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Ignition of a fuel–oxidizer interface by laser-induced breakdown[1]

JONATHAN WANG, University of Illinois at Urbana-Champaign, JONATHAN MACART, University of Notre Dame, JONATHAN FREUND, University of Illinois at Urbana-Champaign — Laser-induced breakdown of a gas produces a high-temperature plasma kernel that expands rapidly and ejects hot gas that can travel several times the kernel size to ignite fuel. Using detailed simulations, we show that the post-breakdown flow and ignition dynamics of such a configuration are highly sensitive to breakdown proximity to the fuel–oxidizer interface and molecular weight disparity. The breakdown-induced flow can enhance, delay, or completely suppress ignition depending on these factors and even subtle alterations to the plasma kernel geometry. This is especially pronounced for a hydrogen–oxygen system. The heat of radical recombination is also surprisingly important as relaxing kernel remnants advect towards fuel. The induced-flow sensitivity can be leveraged in a homogeneous-mixture dual-pulse configuration, where pulse timing and position can enhance dispersal of hot gas and increase the burning rate of nascent flames. Hydrodynamic coupling with the nonequilibrium plasma is also assessed, and it is found that electron recombination can enhance the plasma kernel expansion.

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