DEPARTMENT OF MECHANICAL ENGINEERING
WILLIAM MAXWELL REED SEMINAR SERIES

"Unraveling the Mechanisms of Particle Nucleation in Flames"

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Abstract: Flame-based technologies have ancient origins and, despite their undesirable environmental impact, are foreseen to remain dominant to address worldwide growing energy needs in the next four decades, including electric power generation and aviation propulsion. Many combustion processes involve the formation of particles that are either pollutants, primarily in the form of a carbonaceous material (i.e., soot) or, in some cases, engineered materials for commercial applications (e.g., carbon black, fumed silica). A fundamental and detailed understanding of the physics and chemistry at play behind the formation of particles in flames is still incomplete, despite several decades of intense research in this area. Unravelling the mechanisms which cause the reactants to transition to particles is crucial from a fundamental perspective, but has also a practical impact. The ability to predict and control the relevant kinetics may yield substantial improvements in energy conversion applications, through both the abatement of pollutant particle emissions which affect climate, environment and human health, and the ability to manufacture new materials with improved performances. To achieve this goal, I interrogated experimentally both the growth chemistry of the gas phase and the physics of the aerosol in the nanometric dimensional scale of relevance to particle nucleation. I will present an overview of the results obtained with the approaches I developed to retain spatial resolution while monitoring the perturbation of the flame and possible modifications of the sample. One approach provided an extensive and spatially resolved experimental database of the gas phase of a variety of flames, even at high pressures. The database includes quantitative concentration profiles of multi-ring polycyclic aromatic hydrocarbons whose chemistry is key in the path to nucleate soot particles. Other approaches brought to bear with the application of novel instrumentation allow for the dimensional and chemical characterization of the smallest nuclei in the (sub-) nanometric dimensional range, encompassing both molecules and particles. The introduced novelties not only highlighted quantitative and fundamental problems in the existing soot literature but, more generally, provided tools to shed light on the particle nucleation process in flames.

Bio: **Francesco Carbone** is an Associate Research Scientist in the Department of Mechanical Engineering and Materials Science at Yale University. His research focuses on multiphase reactive flows for energy applications and encompasses reaction kinetics, transport phenomena and aerosol dynamics. He authored twenty-five articles on peer-reviewed journals and contributed to the understanding of the chemistry of hydrocarbon fuels in flames and of the fundamental mechanisms leading to pollutant nanoparticle emissions from combustion applications. After graduating with a PhD in Chemical Engineering from the University of Naples Federico II (Italy), he held research positions in the Combustion Research Institute at the National Research Council (Italy, 2009-2010), in the Department of Mechanical Engineering at Yale University (2010-2012), in the Department of Aerospace and Mechanical Engineering at the University of Southern California (2012-2014), and again in the Department of Mechanical Engineering and Materials Science at Yale University (2014-present).

Date: Wednesday, Feb. 13th
Time: 3PM
Place: CB 114
Contact: Dr. Alexandre Martin 257-4462

Meet the speaker and have refreshments
Attendance open to all interested persons

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