IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Novel approaches in non-equilibrium combustion control and energy conversion

James B. Michael
Iowa State University

January 27, 11:00-11:50 a.m.
2004 Black

Abstract

The urgency of environmental change and high fuel costs continue to drive engine design requirements towards higher efficiency and lower pollution standards. These increased regulatory standards require critical insight into the design of every stage of combustion engines—ranging from fuel injection to aftertreatment systems. This progression has pushed existing combustion technology to challenging operational limits. Plasma-assisted combustion offers an opportunity to continue to advance these technologies for more efficient combustion systems. In addition, plasma and non-equilibrium processes are important to a number of modern engineering applications, ranging from plasma-assisted fuel and pollutant processing to specialty materials fabrication. This talk focuses on several novel approaches of plasma-assisted combustion and the non-equilibrium dynamics involved. Plasma-assisted combustion offers the potential to expand the operating ranges of combustion and air-breathing propulsion devices with efficient, tailored deposition of energy. Two strategies are discussed: (1) the interaction of pulsed microwave radiation with hydrocarbon flame fronts, and (2) ignition via strong coupling between low intensity microwaves and ultrafast laser-generated ionization. Direct microwave plasma generation and heating allows sustained flame propagation at ultra lean conditions well beyond the normal flammability limit. The separate problem of ignition is examined with a combined laser-microwave plasma. Both types of interactions are shown to be efficient and well-localized, allowing for good spatial and temporal control.

In addition, the role of state-of-the-art laser diagnostic measurements in reacting systems are discussed. Both multi-kHz pulsed laser systems and innovative diagnostic approaches including molecular flow-tagging and backward air lasing offer revolutionary new capabilities for measurements of thermochemical and thermo-fluid systems. These measurements are critical to a well-developed understanding of the important underlying mechanisms common to multiphase and multiscale phenomena, including turbulent combustion and non-equilibrium processes. Advances in these diagnostic approaches and future research prospects of plasma-enhanced combustion and laser-plasma interactions will be discussed.

Biography

James B. Michael received his undergraduate degree from the University of Maryland, College Park in Aerospace Engineering (2003). He received his Ph.D. from Princeton University in Mechanical and Aerospace Engineering (2012) within the Applied Physics Group. He was the recipient of the National Defense in Science and Engineering Graduate Fellowship. He joined the Mechanical Engineering Department at Iowa State University in 2012 as a postdoctoral research associate. His research focuses on fundamental non-equilibrium and photophysical processes with the goal of employing these systems for engineering measurement and energy conversion applications. In addition, he has contributed to the development of diagnostic techniques for temperature measurement, molecular tagging velocimetry, trace species identification, and multi-kHz repetition rate time-resolved planar measurements in turbulent flames.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

www.me.iastate.edu