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Overview and Status of Direct-Drive Inertial Confinement Fusion in the United States

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Direct-drive (DD) inertial confinement fusion (ICF) offers a potential path for high yield and ignition. Two approaches –Laser Direct Drive (LDD), being pursued primarily at the OMEGA laser and the National Ignition Facility (NIF), and the Magnetized Liner Inertial Fusion (MagLIF), being pursued primarily at the Sandia National Laboratories, will be discussed in this talk. In LDD nominally identical laser beams are used to drive an imploding cryogenic shell on OMEGA to obtain high pressures and temperatures in a hot spot surrounded by a cold fuel. The goal is to obtain ignition-relevant hot-spot pressures in OMEGA-scale cryogenic deuterium–tritium layered implosions. Hot-spot pressures up to 56⊠7 Gbar have been demonstrated in these implosion experiments. In addition, recent implosion results when scaled to NIF energies are predicted to produce fusion yields approaching 300 kJ. Experiments on the NIF are additionally used to address the MegaJoule-scale physics such as laser coupling and preheat from energetic electrons. In the MagLIF approach, a 1kJ, 1TW laser pulse is used to preheat the plasma just as the 16 MA current begins to quasi-adiabatically compress the pre-magnetized deuterium. Promising ion temperatures (˜ 3KeV) and neutron yields (5x1012 DD neutrons) have been obtained with MagLIF experiments at relatively low implosion speeds of ˜7 ⊠ 106 cm/s, indicating successful magnetic flux compression and decreased thermal conductivity losses required for ignition. Ignition remains a challenge for both the direct-drive approaches, including improving understanding of the plasma conditions, controlling nonuniformity, improving laser coupling, and developing enhanced diagnostics. The motivation, challenges, and status of direct-drive research in the United States is presented in this talk. This material is based upon work supported by the Department of Energy National Nuclear Security Administration under Award Number DE-NA0001944, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

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