

Special Colloquium

Deterministic Solution of the Boltzmann Equation: Fast Spectral Methods for the Boltzmann Collision Operator

Jingwei Hu (University of Purdue)

Abstract: The Boltzmann equation, an integro-differential equation for the molecular distribution function in the physical and velocity phase space, governs the fluid flow behavior at a wide range of physical conditions. Despite its wide applicability, deterministic numerical solution of the Boltzmann equation presents a huge computational challenge due to the high-dimensional, nonlinear, and nonlocal collision operator. We introduce a fast Fourier spectral method for the Boltzmann collision operator which leverages its convolutional and low-rank structure. We show that the framework is quite general and can be applied to arbitrary collision kernels, inelastic collisions, and multiple species. We then couple the fast spectral method in the velocity space with the discontinuous Galerkin discretization in the physical space to obtain a highly accurate deterministic solver for the full Boltzmann equation. Standard benchmark tests including rarefied Fourier heat transfer, Couette flow, and thermally driven cavity flow have been studied and the results are compared against direct simulation Monte Carlo (DSMC) solutions.

Friday, January 18 at 3:00 PM in 636 SEO