For favour of Posting

THE HONG KONG UNIVERSITY OF SCIENCE & TECHNOLOGY

Department of Mathematics

SEMINAR ON APPLIED MATHEMATICS

Towards High-Resolution Simulation of High-speed Compressible Multi-Component Flows (Insight into Model Equations)

By

Prof. Yang-Yao NIU
Department of Aerospace Engineering
Tamkang University

Abstract

This study proposes numerical methods and models for simulating compressible multiphase flows in liquid-gas systems. We present three key innovations: (1) two-fluid models : an efficient AUSMD-type primitive variable Riemann solver (PVRS) that accurately resolves 1D stiffened water-air shock tubes and 2D shock-gas interactions with large pressure/density ratios, while capturing shocks, rarefaction, and cavitation in high-speed droplet impacts; (2) multi-equation multiphase flow models: a hybrid interface-sharpening technique combining MUSCL reconstruction with the THINC scheme (ATM method) using a novel AUSMD(PVRS) flux algorithm with approximate Riemann solver for interfacial fluxes; and An unsteady preconditioning framework for multiphase flows with arbitrary equations of state, employing a homogeneous two-phase mixture model with kinematic/thermodynamic equilibrium. The temperature-dependent hybrid EOS precisely describes liquid, vapor, and phase transition dynamics. Validation includes rigorous benchmark tests: 1D condensation shocks in cavitating nozzles and 2D cavitating blunt body flows.

Results demonstrate exceptional resolution of interfaces, shock waves, and cavitation zones. The PVRS solver maintains computational efficiency while handling extreme thermodynamic conditions, and the ATMhybrid preserves sharp interfaces without artificial dissipation. The preconditioning method proves robust across all flow speeds, successfully capturing complex multiphase phenomena including phase change effects.

These integrated methodologies offer significant improvements for high-fidelity simulations of compressible multiphase flows, particularly for aerospace applications involving shock-induced cavitation, droplet dynamics, and supercavitating flows. The demonstrated accuracy in handling stiff problems with large property gradients suggests strong potential for extension to the emerging technologies like hot-spot liquid cooling of chips.

Date : 13 June 2025 (Friday)
Time : 11:00a.m.-12:00noon
Venue : Room 4502 (Lift 25/26)

All are Welcome!