JOHNS HOPKINS
Center for Environmental & Applied Fluid Mechanics

FALL 2021 CEAFM VIRTUAL SEMINAR SERIES

"Predictive Unsteady Simulations of High-Speed Turbulent Flows"

Presented by Prof. Lian Duan
Ohio State University
Department of Mechanical and Aerospace Engineering
Hosted by Tamer Zaki (MechE)

The development of predictive computational fluid dynamics (CFD) tools is critical for the design of next-generation high-speed vehicles for routine and affordable rapid global transport and space exploration. So far, we have only limited understanding of the intricate interaction between turbulence and many important flow processes typical of high-speed flows, such as laminar-turbulent transition, shock wave-turbulence interaction, and thermochemical non-equilibrium. The lack of physical understanding and physics-based turbulence models will in turn result in unrefined and costly engineering designs. Predictive unsteady simulations such as direct numerical simulations (DNS) can provide detailed data that can be used to study critical turbulence phenomena and to develop physics-based turbulence models.

In this talk, I will first introduce a high-fidelity computational framework for DNS of high-speed turbulent flows. The numerical tool is capable of capturing flow features across a wide range of length and time scales, thus robust for a broad range of turbulent flow conditions, including flows containing shock waves and thermochemical non-equilibrium effects. Next, I will discuss an application of the DNS tool to characterize the freestream acoustic radiation from high-speed turbulent boundary layers. The study enabled the first digital simulation of the freestream acoustic disturbance environment in high-speed ground facilities - a groundbreaking achievement that has paved the way for improved ground-to-flight scalability of measurement data obtained in noisy wind tunnels. If time permits, I will introduce our broader effort of developing a benchmark quality DNS database of supersonic/hypersonic turbulent boundary layers for refining and validating Reynolds-Averaged Navier-Stokes (RANS) models.

Dr. Lian Duan is an associate professor and holder of Honda endowed chair in transportation in the Department of Mechanical and Aerospace Engineering at The Ohio State University (OSU). Before he joined OSU in September 2019, he was an assistant professor at Missouri University of Science and Technology from 2013 to 2019 and worked as a research scientist at the National Institute of Aerospace/NASA Langley Research Center from 2010 to 2013. He received his Ph.D. in Mechanical and Aerospace Engineering from Princeton University in 2011. Duan has held research grants with NSF, AFOSR, ONR, NASA, Sandia National Laboratory, and Honda R&D Americas on topics including (but not limited to) compressible turbulence, flow instability and transition, turbulence modeling and control, high-performance and data-driven computing, and automotive aerodynamics. The significance of his research has been recognized with several accolades including the 2017 Henry J. E. Reid Award (NASA Langley's top award recognizing technical excellence in research publications), 2014 AFOSR Young Investigator Award, 2015 AIAA St. Louis Section Young Professional Engineer Award, and multiple mentions in the annual highlights of Fluid Dynamics research in Aerospace America.

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