

Talk announcement

Theresa Köfler

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High-Order Asymptotic-Preserving Schemes for Kinetic Equations from Rarefied to Incompressible Regimes

This work introduces a novel high-order numerical framework for solving kinetic equations, designed to remain uniformly valid across all regimes of the mean free path, spanning from the rarefied kinetic scale to the incompressible hydrodynamic limit. The method is built upon a micro-macro decomposition, which reformulates the underlying kinetic equation into a coupled system consisting of a macroscopic part, representing the fluid-dynamic evolution, and a microscopic part, describing the non-equilibrium deviations.

The proposed framework ensures high-order temporal accuracy through the use of Implicit-Explicit Runge–Kuttamethods, which provide stability and efficiency in stiff regimes, while spatial resolution is enhanced by combining finite-difference WENOreconstructions with high-order central difference approximations. A key feature of the proposed methodology is its Asymptotic-Preserving (AP) property. We demonstrate that, in the appropriate asymptotic limit as the mean free path tends to zero, the scheme consistently reduces to a high-order finite-difference formulation of the incompressible Navier–Stokes equations.

To support the theoretical findings, a set of numerical experiments are performed on one- and two-dimensional benchmark problems, which confirm the accuracy, stability, and versatility of the method across different flow regimes.