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ICF Ignition, the Lawson Criterion, and Comparison with MFE Ignition[1]

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The Lawson criterion, which determines the onset of thermonuclear ignition, is usually expressed through the product $p\tau >$ 10 atm $\cdot$ s, where p is the plasma pressure in atm and τ is the energy confinement time in seconds. In magnetic fusion devices, both the pressure and confinement time are routinely measured and the performance of each discharge can be assessed by comparing the value of $p\tau$ with respect to the ignition value (10 atm $\cdot$ s). In inertial confinement fusion, both p and τ cannot be directly measured and the performance of surrogate and/or subignited ICF implosions cannot be assessed with respect to the ignition condition. This makes it difficult to compare the performance of ICF implosions with that of magnetic fusion energy (MFE) discharges. Here, we define the meaning of ignition in ICF implosions and compare it to MFE ignition. We then show that a multidimensional ignition condition for inertial confinement fusion can be cast in a form that depends on three measurable parameters of the compressed-fuel assembly: the hot-spot ion temperature T, the neutron yield normalized to the 1-D prediction (yield over clean or YOC) and the total areal density ρR, which includes the cold shell's contribution. A family of marginal-ignition curves are derived in the ρR–T plane.[2] On this plane, hydrodynamic-equivalent curves show how a given implosion would perform with respect to the ignition condition when the laser-driver energy is varied. Such a criterion can be used to measure the ignition margin[3] of NIF targets and to predict the performance of OMEGA targets when scaled up to NIF energies. This work has been supported by the US Department of Energy under Cooperative Agreement Nos. DE-FC02-ER54789 and DE-FC52-08NA28302.

[1]In collaboration with P.Y. Chang, R. Nora, K.S. Anderson (LLE, FSC), D. Shvarts (NRCN), B. Spears (LLNL).
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