极端物理条件下流体力学计算方法研讨会会议日程

2018 年 11 月 4 日—6 日 厦门大学

日期	时间	内容
11 月 4 日	14：00-20：00	报到
11 月 5 日 数学学院 B313	09：00-09：30	熊涛，High order asymptotic preserving DG-IMEX schemes for multi-scale kinetic equations
	09：30-10：00	何志伟，多介质多模型中界面拓扑演化方程的离散方法研究
	10：00-10：20	茶歇
	10：20-10：50	林建芳，High order residual distribution for steady state problems for hyperbolic conservation laws
	10：50-11：20	李诗一，高效统一气体动理学格式及可压缩湍流小尺度特性研究
	11：20-11：50	赵状，A new hybrid WENO scheme for hyperbolic conservation laws
11 月 5 日	14：30-17：30	项目组内部研讨

High order asymptotic preserving DG-IMEX schemes for multi-scale kinetic equations

厦门大学　熊涛

Kinetic equations which arise from dilute gas dynamics or plasma physics has a great challenge for numerical simulations. It is mainly due to its multiscale structure and high dimensionality. Following the framework of asymptotic preserving (AP) schemes, we have proposed a class of high order AP DG-IMEX schemes based on a micro-macro reformulation. The schemes are globally stiffly accurate and asymptotically consistent, and as the Knudsen number becomes small or goes to zero, they recover the compressible Navier-Stokes (CNS) or the Euler limit. In order to save more computational cost due to high dimensionality, we further propose a hierarchical high order DG-IMEX method, namely kinetic, CNS and Euler solvers are automatically applied in regions where their corresponding models are appropriate. The numerical solvers for different regimes are coupled naturally by interface conditions. Numerical experiments demonstrate the efficiency and effectiveness of our proposed approach.

多介质多模型中界面拓扑演化方程的离散方法研究

北京应用物理与计算数学研究所 何志伟

多介质模型中描述界面拓扑演化的的方程通常是某种函数的对流方程。如何离散这类对流方程是多介质模拟中不可避免的问题。本文给出了此类方程的一种离散框架，可以应用于有限体积和有限差分方法。利用此框架，将此框架应用于有限差分方法，复现我们前期给出的差分算法；将此框架应用于有限体积方法，给出一套新的兼容黎曼求解器算法：具体推导了 HLLC、HLL、Rusanov 求解器对应的兼容算法。数值结果初步验证了新方案的可靠性。

High order residual distribution for steady state problems for hyperbolic conservation laws

厦门大学　林建芳

In this paper, we propose a high order residual distribution conservative finite difference scheme for solving steady state conservation laws. A new type of WENO (weighted essentially non-oscillatory) termed as WENO-ZQ integration is used to compute the numerical fluxes and source term based on the point values of the solution, and the principles of residual distribution schemes are adapted to obtain steady state solutions. Extensive numerical examples in both scalar and system test problems in one and two dimensions demonstrate the efficiency, high order accuracy and the capability of resolving shocks of the proposed methods.

高效统一气体动理学格式及可压缩湍流小尺度特性研究

北京应用物理与计算数学研究所　李诗一

跨流域多尺度流动问题具有重要的学术研究和工程应用意义。本文对适合全流域的统一气体动理学格式进行改进，提高其计算效率，并应用到典型跨流域多尺度流动问题的数值模拟研究。

为提高大规模并行时的计算效率，基于物理空间和速度空间同时分块，采用高效的并行分组算法，并调整了UGKS的计算流程，发展了三维复杂分块结构网格上适合大规模高效并行计算的UGKS算法。多种典型算例测试验证了新算法在从小规模到超大规模计算中的高效性。为高效模拟全流域轴对称流动，基于局部笛卡尔坐标系下的分布函数演化解，构造了轴对称源项的时间演化解，进而发展了具有多尺度特性的UGKS-AS及其隐式算法，多种典型算例测试验证了新方法的高效性。针对连续流/稀薄流共存的多尺度流动，在连续流区对UGKS进行了简化，避免了速度空间的离散，提高了总的计算效率。

应用UGKS对典型可压缩湍流中的小尺度脉动特征进行了数值模拟研究。通过对声波与马赫数为8的激波相互作用的模拟，发现考虑到真实强激波结构与高频声波的稀薄效应，激波对高频声波幅值的放大作用得到了削弱，声波频率大于分子平均碰撞频率后放大因子几乎减小了一半。对二维、三维可压缩均匀各向同性衰减湍流进行了直接数值模拟，研究了不同尺度脉动的统计特性，分析了小尺度脉动的稀薄效应并定量评估了NS方程的适用性。

A new hybrid WENO scheme for hyperbolic conservation laws

厦门大学　赵状

In Zhu and Qiu (J. Comput. Phys., 318, 110-121, 2016), a simple fifth order weighted essentially non-oscillatory (WENO) scheme was presented in the finite difference framework for the hyperbolic conservation laws, in which the reconstruction of fluxes is a convex combination of a fourth degree polynomial with two linear polynomials. In this follow-up paper, we propose a new fifth order hybrid weighted essentially non-oscillatory (WENO) scheme based on the simple WENO. The main idea of the hybrid WENO scheme is that if all extreme points of the reconstruction polynomial for numerical flux in the big stencil are located outside of the big stencil, then we reconstruct the numerical flux by upwind linear approximation directly, otherwise use the simple WENO procedure. Compared with the simple WENO, the major advantage is its higher efficiency with less numerical errors in smooth regions and less computational costs. Likewise, the hybrid WENO scheme still keeps the simplicity and robustness of the simple WENO scheme. Extensive numerical results for both one and two dimensional equations are performed to verify these good performance of the proposed scheme.