Progress in Direct Drive Inertial Confinement Fusion: Conventional and Shock Ignition

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Direct laser illumination of spherical targets (direct drive) is a flexible scheme to implode shells of cryogenic DT to achieve ignition conditions. It enables different ignition concepts to be explored and tested on current laser facilities. The conventional direct-drive approach uses thin shells of DT driven to high implosions velocity ~400 to 500 km/s. The imploding shell acts as a spherical piston heating and compressing the central low-density DT plasma. At stagnation, the fuel assembly consists of a central hot DT plasma (the hot spot) surrounded by a dense DT shell. Because of the high velocity, the hot spot is heated to ignition temperature of ~5 keV and the dense shell is compressed to a few hundred g/cc. The shell is kept at relatively high adiabats ($\alpha > 3$) to maintain good hydrodynamic stability. In shock ignition, the DT shell is much thicker and massive, driven at low implosion velocities of about 200 km/s and low adiabats to achieve high areal density. Because of the low adiabat and low velocity, the central hot spot is relatively cold (few keV), far from the ignition conditions. A carefully timed strong shock (>300 Mbar) is launched at the end of the laser pulse through a spike in laser power to compress the hot spot to ignition temperatures and pressures. While shock pressures >300 Mbar cannot be achieved on OMEGA in current DT layered implosions due to power limitations, the shock ignition scheme can be studied using a moderate power spike at the end of the pulse. Recent progress in both conventional and shock ignition are described and the outlook for ignition experiments with a laser of megajoule scale is discussed. This material is based upon work supported by the Department of Energy National Nuclear Security Administration under Award Number DE-NA0003856.