

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

By

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

<u>Abstract</u>

To address the growing demands of the aerospace industry, a deeper understanding of compressible flows, whether over high-speed transportation vehicles or within internal flow systems—is essential. Key phenomena such as injection, spray, and detonation require thorough investigation. Consequently, this study is motivated by the need to simulate compressible, multiphase, multicomponent chemically reactive flows, which are critical for aerospace applications. These flows present significant numerical challenges, stemming from both the inherent complexity of the physical models and the approximations introduced by the chosen numerical methods. To accurately resolve shock waves, detonation waves, material interfaces, and shear layers, we employ the time-dependent five-equation Euler equations and Navier-Stokes equations, augmented with chemical reaction effects. For temporal resolution, Strang splitting is applied to discretize the governing equations, mitigating stiffness induced by multiphase flow interactions and chemical reactions. Additionally, numerical fluxes at cell interfaces are evaluated using the ATM-type AUSM+ scheme. In this study, to validate the proposed numerical method, one and twodimensional shock tube and the detonation tube and nozzles are chosen as benchmark test cases. Our numerical results show that the proposed ATM type AUSM+ scheme has great potential for handling more complex detonation problems and pulse detonation engine flow problems. Also, we further propose a new methodology of multi-fluid model to include Lagrangian method to simulate the atomization of liquid droplets using the combined KH-RT breakup model. A supersonic liquid jet flow is simulated.

> Date : 13 June 2025 (Friday) Time : 10:00a.m.-11:00a.m. Venue : Room 4502 (Lift 25/26)

> > All are Welcome!