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Title: Novel Laser Ignition Technique Using UV Pre-ionization and Recent Developments in Femtosecond Diagnostics for Combustion

Abstract:

The seminar discusses two inter-related topics: (I) Laser Ignition and (II) Recent developments in femtosecond diagnostics.

Conventionally, laser ignition is achieved by tightly focusing a high-power q-switched laser pulse until the optical intensity at the focus is high enough to ionize the gas molecules. This leads to the formation of a spark that serves as the ignition source in engines. However, such an ionization technique is energetically inefficient as the medium is transparent to the laser radiation until the laser intensity is high enough to cause gas breakdown.

The work to be presented addresses this issue by introducing a novel approach based on a dual-pulse pre-ionization scheme. The technique works by decoupling the effect of the two ionization mechanisms governing plasma formation: multiphoton ionization (MPI) and electron avalanche ionization (EAI). An UV nanosecond pulse (λ=266 nm) is used to generate initial ionization through MPI. This is followed by an overlapped NIR nanosecond pulse (λ=1064 nm) that adds energy into the pre-ionized mixture into a controlled manner until the gas temperature is suitable for combustion (T=2000-3000 K).

Another area of research that is generating an increasing interest in the plasma-assisted combustion community is the development of laser spectroscopic methods for flame characterization. The current state of the art relies heavily on nanosecond laser technology. However, recent advances in ultra-short (femtosecond) high-power lasers opens new opportunities for the development of novel non-invasive diagnostics techniques with high temporal and spatial resolution. An example is the femtosecond two-photon absorption laser-induced fluorescence (fs-TALIF) technique that is currently being developed at the EM2C laboratory. The high laser fluence of the femtosecond laser enables the development of a quench-free measurement. This expands the capability of current ns-TALIF to measure important combustion species such as CO, O, H, N at above-atmospheric pressure conditions, making them relevant tools for reciprocating and jet engines.

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- Short Bio –

Ciprian Dumitrache is a postdoctoral research fellow at the Laboratoire d'Energétique Moléculaire et Macroscopique, Combustion (EM2C) of Ecole CentraleSupelec in Paris, France. His current research interests include the development of femtosecond laser diagnostics for plasma and combustion applications, numerical modeling of plasma induced hydrodynamics, plasma kinetics, and plasma-assisted combustion. Dr. Dumitrache received his undergraduate degree in Aerospace Engineering from University "Politehnica" of Bucharest in 2010. In the fall of 2011, Dr. Dumitrache was awarded a 9-month Fulbright grant to pursue his graduate studies at Georgia Institute of Technology. He earned his MSc in Aerospace Engineering in 2012 with a thesis on active control of combustion instabilities in liquid rocket engines (project funded by the US Air Force). Between 2013 and 2017, Dr. Dumitrache pursued a PhD degree at Colorado State University where he worked under the guidance of professor Azer P. Yalin on the development of a novel laser ignition technique using dual-pulse pre-ionization. During his doctoral studies he was the recipient of the prestigious AIAA Gordon C. Oates Airbreathing Propulsion Award and the CSU Drivers for Innovation Award.