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Three-dimensional effects in vorticity production, cellular instabilities, and transition to turbulence in focused-laser-induced ignition kernels JONATHAN F. MACART, JONATHAN M. WANG, JONATHAN B. FREUND, University of Illinois at Urbana-Champaign — Ignition of combustible mixtures via laser-induced breakdown (LIB) involves interactions between thermal, chemical, and hydrodynamic processes. An initially axisymmetric plasma core has large density, pressure, and velocity gradients that lead to vorticity production, collapse of the plasma core, and a transition to three-dimensional evolution. These stages and their co-evolution with the thermochemical state are investigated in lean hydrogen-oxygen premixtures using three-dimensional detailed numerical simulations, in which the compressible Navier-Stokes and reactive species equations are solved assuming local thermodynamic equilibrium and charge neutrality. The initial LIB and gasdynamics are simulated in auxiliary calculations employing a two-temperature non-local thermodynamic equilibrium kinetic model and a radiative transfer equation. Three-dimensional vorticity is observed in the plasma core, but this initial vorticity diffuses during the collapse of the core and transition to laminar burning. After an initial period of laminar propagation, the flame develops a cellular instability, which accelerates the flame-front and produces flame-front vorticity leading to sustained turbulence.

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