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Burning and ignited plasmas at the National Ignition Facility*

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Thermonuclear fusion in the laboratory is a scientific grand challenge, a highly compelling problem because the fusion reactions can self-heat the fuel and continue the burn. Predominantly approaches use the fusion of deuterium and tritium nuclei, which generates 17.6 MeV of energy released in a neutron and alpha particle. The alpha particle, which carries 1/5 of the energy, can heat the plasma. A plasma in which the alpha self-heating is greater than external heating is termed a 'burning plasma', and one in which the self-heating dominates over all loss mechanisms, leading to a run-away increase in temperature, is termed 'ignited'. Inertial confinement fusion (ICF) has pursued these scientific milestones using large laser drivers, notably the National Ignition Facility (NIF) at LLNL. Here we use the laser energy, up to 1.9MJ, to generate a hot x ray bath, which creates ablation pressures of hundreds of Mbar at the outer surface of a fuel-containing capsule. The ablation pressure implodes the capsule, with fuel pressures of several hundred GBar generated as the fuel stagnates at the center. The combination of these extreme pressures and inertial confinement times from the surrounding material can lead to burning and ignited plasmas. Experiments on NIF first passed the burning plasma threshold[1][2] and have since passed Lawson's criteria for ignition and produced a fusion yield in excess of a megajoule, conditions that were previously inaccessible in the laboratory.

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References

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