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THE HONG KONG UNIVERSITY OF SCIENCE & TECHNOLOGY

Department of Mathematics

PHD STUDENT SEMINAR

Wave-Particle Method for Wall-Bounded Turbulent Flows

By

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Abstract

This work proposes a unified framework for the direct modeling and simulation of wall-bounded turbulence. By extending a kinetic model equation to turbulent flows, the method establishes a consistent description of both laminar and turbulent motions through a wave–particle decomposition. Within this framework, the resolved background flow is represented by the wave component governed by the Navier–Stokes equations, while the unresolved turbulent dynamics are described through particle transport. To account for both the multiscale nature of turbulence and the observational scale imposed by numerical discretization, the method adaptively determines, within each control volume, the degrees of freedom required for turbulence representation based on the grid size, time step, and locally resolved flow structures, and subsequently constructs a nonequilibrium transport model for discrete fluid particles. The coupled evolution of the wave and particle components thus provides a scale-consistent description of the flow across different numerical resolutions. The proposed framework is evaluated through simulations of turbulent channel flow. The results demonstrate the expected asymptotic behavior under mesh refinement, yielding LES-like predictions at partially resolved scales and approaching DNS in the fully resolved limit. In addition, when the grid resolution is insufficient to capture the anisotropic near-wall structures, where the assumptions underlying LES models break down, particle generation and nonequilibrium transport remain capable of representing the associated anisotropic Reynolds stresses. These findings suggest that the proposed framework offers a promising multiscale methodology for the physically consistent simulation of wall-bounded turbulent flows.

Date : 5 May 2026 (Tuesday)
Time : 10:00am
Venue : Room 2612A (near Lift 31/32)

All are Welcome!