Understanding the Performance Limitations of Direct-Drive Implosions on OMEGA

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A major advantage of the laser direct-drive (DD) approach to ignition is the increased coupled laser energy to the hot spot and relaxed hot-spot requirements for the peak pressure and convergence ratios relative to the indirect-drive approach. With the goal of a successful ignition demonstration using direct drive, the recently established National DD strategy has several elements and involves multiple facilities and institutions. These elements include the experimental demonstration on OMEGA cryogenic implosions of hot-spot conditions relevant for ignition at MJ-scale energies available at the National Ignition Facility (NIF) and developing an understanding of direct-drive physics using experiments on the NIF. Direct-drive designs require reaching central stagnation pressures in excess of 100 Gbar. The current experiments on OMEGA have achieved inferred peak pressures of ~56 Gbar. Extensive analysis of the cryogenic target experiments and two- and three-dimensional simulations suggest that power balance, target offset, target quality, target mounts, and modeling uncertainty are the major contributors to the performance degradation. These limitations lead to both breakup of the compressed shell during deceleration caused by long-wavelength nonuniformity growth and mix of cold DT and ablator material into the hot spot caused by growth of target imperfections. The near-term (next five years) plan for reaching hydrodynamic equivalence on OMEGA includes improving laser power balance and target quality at shot time, as well as reducing coupling losses caused by cross-beam energy transfer. This talk will summarize the latest results in DD implosions and discuss the plans for demonstrating DD ignition.

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