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Multi-Dimensional Study of Laser Spot Zooming for Direct-Drive Fusion Targets

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Laser spot size is a critical parameter in direct-drive implosions. A larger spot generally improves illumination uniformity and enhances implosion sphericity, but an excessively large spot results in a significant fraction of laser energy bypassing the target ("blowby") and not being absorbed [1]. This blowby light also seeds Cross-Beam Energy Transfer (CBET) [2], a laser-plasma instability that reduces absorbed energy and enhances asymmetries from the beam geometry.

During the implosion, the capsule's critical surface moves inward. A spot size that provides optimal illumination early in the pulse may become too large later in the implosion, reducing energy absorption in its final stages. Focal spot zooming is a proposed solution that dynamically decreases the spot size over time to match the critical radius trajectory [3]. This approach could optimize both illumination uniformity and efficiency, overcoming the limitations of static spot sizes.

This work presents multi-dimensional simulations of direct-drive implosions using the CHIMERA radiation-hydrodynamics code, incorporating the SOLAS laser ray-trace and CBET package. We investigate the performance enhancement of zooming, relative to implosions with a static spot size. Improved performance derives from enhanced laser absorption, without significant degradation from beam geometry asymmetries. Simulations are also presented featuring both zooming and CBET mitigation via enhanced laser bandwidth.

References :

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