数学与系统科学研究院

计算数学所学术报告

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报告题目： 基于 Boltzmann 模型方程各流域气体流动问题统一算法研究与应用(Gas–Kinetic Unified Algorithm Covering Various Flow Regimes:Solving Boltzmann Model Equation)

邀请人: 袁礼研究员

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计算数学所报告厅

Abstract:

Complex flow problems from rarefied to continuum regimes have been being one of the principal subjects of gas dynamics with the development of spaceflight involving atmosphere re-entry. A gas-kinetic unified algorithm solving the Boltzmann model equation has been presented and applied to study the complex flows covering various flow regimes. In this study, the unified velocity distribution function equation adapted to various flow regimes can be presented on the basis of the kinetic Boltzmann-Shakhov model equation. The gas-kinetic finite-difference numerical schemes directly solving the velocity distribution function are constructed by developing the discrete velocity ordinate method of gas kinetic theory and the unsteady time-splitting technique from computational fluid dynamics. The discrete velocity numerical quadrature methods for different Mach number flows are developed to evaluate the macroscopic flow variables in the physical space. The HPF parallel strategy suitable for the gas-kinetic numerical method is investigated and founded to solve three-dimensional flow problems. To test the accuracy and reliability of the unified algorithm, the one-dimensional shock-tube problems, two-dimensional supersonic flows past cylinder, the three-dimensional flows around sphere and complex shape from various flow regimes are simulated. The computational results are found in high resolution of the flow fields and good agreement with the theoretical, DSMC, N-S and

experimental results. On the other hand, the gas-kinetic numerical method is extended and used to study the two-dimensional micro-channel gas flows. The gas-kinetic algorithm may be a powerful tool in the numerical simulation of micro-scale gas flows from the Micro-Electro-Mechanical System (MEMS). The numerical experience indicates that the present gas-kinetic unified algorithm by directly solving the Boltzmann simplified velocity distribution function equation from the point of view of mesoscopic theory can preferably remedy the insufficiency of the molecular-based schemes merely based on the microscopic theory and the fluid dynamics solver from the macroscopic continuum theory, and provide a successful and promising approach effectively to resolve the complex aerothermodynamic problems and flow mechanism from the complete spectrum of flow regimes. It is practical and considerable that the gas-kinetic massive-scale parallel algorithm in solving three-dimensional complex hypersonic problems covering various flow regimes can be effectively developed.

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