汕頭大學
SHANTOU UNIVERSITY

汕头大学数学研究所成立三十周年系列学术活动

科学计算及其应用研讨会
汕头大学数学系

2023年5月12-14日

组委会：侯延仁、单丽、郑海标

会议日程

5 月 13 日 星期六　　　汕头大学行政楼东 E401 会议室	
8:30-9:00	**开幕式**
9:00-9:30	Chair： 侯延仁（西安交通大学） Speaker：陈黄鑫（厦门大学） Efficient numerical methods for thermodynamically consistent model of two-phase flow in porous media
9:30-10:00	Chair：侯延仁（西安交通大学） Speaker：陈艺冰（北京应用物理与计算数学研究所） 可压缩流体力学计算的时空高精度动理学格式
10:00-10:30	Chair：侯延仁（西安交通大学） Speaker：成娟（北京应用物理与计算数学研究所） The high order positivity-preserving conservative remapping methods and their application in the ALE simulation of compressible fluid flow
茶歇（30 分钟）	
11：00-11：30	Chair：郑海标（华东师范大学） Speaker：谢和虎（中国科学院数学与系统科学研究院） Augmented Subspace Method and Its Applications
11:30-12:00	Chair：郑海标（华东师范大学） Speaker：谢小平（四川大学） An unfitted finite element method with direct extension stabilization for time-harmonic Maxwell problems on smooth domains
5 月 13 日 星期六下午　　　自由交流	

5月14日 星期日　　　汕头大学图书馆研讨室 30C	
8:30-9:00	Chair：陈艳萍（华南师范大学） Speaker：蔡晓峰（北京师范大学、北京师范大学-香港浸会大学联合国际学院） Fourth-order conservative non-splitting semi-Lagrangian Hermite WENO schemes for kinetic and fluid simulations
9:00-9:30	Chair：陈艳萍（华南师范大学） Speaker：崔明（北京工业大学） Numerical Methods for Nonlinear Aerosol Dynamic Equations
9:30-10:00	Chair：陈艳萍（华南师范大学） Speaker：李东方（华中科技大学） High-order energy-preserving relaxation schemes for highly oscillatory Hamiltonian systems
茶歇（30 分钟）	
10:30-11:00	Chair：单丽（汕头大学） Speaker：许传炬（厦门大学） A SVV Triangle Spectral Element Method for Large Eddy Simulation of Turbulent Flows
11:00-11:30	Chair：单丽（汕头大学） Speaker：张振（南方科技大学） Energy stable methods for phase-field surfactant model and simulation of droplet impact
11：30-12：00	Chair：单丽（汕头大学） Speaker：钟柳强（华南师范大学） 二阶非线性椭圆问题有限元离散系统的两水平法
5月14日 星期日下午　　　自由交流	

Efficient numerical methods for thermodynamically consistent model of two-phase flow in porous media
陈黄鑫（厦门大学）

In this talk we will introduce a thermodynamically consistent mathematical model for incompressible and immiscible two-phase flow in porous media with rock compressibility. An energy stable numerical method will be introduced, which can preserve multiple physical properties, including the energy dissipation law, full conservation law for both fluids and pore volumes, and bounds of porosity and saturation. Numerical results are given to verify the features of the proposed methods.

可压缩流体力学计算的时空高精度动理学格式
陈艺冰（北京应用物理与计算数学研究所）

时空一致高精度格式是可压缩流体力学计算方法发展的重要趋势之一。本报告将介绍在动理学方法框架下如何设计时空一致任意高精度格式，并介绍在结合紧致的 SimpleHWENO 重构算法可以进一步提升计算效率。最后将给出这一研究方向未来发展的一些展望。

The high order positivity-preserving conservative remapping methods and theirs application in the ALE simulation of compressible fluid flow
成娟（北京应用物理与计算数学研究所）

The arbitrary Lagrangian Eulerian (ALE) method has a wide range of applications in numerical simulation of multi-material fluid flow. The indirect ALE method consists of three steps: Lagrangian step, rezone step and remapping step. In this talk, we propose two classes of high order positivity-preserving conservative remapping methods on 2D and 3D meshes in the finite volume and discontinuous Galerkin (DG) frameworks respectively. Combined with the finite volume and DG Lagrangian schemes and the rezoning strategies, we present two types of high order positivity-preserving conservative ALE methods individually. For the finite volume framework, we adopt the multi-resolution WENO reconstruction which can achieve optimal accuracy in the smooth regions and keep non-oscillatory near discontinuities. Also we incorporate an efficient local limiting to preserve positivity for the positive physical variables involved in the ALE framework without sacrificing the original high-order accuracy and conservation. For the DG framework, we develop a high-order positivity-preserving polynomial projection remapping method based on the L2 projection for the DG scheme. A series of numerical tests are provided to verify properties of our remapping algorithms, such as high-order accuracy, conservation, essential non-oscillation, positivity-preserving and efficiency. The performance of the ALE methods using the above discussed remapping algorithms is also tested for the Euler system.

Augmented Subspace Method and Its Applications
谢和虎（中国科学院数学与系统科学研究院）

This talk will introduce some new results and applications of the augmented subspace methods. First, I will introduce some new second order convergence results for the augmented subspace. Also, the combination of the augmented subspace method with other techniques will also be remarked. Then, the applications in the nonconforming finite element methods for the eigenvalue problems will also be presented.

An unfitted finite element method with direct extension stabilization for time-harmonic Maxwell problems on smooth domains
谢小平（四川大学）

We propose an unfitted finite element method for numerically solving the time-harmonic Maxwell equations on a smooth domain. The model problem involves a Lagrangian multiplier to relax the divergence constraint of the vector unknown. The embedded boundary of the domain is allowed to cut through the background mesh arbitrarily. The unfitted scheme is based on a mixed interior penalty formulation, where Nitsche penalty method is applied to enforce the boundary condition in a weak sense, and a penalty stabilization technique is adopted based on a local direct extension operator to ensure the stability for cut elements. We prove the inf-sup stability and obtain optimal convergence rates under the energy norm and the L^2 norm for both the vector unknown and the Lagrangian multiplier. Numerical examples in both two and three dimensions are presented to illustrate the accuracy of the method.

Fourth-order conservative non-splitting semi-Lagrangian Hermite WENO schemes for kinetic and fluid simulations
蔡晓峰（北京师范大学、北京师范大学-香港浸会大学联合国际学院）

We present fourth-order conservative non-splitting semi-Lagrangian (SL) Hermite essentially non-oscillatory (HWENO) schemes for linear transport equations with applications for nonlinear problems including the Vlasov-Poisson system, the guiding center Vlasov model, and the incompressible Euler equations in the

vorticity-stream-function formulation. The proposed SL HWENO schemes combine a weak formulation of the characteristic Galerkin method with two newly constructed HWENO reconstruction methods. Fourth-order accuracy is accomplished in both space and time under a non-splitting setting. Mass conservation naturally holds due to the weak formulation of the characteristic Galerkin method and the design of the HWENO reconstructions. We apply a positive-preserving limiter to maintain the positivity of numerical solutions when needed. Although the proposed SL framework allows us to take large time steps for improving computational efficiency, it also brings challenges to the spatial reconstruction technique; we construct two kinds of novel HWENO reconstructions to fit the need for the proposed SL framework. Abundant benchmark tests are performed to verify the effectiveness of the proposed SL HWENO schemes.

Numerical Methods for Nonlinear Aerosol Dynamic Equations
崔明（北京工业大学）

It is important to study the behavior of aerosol dynamics in atmospheric environment. In this talk, we consider numerical methods for the nonlinear aerosol dynamic equations on time and particle size. The finite volume element methods based on the linear interpolation and Hermite interpolation are provided to approximate the aerosol dynamic equation where the condensation and removal processes are considered. Numerical examples are provided to show the efficiency of these numerical methods.

High-order energy-preserving relaxation schemes for highly oscillatory Hamiltonian systems
李东方（华中科技大学）

A family of novel energy-preserving schemes are presented for numerically solving highly oscillatory Hamiltonian systems. These schemes are constructed by using the relaxation idea in the extrapolated Runge-Kutta (ERK) methods. After obtaining the relaxation parameter, it is shown that the methods can be arbitrarily high order accurate, linearly implicit and keep the original discrete energy conserved, while the previous energy-preserving schemes for highly oscillatory Hamiltonian systems are usually fully implicit. Numerical comparisons with various typical energy-preserving schemes are presented. The numerical results show that the proposed schemes are highly competitive and effective.

A SVV Triangle Spectral Element Method for Large Eddy Simulation of Turbulent Flows
许传炬（厦门大学）

In this talk, I will talk about a spectral vanishing viscosity (SVV) method for the triangular spectral element computation of high Reynolds number incompressible flow. The stabilized formulation can be implemented in standard triangular element solvers. We will show that the SVV-stabilization not only preserves the exponential convergence, but also improves the accurate when applied to the unsteady Navier-Stokes equation. Especially, this method would increase the stability tremendously in simulation of the high Reynolds flows and turbulence flows.

Energy stable methods for phase-field surfactant model and simulation of droplet impact
张振（南方科技大学）

We develop energy stable and bound preserving schemes for phase-field surfactant model with moving contact lines. The desired properties of the schemes are rigorously proved. We numerically validate the accuracies of the schemes and apply them in simulating droplet impact problems. Qualitative agreements with experiments are obtained. Moreover, surfactants are observed to have effect on enhancing droplet deformation and reducing dissipations.

二阶非线性椭圆问题有限元离散系统的两水平法
钟柳强（华南师范大学）

首先，针对拟线性椭圆问题的协调有限元离散系统，设计和分析了相应的迭代两网格法；其次，针对拟线性椭圆问题的内罚间断有限元离散系统，证明了有限元解的存在唯一性和先验误差估计，并设计和分析了一种迭代两网格算法，值得注意的是，该算法的有效性依赖于迭代算法初值的选取，为此需构造了一个相应的辅助变分问题. 最后，针对强非线性椭圆问题的协调有限元离散系统，设计和分析了相应的迭代两网格法. 相应的数值实验验证了上述算法的有效性.

汕头大学简介

　　汕头大学是 1981 年经国务院批准成立的广东省属综合性大学，是教育部、广东省、李嘉诚基金会三方共建的省部共建大学，广东省高水平大学重点学科建设高校，广东省首家高等教育体制机制改革实验示范校，广东省深化新时代教育评价改革试点高校，也是全球唯一一所由私人基金会——李嘉诚基金会持续资助的公立大学。

　　学校设有文学院、理学院、工学院、法学院、商学院、长江艺术与设计学院、长江新闻与传播学院、医学院、公共卫生学院、国际学院、马克思主义学院、继续教育学院，以及 2022 年 7 月成立的化学化工学院（碳中和未来技术学院）等 13 个学院，面向全国（含港澳台地区）招收博士、硕士和本科生，并设研究生院和 9 个住宿学院（书院）。现有专任教师 1294 人，全日制在校生近 2 万人，已为社会培养出各类人才逾 14 万人。

学校现有国家重点学科1个，设置了 长江学者 特聘教授岗位，博士后科研流动站5个，一级学科博士学位授权点6个、一级学科硕士学位授权点19个，含一级学科点覆盖数我校共有二级学科博士学位授权点52个、二级学科硕士学位授权点127个，硕士专业学位授权点17个；广东省高水平大学重点建设学科5个（临床医学、化学、海洋科学、数学、滨海智慧城市交叉学科），广东省重点学科8个；省部级重点实验室9个，广东省高校重点实验室4个，广东高校国际科技合作创新平台6个，广东省国际科技合作基地4个，广东省工程技术研究中心8个，广东省卫生厅重点实验室3个，广东省高等学校人文社科重点研究基地2个，教育部2007年度人才培养模式创新实验区2个，广东高等学校实验教学示范中心18个，省级人才培养模式创新实验区10个，省级大学生实践教学基地26个；国家级一流本科专业建设点18个（法学、汉语言文学、数学与应用数学、生物技术、机械设计制造及其自动化、临床医学、视觉传达设计、土木工程、电子信息工程、应用化学、海洋科学、会计学、工商管理、计算机科学与技术、国际经济与贸易、英语、护理学、新闻学），省级一流本科专业建设点12个（产品设计、行政管理、数据科学与大数据技术、通信工程、环境工程、智能制造工程、统计学、光电信息科学与工程、材料科学与工程、金融学、市场营销、公共艺术），国家级专业综合改革试点2个（临床医学、机械设计制造及其自动化），国家级 第一类特色专业建设点 建设项目7个（工商管理、艺术设计、法学、临床医学、机械设计制造及其自动化、土木工程、广播电视新闻学），教育部（国家级）精品课程4门，教育部（国家级）一流本科课程5门，教育部（国家级）精品资源共享课程2门，教育部（国家级）双语教学示范课程2门，教育部（国家级）虚拟仿真实验教学项目1个，教育部（国家级）教学团队1个，广东省名

牌专业 4 个，广东省重点专业 7 个，开设 5+3 一体化培养模式的临床医学专业，形成了从本科生到博士研究生完整的人才培养体系。

2022 年 10 月，汕头大学东海岸校区正式启用。东海岸校区将以交叉学科、新兴工科和应用型人文社科为主体，直接对接区域经济社会发展需求。未来学校将以高水平大学建设重点学科为抓手，推动基础学科与应用学科的交叉融合，完善多学科背景教师队伍，构建适合交叉学科人才培养的课程体系，提高科研人才的学术能力和创新能力，凝心聚力推动多校区一体协同，助力高水平大学建设，为实现汕头大学第五次党代会确立的 三步走 战略目标，为建设一所 文理医工融合发展，突出学科交叉特色的研究型大学 而接续奋斗。