Our Mission

To provide the next generation of combustion researchers with a comprehensive knowledge in the technical areas of combustion theory, chemistry, experiment, computation and applications.

The 2023 Session

The 2023 Princeton-Combustion Institute **Summer School on Combustion and the Environment**, scheduled for **June 25 to June 30, 2023,** will offer the following courses: (1) Combustion Theory and Applications in CFD; (2) Fuel Chemistry and Combustion Kinetics; (3) Particulate Formation, Evolution, and Fate; (4) Mitigating the Carbon Footprint of Combustion through CO_2 Capture and Storage; (5) Combustion of Energetic Materials; (6) Combustor Physics: Emissions and Operability.

Application Materials

Submit application at https://cefrc.princeton.edu/combustion-summer-school by March 15, 2023. Acceptance will be communicated by April 5, 2023.

Program Dates

Arrival & Welcome Dinner: Sunday, June 25, 2023; dinner at 6:30pm
Class Schedule: Monday, June 26, to Friday, June 30, 2023
Celebration & Farewell Banquet: Thursday, June 29, 2023
Departure/Check Out: Friday, June 30, 2023

Course Description

Combustion Theory and Applications in CFD (Monday-Friday)
Lecturer: **Heinz Pitsch**, RWTH Aachen University, Germany
Course Content: Fundamental knowledge in laminar and turbulent combustion, applications in CFD, machine learning and data analysis: laminar premixed and diffusion flame structure, flammability limits, laminar flame simulations using the FlameMaster code, introduction to turbulence, DNS and LES, turbulent combustion and modeling, CFD and numerical combustion with application to internal combustion engines and gas turbines. Focus topic: Hydrogen combustion.

Fuel Chemistry and Combustion Kinetics (Monday-Friday)
Lecturer: **S. Mani Sarathy**, KAUST, Saudi Arabia
Course Content: The course will cover the development of large databases of chemical reaction pathways with associated kinetic rate parameters, as well as thermochemical and transport properties for all reactant, intermediate, and product species. First, the mapping out of detailed reaction pathways at the temperatures and pressures relevant to chemical reactors and combustion applications will be discussed. Next, the art of assigning rate constants using chemical intuition and quantum chemical modeling will be covered. The determination of thermochemical and transport properties is achieved using both molecular modeling tools and empirical methods. The comprehensive models are then validated against data from well-defined experimental configurations using zero-dimensional and one-dimensional reacting flows whose physics can be simulated exactly. These models are finally employed to determine the thermal degradation and oxidation pathways relevant to the prediction of combustion performance in practical applications. The course will provide key insights into the chemical kinetics of complex hydrocarbon fuels (e.g., gasoline, diesel, jet, and heavy oils) and renewable e-fuels such as hydrogen and ammonia.

Particulate Formation, Evolution, and Fate (Monday-Wednesday)
Lecturer: **Hope A. Michelsen**, University of Colorado Boulder, USA
Course Content: A great deal of mystery surrounds the formation of soot, the carbonaceous particles produced from incomplete combustion or pyrolysis of hydrocarbons. This course will delve into the mystery of soot formation, introducing the various theories of soot inception and growth and the clues derived from measurements. We will discuss the measurement methods available for probing identities of particle precursors, characteristics of incipient particles, and evolution of particle fine structure, size, and morphology. We will also discuss the evolution and fate of these particles once emitted into the atmosphere.

Course Description (continued...)

Mitigating the Carbon Footprint of Combustion through CO_2 Capture and Storage (Thursday-Friday)

Lecturer: **Howard J. Herzog**, Massachusetts Institute of Technology, USA

Course Content: The combustion of fossil fuels with its release of CO_2 to the atmosphere is the number one contributor to climate change. Through carbon capture technologies, it is possible to capture the CO_2 produced by combustion and prevent it from being emitted to the atmosphere. This course will cover the following topics: climate change fundamentals and the role of CO_2; approaches to carbon capture, including post-combustion, oxy-combustion, and pre-combustion; novel combustion processes aimed at facilitating CO_2 capture; what to do with the captured CO_2 (CO_2 storage and utilization); and carbon removal (creating offsets by removing CO_2 from the atmosphere).

Combustion of Energetic Materials (Monday-Wednesday)

Lecturer: **Richard A. Yetter**, Pennsylvania State University, USA

Course Content: This course will cover fundamentals of energetic materials combustion including experimental techniques and theoretical and numerical analyses, the classification of energetic materials, and application examples. The burning behavior, chemistry, and flame structure of solid propellants, as well as the ignition and combustion of particulate metals will be discussed. Nanoengineered energetic materials, the roles of self-assembly and additive manufacturing, and the integration of nanoenergetics into microsystems will be presented. Future directions and research needs will be summarized.

Combustor Physics: Emissions and Operability (Thursday-Friday)

Lecturer: **Timothy C. Lieuwen**, Georgia Institute of Technology, USA

Course Content: These sessions will present a unified treatment of the coupled flame dynamic, acoustic, and fluid mechanic processes that control combustor emissions and operational characteristics, such as in gas turbines or boilers. We will also discuss these issues in the context of cycles for net-zero CO2 emissions concepts. First, we will overview the interacting processes associated with practical combustors- namely flame stability, flashback and autoignition avoidance, pollutant emissions, and thermoacoustic instability. Then we will delve into fundamental physical processes associate with each of these issues. Content will include: acoustics of combustion systems, hydrodynamic stability of reacting flows and flame aerodynamics, flame stretch, flame extinction, edge flames, flame stability, and response of flames to flow disturbances.

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