THE QUEST FOR LABORATORY INERTIAL FUSION BURN IN THE US

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Ignition and significant fusion yield from Inertial Confinement Fusion (ICF) remains a grand scientific challenge with significant near-term and long-term applications. The ICF community in the US is executing a coordinated effort exploring 3 viable approaches: indirect laser drive, direct laser drive, magnetic compression. This relies on combined talents of people at national laboratories, universities, private companies and international partners, including experiments at the major facilities and coordinated diagnostic development, target fabrication and simulations. This talk presents the status of these approaches in the US.

Indirect drive is pursued at the National Ignition Facility (NIF) with contributions from the Omega laser and many people. The original target design used in the National Ignition Campaign gave fusion yields that were ~ a thousand times below ignition (defined by a neutron yield ~ $5x10^{17}$) because of both the challenging hydrodynamics associated convergence of ~35 times and the laser plasma instabilities (LPI) in the hohlraum. A variation of the laser pulse, that raised the capsule adiabat resulting in a less demanding implosion, has achieved yields approaching 10^{16} neutrons and for the first time demonstrated significant fusion heating contributions. It has become clear that further improvements require reductions of LPI that prevent the precision capsule drive control needed for ignition.

Direct drive is being refined at the LLE's Omega laser and at NIF with related work by the NRL to reduce laser imprinting and LPI. Modeling of laser coupling physics is being developed on Omega where layered DT ignition hydro-equivalent designs have achieved implosion performance, relative to that needed for ignition, comparable to that of indirect drive when scaled to spherical direct drive at NIF. Mitigation strategies for crossbeam energy transport (CBET) and other improvements have been identified that may lead to performance that scales to ignition at NIF.

At the Z facility at Sandia a new approach for compressing magnetized and laser-heated plasma is being tested. Integrated experiments have produced fusion-relevant temperatures, a highly-magnetized plasma and DD fusion neutron yields equivalent to ~10^{14} DT, demonstrating the basic physics of this approach. Experiments to advance this Magnetized Liner Implosion Fusion (MagLIF) concept are being performed at Omega, Z and Z-Beamlet, and NIF to explore target performance as a function of laser preheat, magnetic field, liner material and drive current.

At LANL a new "shock-shear platform" has been developed for NIF that allows seeing combined effects of plasma instabilities that may affect fusion performance. LANL also is leading to develop concepts for Beryllium ablators and for double shell targets that can be fielded at the NIF.

At US universities and the laboratories, with international collaborators, a number of fundamental physics phenomena at high energy density are being studied as well as phenomena of astrophysics interest and basic materials behavior at high pressures. Some of these studies are advanced to Omega and NIF lasers and Z and have significant impact in their fields.

Emphasis of the talk will be on possible routes to inertial fusion ignition and burn.
Over the next few years, alternatives for future directions will be considered.

Laboratory representative consulting on this talk are: John Edwards and Joe Kilkenny (LLNL), Craig Sangster and Mike Campbell (LLE), Steve Batha (LANL), Dan Sinars (SNL), Steve Obenschain (NRL), Christina Back (GA), Nicole Petta (Schafer), Rich Petrasso (MIT).

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