JOHNS HOPKINS
Center for Environmental
& Applied Fluid Mechanics

FALL 2020 CEAFM VIRTUAL SEMINAR

"Simulations of Particulate-Induced Transition in High-Speed Boundary-Layer Flows"

Presented by Prof. Christoph Brehm

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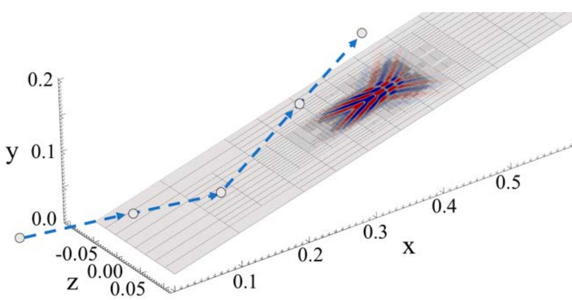
Hosted by Tamer Zaki (JHU - MechE)

Various types of particulates with different origins are present in the stratosphere and the role they play in the free-flight boundary layer transition process is not well understood. Atmospheric particulates impinging on the surface of high-speed vehicles trigger disturbances inside the boundary layer which evolve into wavepackets and through exponential growth can provide a path to turbulence. This talk will present particulate-induced transition simulation results for flow conditions relevant to high-speed flight through the atmosphere.



Particle-Induced Transition Simulation

In the first part of the presentation, a newly developed wavepacket tracking strategy coupled with a particle model will be presented. The wavepacket tracking approach, namely AMR-WPT (adaptive mesh refinement wavepacket tracking), relies on (1) the nonlinear disturbance flow formulation of the compressible Navier-Stokes equations, (2) a dual mesh overset approach, and (3) adaptive mesh refinement. The accuracy and efficiency of the AMR-WPT approach has been demonstrated for a wide range of transition mechanisms, e.g., receptivity, first and second mode, and cross-flow instabilities for 2-D and 3-D baseflows. To model particulate-induced transition, AMR-WPT was initially coupled with a particle solver based on the particle-in-cell approach. The second part of this talk will present a higher-fidelity simulation approach where the particle flow is fully-resolved utilizing an immersed boundary method in conjunction with the AMR-WPT method. Both methods are compared for first and second-mode dominated hypersonic transition prediction test cases. A detailed analysis of the simulation results provide insight into the relevant physical mechanisms involved in particle-induced transition. Finally, bi-orthogonal decomposition based on the continuous and discrete eigenmodes of the compressible boundary layer flow is employed to study the receptivity process.

Friday, October 16, 2020 at 3:00 PM

https://wse.zoom.us/j/93762992307