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The Quest For Laboratory Inertial Fusion Ignition in the US

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Ignition and significant fusion yield from Inertial Confinement Fusion (ICF) remains a grand scientific challenge. The ICF community in the US, together with international collaborators is executing a coordinated effort exploring 3 approaches to ignition each with different risks and advantages: laser driven x-ray drive, laser direct drive, and magnetic direct drive. This talk presents the status and future focus of these approaches in the US.

X-ray drive is pursued at the National Ignition Facility (NIF). In this approach ˜ 1.8 MJ of laser light illuminates a cylindrical gold hohlraum to produce a highly uniform x-ray field to implode a spherical capsule containing DT fuel. The original ignition target design gave fusion yields (˜2kJ or ˜5x1014 neutrons) far from ignition because of the challenging hydrodynamics associated with the high (˜35X) convergence ratio (CR) compounded by laser plasma instabilities (LPI) in the hohlraum introducing strong time dependent drive asymmetry. A more stable, lower CR variation of that design resulted in yields approaching 1016 neutrons (˜26kJ) and for the first time demonstrated significant alpha self-heating that roughly doubled the fusion yield. It has become clear that further improvements in performance will require better control of the implosion shape by reducing the LPI that currently prevents the precision drive symmetry needed for ignition as well as improved capsule mounting schemes that perturb the implosion less.

In laser direct drive (LDD) the capsule is directly irradiated spherically with laser light. This couples more energy to the fuel than in x-ray drive reducing the capsule convergence ratio needed for ignition to ˜ 20 at NIF's energy. However, the proximity of the laser to the capsule places stringent demands on the laser target coupling uniformity and the allowable levels of LPI. The laser coupling and hydrodynamics of LDD are being refined at the LLE's Omega laser in hydro-scaled targets with laser imprinting and LPI mitigation being studied in collaboration with NRL.

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