Boulder Fluid and Thermal Sciences Seminar Series

Thursday, May 4, 2017
9:30am-10:30am (refreshments at 9:15am)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado, Boulder

Advanced Laser Diagnostics for Turbulent, Multiphase, and Reacting Flows

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Turbulent, multiphase, and reactive flows underpin the operation of modern combustion systems, which account for the majority of the world's energy usage and will continue to do so for the foreseeable future. Applications, which range from power generation to transportation, will rely on advancements in energy-conversion systems that simultaneously increase efficiency, decrease emissions, and offer increased fuel flexibility. However, such advancements are quite challenging due to the complex (and often dynamic) coupling of turbulent fluid dynamics and chemistry over a broad range of length and time scales. Over the last several decades, the use of non-intrusive laser diagnostics in experimental fluid and combustion research has evolved from a luxury to a near necessity in order to decipher the coupled and multi-scale processes underpinning turbulent combustion systems. Such measurement capabilities have played a critical role in providing new fundamental insight on processes include reactant mixing, flame stabilization, ignition and extinction, dynamic instabilities, and the identification of rare, but extremely important, events including engine misfire, flashback, and flame blowoff.

In this seminar, I will discuss the development and targeted application of quantitative laser-based measurements for examining and understanding flow turbulence, mixing, and turbulence-chemistry interaction in turbulent, multiphase, and reacting flow environments. First, I will describe our efforts in high-speed measurements for investigating temporally evolving flows and transient events. Our research involves the development and application of a unique high-energy pulse burst laser system (HEPBLS), which allows the generation of ultra-high pulse energies at repetition rates >> 1 kHz. Such a system provides opportunities to utilize many combustion diagnostics traditionally limited to low acquisition rates for the investigation of turbulence and combustion dynamics. Specifically, I will focus on recent advancements in multi-kHz-rate Rayleigh/Raman scattering in turbulent flows and flames and the application to simple jets, jet flames, and more complex auto-ignition environments.

I will discuss new advancements in laser-based measurement approaches that have been the focus of our recent research. This includes the application of filtered Rayleigh scattering (FRS) for multi-dimensional temperature imaging in turbulent non-premixed flames in the presence of particles. Specifically, FRS allows both (i) simultaneous temperature and PIV-based velocity measurements in order to examine the relationship between flow field kinematic properties and scalar gradients and (ii) temperature measurements in sooting flames. FRS also is applied to spray flows for quantitative mixing measurements in the presence of liquid-phase droplets. Finally, I will describe a new high-resolution velocimetry technique using a wavelet-based optical flow methodology applied to both scalar and "seed particle" fields. The approach is shown to be accurate and yields a dense velocity vector field; that is, a velocity measurement at each camera pixel, which is in stark contrast to standard correlation-based methods (i.e., PIV).

Biography: Jeffrey A. Sutton received his Ph.D. (2005) in Aerospace Engineering from the University of Michigan and subsequently accepted a National Research Council Postdoctoral Fellowship within the Chemistry Division of the Naval Research Laboratory in Washington, D.C. In 2008, Prof. Sutton joined the faculty at Ohio State University, where he is currently an Associate Professor in the Department of Mechanical and Aerospace Engineering. Prof. Sutton's current research interests include turbulent mixing and combustion, the development and application of advanced laser diagnostics, vaporization and gas-phase mixing in turbulent sprays, auto-ignition dynamics, particle-laden flows, and turbulent sooting flames. Prof. Sutton is an Associate Fellow of AIAA, Associate Editor of the Proceedings of the Combustion Institute and author of more than 100 journal and conference publications. He is the recipient of the National Science Foundation CAREER award, the Air Force Office of Scientific Research Young Investigator Program award, the Ohio State University College of Engineering Lumley Research award, and the Distinguished Paper award at the 31st International Symposium on Combustion.