



ME Seminar



Advancing turbulence research: Data assimilation and sub-grid scale modeling

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ABSTRACT

Computationally efficient and accurate numerical models are central to advancing our understanding of turbulent flows and have wide-ranging engineering applications. This talk will focus on data assimilation and inverse problems in turbulence, with emphasis on adjoint-based methods for back-in-time tracking of extreme events and the optimal design of experiments. Using four-dimensional variational data assimilation (4DVar) with the Navier–Stokes equations, high-Reynolds-number turbulent boundary layers are reconstructed from spatio-temporally sparse experimental measurements, demonstrating the capability of physics-based assimilation frameworks in complex flows.

Sub-grid scale models, which play a crucial role in the computational description of turbulence, rely on assumptions about small-scale dynamics. Truncated inviscid hydrodynamic equations are used to develop a new class of sub-grid scale models. While numerical solutions of such ideal fluid equations tend toward thermal equilibrium—masking the true dissipative behavior—a physics-informed numerical method is introduced to suppress such thermalization, enabling the recovery of weakly dissipative solutions that effectively model fully developed turbulence.

ABOUT THE SPEAKER

Sugan Durai Murugan is a Postdoctoral Fellow in the Department of Mechanical Engineering at the Whiting School of Engineering, Johns Hopkins University. He received his Ph.D. in Physics from the International Centre for Theoretical Sciences, Tata Institute of Fundamental Research (ICTS–TIFR), and his B.Tech. in Mechanical Engineering from the Indian Institute of Technology Madras. His research focuses on high-fidelity direct numerical simulations and theoretical analysis to study turbulence.



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