Boulder Fluid and Thermal Sciences Seminar Series

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3:30pm-4:30pm (refreshments at 3:15pm)
Fleming 157
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Turbulent Combustion Modeling: A Combustion Perspective and a Turbulence Perspective

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Turbulent combustion modeling is a challenging multi-physics, multi-scale modeling problem. Both turbulence and combustion are already difficult multi-scale modeling problems, and the combination of the two brings in new interactions across various length scales and time scales that fundamentally change both the combustion processes and the turbulence. However, the prevailing practice in turbulent combustion modeling is to essentially decouple the two phenomena and approach the problem from independent combustion and turbulence modeling perspectives. From the combustion perspective, we have developed computationally efficient models for describing “multi-modal” turbulent combustion, that is, combustion beyond the asymptotic “modes” of premixed flames, nonpremixed flames, and homogeneous chemistry. As a first step of development, we developed models that locally identify the appropriate asymptotic mode. More recently, we developed a new approach that captures not only the three asymptotic regimes but also intermediate regimes at essentially the same computational cost as simpler approaches. From the turbulence perspective, which has received far less attention, we have utilized full-fidelity “numerical experiments” to identify the regimes in which combustion heat release can fundamentally alter turbulence. Based on the physical insights from these simulations, we developed new algebraic turbulence models that directly leverage information about the underlying flame structure and qualitatively capture, for the first time in the literature, the effects of combustion heat release on turbulence. The seminar will conclude with a look forward and proposes a completely new framework for a unified approach to turbulent combustion modeling potentially capable of capturing far richer interactions between turbulence and combustion.

Biography: Michael E. Mueller is an Assistant Professor in the Department of Mechanical and Aerospace Engineering at Princeton University, an associated faculty member in the Princeton Institute for Computational Science and Engineering, and an associated faculty member in the Andlinger Center for Energy and the Environment. He received a BS degree in mechanical engineering from The University of Texas at Austin in 2007, a MS degree in mechanical engineering from Stanford University in 2009, and a PhD degree in mechanical engineering from Stanford University in 2012 before moving to Princeton in 2012. In 2017, he was recognized with an award through the Young Investigator Program (YIP) of the Army Research Office (ARO). His expertise is the computational modeling of turbulent reacting flows, where he utilizes a multi-fidelity approach leveraging first-principles calculations for physics discovery for the development of physics-based models for engineering calculations.