A Multi-Dimensional View of the U.S. Inertial Confinement Fusion Program

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The U.S. Inertial Confinement Fusion (ICF) Program is pursuing three major approaches with a goal of achieving multi-mega-Joule fusion yields in the laboratory: laser indirect drive (LID), laser direct drive (LDD), and magnetic direct drive (MDD), each with unique physics and engineering challenges. There are, however, many commonalities in the plasma conditions and dynamics that occur near peak compression (termed stagnation), the need for new diagnostic capability, and the need to control laser plasma instabilities (LPI). Greater cross-fertilization of expertise and ideas across the national program combined with advancements in experimental methods and new technologies is leading to new insights into the physical processes of each approach. In LID, higher adiabat implosions with high density carbon and beryllium ablators have been performed on the National Ignition Facility (NIF). A shift to lower-gas-fill hohlraums have produced implosions that are in better agreement with modeling, and advanced hohlraum experiments have begun using foam liners to reduce wall motion. Additional experiments clearly show the effects of shadowing by the fill tubes on implosions, and diagnostic enhancements are providing more information on the properties of the hot fuel and colder compressed deuterium-tritium shell. In LDD, hydro-equivalent implosions are being pursued on OMEGA with the goal of advancing hot spot pressures from 50 to 100 Gbar. Parallel efforts are underway to understand the length and temperature scaling of hydro-equivalent implosions and laser energy coupling from OMEGA to NIF, while LPI mitigation and control experiments are being performed on NIF, OMEGA, and Nike, all linked via a common LPI modeling platform. In MDD, experiments at NIF, OMEGA, and Z have demonstrated effective gas heating for the laser preheating phase of the Magnetized Liner Inertial Fusion (MagLIF) approach with a significantly reduced effect of LPI at 2ω wavelengths. Integrated MagLIF experiments on Z have demonstrated key elements of the concept including fuel preheating, magnetic flux compression, and robustness in the target performance across a range of drive current, preheat, and liner conditions.

This talk reviews the status and future outlook of U.S. efforts in ICF through a comparison of the common challenges and key differences of the three major approaches and highlights of recent accomplishments and future plans.

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