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**THE HONG KONG UNIVERSITY OF SCIENCE & TECHNOLOGY**

**Department of Mathematics**

# SEMINAR ON APPLIED MATHEMATICS

## Unified gas-kinetic framework from Boltzmann to Navier-Stokes scales

**By**


**Prof. Zhaoli GUO**

Institute of Multidisciplinary Research for Mathematics and Applied Science
Huazhong University of Science and Technology



**Abstract**

Modeling gas flows across multiple regimes remains challenging because neither molecular kinetics nor continuum fluid dynamics alone is sufficient when scale separation breaks down. This talk will present a unified gas-kinetic framework (UGKF) that bridges the Boltzmann and Navier–Stokes descriptions within a single self-consistent formulation. The central idea is to classify molecules according to their collision histories over a prescribed observation time scale, leading to a decomposition into collided, free-transport, and transitional populations. From this classification, three coupled kinetic equations are derived from the formal solution of the Boltzmann equation. The UGKF provides a transparent picture of how macroscopic fluid behavior emerges from microscopic transport, and it naturally recovers both the Boltzmann and Navier–Stokes equations in the appropriate limits. At the same time, it offers a flexible foundation for developing multiscale numerical methods. By describing strongly collided molecules hydrodynamically while retaining kinetic treatments for uncollided and transitional particles, the framework preserves physical fidelity in nonequilibrium regimes and computational efficiency in continuum regimes. In this way, UGKF serves not only as a conceptual bridge between kinetic and continuum theories, but also as a practical framework for efficient multiscale simulation of gas flows.


**Date : 29 April 2026 (Wednesday)**
**Time : 10:00a.m.-11:00a.m.**
**Venue : Room 3598 (Lift 27/28)**

*All are Welcome!*