COMBUSTION WEBINAR

Data-Based Modeling in Turbulent Combustion: From Traditional Paradigms to Applications in Data Science

Speaker: Tarek Echekki, North Carolina State University

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Biography: Dr. Tarek Echekki is a Professor at the Department of Mechanical and Aerospace Engineering at North Carolina State University (NC State) since 2002. He received his PhD in Mechanical Engineering from Stanford University in 1993. Subsequently he held different research positions at the French Petroleum Institute (92-94), Sandia National Laboratories (94-96, 98-01) and the University of California at Berkeley (97-98). Prof. Echekki's research interests are in combustion theory and turbulent combustion modeling. His most recent work has focused on the development of multiscale and data-based modeling frameworks to overcome challenges in turbulent combustion closure and to accelerate the simulation of turbulent reacting flows.

Prof. Echekki is a Fellow of the American Society of Mechanical Engineers and an Associate Fellow of the American Institute of Aeronautics and Astronautics. He is the co-editor, with Prof. Epaminondas Mastorakos (University of Cambridge), of "Turbulent Combustion Modeling – Advances, New Trends and Perspectives" (Springer, 2011). He also serves as Associate Editor for ASME Journal of Heat Transfer.

Abstract: Data has played a central role in combustion modeling. Data from time or space-resolved mutli-scalar measurements has helped accelerate the development and validation of turbulent combustion models. A number of state-of-the-art models, such as the flamelet approach, rely on data tabulated from canonical low-dimensional reactor simulations as an integral part of their closure. With the increasing availability of simulation and experimental data, additional opportunities have arisen. These opportunities are related to the construction of turbulent combustions starting from simulation, experiments or multi-source and heterogeneous data. Ideas and proposals for research opportunities to develop data-based modeling frameworks are presented. Machine learning provides important and alternative set of tools to enable a robust implementation of such frameworks. As an illustration, a novel framework for developing closure models in turbulent combustion using experimental multi-scalar measurements is discussed. The framework is based on the construction of conditional means and joint scalar PDFs from experimental data based on a low-dimensional manifold derived from the data using principal component analysis (PCA). The resulting principal components (PCs) act as both conditioning and transported variables. Strategies for the construction of statistics, the recovery of missing species and the development of closure models for PCs chemical source terms are discussed and future extensions are identified. Results of the framework's *a posteriori* validation on two laboratory-scale flames, the Sandia and the Sydney flames, are presented.

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