ME Seminar

Modeling and simulations of transitional and turbulent variable-density flows

Sidharth GS, Iowa State University, USA

ABSTRACT

We will discuss a few research problems in variable-density compressible flows. Density variations on the order of mean density are encountered in many technological and natural flows and arise from compressibility, heat transfer, compositional inhomogeneity and/or reactions.

(1) To explicitly represent compressibility effects at the small scales, we derive a new form of governing equations for large eddy simulations, meaningfully simplifying the closure problem as it involves only double correlations, not triple and higher correlations that appear in conventional equations. We demonstrate the use of the new equations in complex flows.

(2) Diffusive models using gradient transport arguments are the norm in engineering turbulence closures. However, strong anisotropy and counter-gradient effects in variable-density flows require a more accurate representation. We re-examine gradient transport in the context of variable-density turbulence.

(3) Non-local linear instabilities can cause transition to turbulence in separated hypersonic boundary layers. Using global tools, we analyze global instabilities in separation zones and identify the role of centrifugal and deceleration effects in the instability mechanisms.

(4) Wall temperature plays a role in high-speed boundary layer transition. Recent experimental results on transition point to observations that cannot be explained by the boundary layer instability theory. We analyze the receptivity of high-speed boundary layers to freestream perturbations and find low-frequency regimes that suggest lower receptivity of cooled walls.

All of these efforts account to put engineering simulations of high-speed aerodynamics and propulsion on a first-principles basis.

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ABOUT THE SPEAKER

Dr. Sidharth GS is an Assistant Professor at the Department of Aerospace Engineering at Iowa State University. He was previously a postdoctoral researcher at the Los Alamos National Laboratory, where he worked on modeling mix and burn in multimaterial turbulence and separately on feature-based dynamic reconstructions. He received his PhD at the University of Minnesota specializing in computations of hypersonic flows and modeling variable-density subgrid effects relevant to supersonic combustion.

March 27, 2024, (Wednesday)
12:00 NOON, AR Auditorium