be extended by further hydrodynamic calculations using finer resolution, complemented with turbulent mix modeling and validated by experiments, to ascertain the stability of the X-target design.

[1] E. Henestroza and B. G. Logan, Phys. Plasmas 19, 072706 (2012).
[2] M. M. Marinak et al., Phys. Plasmas 8, 2275 (2001)

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