Ph. D. Thesis Defence

Structure-Preserving Numerical Schemes for Asymptotic Regimes in Some Fluid and Plasma Models

By

Mr. Rahuldev Ghorai

Abstract

Accurate numerical simulation of fluid and plasma models requires schemes that preserve the underlying mathematical and physical structures of the governing partial differential equations, particularly in asymptotic regimes. In this talk, we present a class of structure-preserving numerical schemes designed to maintain key properties such as conservation, positivity, energy stability, and weak consistency with the continuous models. Using a finite volume framework, upwind fluxes with CFL-type conditions, and stabilisation techniques, the schemes are robust across regimes. For the Ripa system, a temperature-extended shallow water model, the scheme is also well-balanced, preserving steady states exactly. For the Euler–Poisson–Boltzmann system and the Euler equations with potential temperature transport, we develop asymptotic-preserving IMEX schemes that remain stable and accurate in the quasineutral and low Mach number limits, respectively. We support our approach with extensive numerical studies that validate both the theoretical properties and practical performance of the methods.

Date: December 19, 2025

Time: 4.00 PM, Venue: PSB Seminar Room