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Hydrodynamic Ejection from a Laser-induced Breakdown and its Implications for Ignition JONATHAN WANG, University of Illinois at Urbana-Champaign, DAVID BUCHTA, JONATHAN MACART, The Center for Exascale Simulation of Plasma-coupled Combustion, University of Illinois at Urbana-Champaign, JONATHAN FREUND, University of Illinois at Urbana-Champaign — Optical breakdown of a gas by a focused laser produces a high-temperature, high-pressure plasma kernel that expands rapidly and, in some cases, ejects hot gas along the laser axis. Traveling as a hot vortex ring, this ejected gas can reach distances several times the size of the plasma kernel and, in a combustible mixture, initiate flame growth away from the laser focal region. Under certain conditions (e.g. sub-atmospheric pressure), however, the ejection can fail to form or even reverse direction, altering the distribution of heat and radical species necessary for ignition. Detailed simulations of a model kernel, confirmed to reproduced key experimental observations, show how the ejection and its reversal are caused by two primary mechanisms of vorticity production: tangential variations in the strength of the shock produced by the breakdown, and baroclinic generation in the trailing rarefaction. Relatively mild changes in the early-time kernel geometry alone—including, for example, a 20% increase in overall aspect ratio—can alter the subsequent interaction of auto-advecting vorticity and ultimately precipitate ejection failure or reversal. The ejection influences ignition via the competing effects of strain and heating.

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