数学与系统科学研究院

计算数学所学术报告

报告人：　Prof. Zhi-Hui Li

（ *Hypervelocity Aerodynamics Institute, China Aerodynamics Research and Development Center and National Laboratory for Computational Fluid Dynamics, China* ）

报告题目：

Gas-Kinetic Unified Algorithm for Computable Modeling of Boltzmann Equation and Applications to Aerodynamics during Spacecraft Falling Disintegration

邀请人：　曹礼群 研究员

报告时间：2017 年 3 月 7 日（周二）

上午 10:00-11:00

报告地点：　数学院南楼九层

902 教室

Abstract:

How to solve the hypersonic aerothermodynamics around uncontrolled spacecraft during falling and disintegrating process from outer space to earth, is the key to resolve the end-of-life spacecraft reentry crash.

To study aerodynamics of spacecraft reentry covering various flow regimes, a gas-kinetic unified algorithm (GKUA) has been presented by computable modeling of the collision integral of the Boltzmann equation over tens of years. In this work, the unified expressions on the molecular collision relaxing parameter and the local equilibrium distribution function involving non-equilibrium effect are deduced, in which the effect of rotational non-equilibrium is investigated recurring to the kinetic Rykov model. The spin movement of diatomic molecule is described by moment of inertia, and the conservation of total angle momentum is taken as a new Boltzmann collision invariant. The gas-kinetic numerical scheme is constructed for three-dimensional problems to capture the time evolution of the discretized velocity distribution functions by developing the discrete velocity ordinate (DVO) method. The gas-kinetic massive parallel algorithm is developed to solve the hypersonic aerothermodynamics with the processor cores 500~115000 at least 90% parallel efficiency. To validate the accuracy of the GKUA, the hypersonic flows are simulated including the sphere, reentry ramp and low-orbit vehicles with the wide range of Knudsen numbers of $5.1 \times 10^{-5} \le Kn_{\infty} \le 10$**. For un-controlling spacecraft falling problem, the finite-element algorithm of dynamic thermal-force coupling response is presented, and the unified simulation of the thermal structural response and the hypersonic flow field is tested on the vertical plate, hollow sphere and low-orbit vehicle under reentry aerodynamic environment. The unsteady evolving mechanism on deformation, failure and disintegration of metal truss structure is revealed from strong aerothermodynamic effect.**

The multi-body flow problems including two and three side-by-side cylinders are simulated from highly rarefied to near-continuum transitional flow regimes to verify the accuracy and reliability of the GKUA in solving the multi-body aerothermodynamics for spacecraft falling disintegration. Combining the DSMC and N-S coupled methods etc., the forecasting analysis platform of end-of-life spacecraft flying track has been established for the unified computation to the reentry aerothermodynamics and ablation/deformation failure/disintegration.

欢迎大家参加！