2018 年应用与计算数学
学科进展报告会

国家天元数学西北中心

新疆大学数学与系统科学学院

2018 年 7 月 10-12 日

程序册

新疆乌鲁木齐市钱塘江路 216 号

雪莲酒店

会议须知

会议时间：7 月 10 日中午 15：30-20：00 报到

7 月 11-12 日开会，7 月 13 日离开

报到和住宿地点：雪莲酒店(新疆乌鲁木齐市钱塘江路 216 号)

到达雪莲酒店的乘车路线：

地窝堡国际机场：乘出租车到雪莲酒店约 45 元；

乌鲁木齐火车南站：乘出租车到雪莲酒店约 10 元；

乌鲁木齐站：乘出租车约雪莲酒店约为 30 元。

开会地点：雪莲酒店 三楼贵宾厅

早餐以及自助中餐和晚餐地点：

早餐雪莲酒店自备，用餐时间：7:30-10：00

午餐（13:30-14:30）、晚餐（19:30-20:30）：雪莲酒店二楼自助餐

本次会议由国家天元数学西北中心主办，新疆大学数学与系统科学学院

承办

会务人员及联系电话：

赵建平（新疆大学）：13899862123, zhaojianping@126.com

刘德民（新疆大学）：13619911280, followtime@126.com

在会议期间，如您遇到任何问题，可随时与会务工作人员联系，我们将竭诚为您提供周到服务。

预祝您在会议期间工作顺利，生活愉快！

会议日程表

2018 年 7 月 11 日（星期三）

10:00-10:20 开幕式及合影

Session 1（主席：聂玉峰 教授）

10:20-11:00 **黄艾香 教授**（西安交通大学）

Post-Galerkin Methods Based on an Approximate Inertial Manifold

11:00-11:40 **李若 教授**（北京大学）

Finding 13-Moment System Beyond Grad

11:40-12:00 茶歇

Session 2（主席：李若 教授）

12:00-12:40 **郑伟英 教授**（中科院数学与系统科学研究院）

A charge-conservative mixed finite element method for inductionless and incompressible equations

12:40-13:20 **应文俊 教授**（上海交通大学）

Recent Developments of a Potential Theory based Cartesian Grid Method for Partial Differential Equations

13:20-15:30 二楼自助餐午餐，午休

Session 3（主席：郑伟英 教授）

15:30-16:10 **李开泰 教授**（西安交通大学）

球单元和球壳单元有限元及其在弹性力学和流体力学中的应用

16:10-16:50 **聂玉峰 教授**（西北工业大学）

泡泡布点方法及其应用研究进展

16：50-17：20 **郑海标 副教授**（华东师范大学）

A new coupled model and stabilized decoupled numerical method for closed-loop geothermal system

17:20-17:40 茶歇

Session 4（主席：何银年 教授）

17:40-18:20 **黄建国 教授**（上海交通大学）

题目待定

18:20-18:50 **单丽副教授**（辽宁科技大学）

扭曲网格上扩散与对流扩散方程的有限体积法研究

18:50-19:20 **黄鹏展 副教授** （新疆大学数学与系统科学学院）

An efficient two-level algorithm for the 2D/3D stationary incompressible magnetohydrodynamics

19：20-20：30 晚餐，雪莲酒店餐厅

2018 年 7 月 12 日（星期四）

Session 5（主席：张庆海 教授）

09:30-10:10 **刘铁刚 教授** （北京航空航天大学）

带加速修正的 MGFM 方法（MGFM+A）

10:10-10:50 **张辉 教授** （北京师范大学）

A positivity-preserving, energy stable and convergent numerical scheme for the Cahn-Hilliard equation with a Flory-Huggins-deGennes energy

10:50-11:10 茶歇

Session 6（主席：张辉 教授）

11:10-11:50 **张庆海 教授**（浙江大学）

Interface tracking close to machine precision and the b est estimates of interface curvature

11:50-12:30 **邓伟华 教授** （兰州大学）

Modelling and Simulation for Anomalous and Non-ergodic Diffusion

12:30-13:10 **何银年 教授** （西安交通大学）

Decoupled Finite Element Methods for the 3D Primitive Equations of Ocean

13:10-13:30 闭幕式

13:30-15:30 午餐及午休

15:30-19:00 座谈与讨论

19:00-20:00 晚餐（二楼自助餐）

附件 1 报告摘要；附件 2：天元西北中心简介；附件 3：酒店地图位置

附件 1　　报告摘要

Post-Galerkin Methods Based on an Approximate Inertial Manifold

黄艾香教授，西安交通大学

摘要：
1 Introduction
2 Projection
3 Lower Frequency Components
4 Approximate Inertial Manifold and Higher Frequency Components
5 Post-Galerkin Approximation Solution
6 Numerical Example

Finding 13-Moment System Beyond Grad

李若教授，北京大学

摘要：We point out that the thermodynamic equilibrium is not an interior point of the hyperbolicity region of Grad's 13-moment system. With a compact expansion of the phase density, which is compacter than Grad's expansion, we derived a modified 13-moment system. The new 13-moment system admits the thermodynamic equilibrium as an interior point of its hyperbolicity region. We deduce a concise criterion to ensure the hyperbolicity, thus the hyperbolicity region can be quantitatively depicted.

A charge-conservative mixed finite element method for inductionless and incompressible equations

郑伟英研究员，中科院数学与系统科学研究院

摘要：We propose a charge-conservative mixed finite element method for inductionless and incompressible magnetohydrodynamic (MHD) equations. The discrete current density satisfies the divergence-free constraint exactly. A robust and quasi-optimal solver is proposed to solve the discrete problem by the preconditioning of the MHD differential operators. The preconditioning for the stiffness matrix is then obtained by transferring the operator preconditioning to its algebraic counterpart. The discrete solver is optimal in the sense that the number of iterations is uniform with respect to mesh refinements. By extensive numerical examples for both stationary and time-dependent MHD problems, we demonstrate the robustness of the solver to Reynolds number and the optimality of the solver to the number of unknowns.

Recent Developments of a Potential Theory based Cartesian Grid Method for Partial Differential Equations

应文俊教授，上海交通大学

摘要：I will talk on recent developments of a potential theory based Cartesian grid method for partial differential equations. The method is a generalization of the traditional boundary integral method for elliptic PDEs and works for variable coefficients and nonlinear PDEs. It is a Cartesian grid method. It shares general advantages with other Cartesian grid methods. Grid generation is easy and cheap. Discrete equations on Cartesian grids can be efficiently solved with fast algorithms such as an FFT based direct solver or a geometric multigrid iterative solver. It is convenient to work with moving interface and free boundary problems. This talk will present recent development of a fourth-order version of the method for the biharmonic equation as well as its application in computation of incompressible fluids.

球单元和球壳单元有限元及其在弹性力学和流体力学中的应用

李开泰教授，西安交通大学

摘要：给出有六个网格节点的球单元或球壳单元的形状函数，他是由球函数构造的。应用于：线性和非线性弹性力学的结构强度分析，特别是由 3D 打印所生成的复合弹性材料； 应用于三维球的 Stokes 绕流和 两个同心旋转球壳内的三维粘性流动的 Navier-Stokes 方程有限元逼近，研究他的 Taylor 的基本流和他的分歧问题。

泡泡布点方法及其应用研究进展

聂玉峰 教授

西北工业大学

摘要：简要介绍泡泡布点方法原理及其在曲面、区域的各向同性、异性网格生成研究进展，及其在并行生成和自适应有限元方法中的应用研究进展。

A new coupled model and stabilized decoupled numerical method for closed-loop geothermal system

郑海标副教授，华东师范大学

摘要： This talk is to propose a new coupled multi-physics model and a decoupled stabilized finite element method for the closed-loop type geothermal system, which mainly consists of a network of underground heat exchange pipelines to transfer the geothermal heat from the geothermal reservoir. The new mathematical model considers the heat transfer between two different flow regions, namely the porous media flow region in the geothermal reservoir and the free flow region in the pipes. Darcy's law and Stokes equations are considered to govern the flows in these two regions, respectively, while the heat equation is coupled with the flow equations to describe the heat transfer in both regions. Furthermore, on the interface between the two regions, four physically valid interface conditions are considered to describe the continuity of the temperature and the heat flux as well as the no-fluid communication feature of the closed-loop geothermal system. In the variational formulation, a stabilization term with a stabilization parameter is added to ensure the stability. To solve the proposed model accurately and efficiently, we develop a decoupled stabilized finite element method which decouples not only the two flow regions but also the heat field and the flow field in each region. The stability of the proposed method is proved. Three numerical experiments are provided to validate and illustrate the proposed model and numerical method.

题目待定

黄建国教授， 上海交通大学

摘要：待定

扭曲网格上扩散与对流扩散方程的有限体积法研究

单丽副教授，辽宁科技大学

摘要：本文在严重扭曲的四边形网格上利用有限体积方法研究扩散方程和对流扩散方程的数值计算问题. 首先为扩散型方程和求解区域内的控制体网格引入必要的符号系统，并通过积分原方程，应用 Gauss-Green 公式，选择合适的网格中心和网格边界辅助插值节点离散网格边上的法向流，利用插值公式将网格边界上的未知量替换为网格中心未知量，建立起步骤化的有限体积法框架. 然后，针对扩散方程问题和对流扩散方程问题建立相应的有限体积格式，并进行数值实验. 其中，在网格边界上的辅助插值节点选为调和平均点，使得最终形成的扩散方程的有限体积格式在结构四边形上是一个九点格式，并且遵循线性精确准则. 对于对流扩散方程，首先借助辅助函数将原方程转化为守恒型方程，然后仿照扩散方程建立对流扩散方程的有限体积格式. 数值实验表明，扩散方程和对流扩散方程的有限体积格式均具有二阶或接近二阶的收敛精度.

An efficient two-level algorithm for the 2D/3D stationary incompressible magnetohydrodynamics

黄鹏展副教授，新疆大学数学与系统科学学院

摘要： In the talk, we show a two-level finite element algorithm for solving the 2D/3D stationary incompressible magnetohydrodynamics based on the Newton iterative method. This algorithm is consisting of solving one nonlinear system on a coarse mesh with mesh size H and two linearized problems with different loads on a fine mesh with mesh size h. Compared with existing work on the two-level method for the MHD model, our two-level method allows a much high order scaling between the coarse and fine grid sizes. Furthermore,stability and convergence of this present method are analyzed. Finally, the applicability and effectiveness of the present algorithm are illustrated by several numerical experiments.

带加速修正的 MGFM 方法（MGFM+A）

刘铁刚教授，北京航空航天大学

摘要： 通过建立广义多介质 Riemann 问题分析了各种虚拟介质（GFM）类方法在应用到处理带加速度的多介质物质界面时遇到的问题，给出了带加速修正的 MGFM 方法（MGFM+A），新的方法可以很好地克服目前 GFM 类方法处理带加速度物质界面所遇到的问题。

A positivity-preserving, energy stable and convergent numerical scheme for the Cahn-Hilliard equation with a Flory-Huggins-deGennes energy

张辉教授，北京师范大学

摘要： This talk is focused on the bound estimate and convergence analysis of an unconditionally energy stable scheme for the MMC-TDGL equation, a Cahn-Hilliard equation with a Flory-Huggins-deGennes energy. The numerical scheme, a finite difference algorithm based on a convex splitting technique of the energy functional, was proposed in

[Sci. China Math. 59(2016),1815]. We provide a theoretical justification of the unique solvability for the proposed numerical scheme, in which a well-known difficulty associated with the singular nature of the logarithmic energy potential has to be handled. Meanwhile, a careful analysis reveals that, such a singular nature prevents the numerical solution of the phase variable reaching the limit singular values, so that the positivity preserving property could be proved at a theoretical level. In particular, the natural structure of the deGennes diffusive coefficient also ensures the desired positivity-preserving property. In turn, the unconditional energy stability becomes an outcome of the unique solvability and the convex-concave decomposition for the energy functional. Moreover, an optimal rate convergence analysis is presented.

Interface tracking close to machine precision and the best estimates of interface curvature

张庆海教授，浙江大学

摘要： Most interface tracking IT methods are at best second-order accurate. The most serious disadvantage of explicit IT methods, however, is probably the absence of an analytic framework. Based on the donating region theory, and a topological space that models physically meaningful material regions, we resolve this deficit by proposing a generic framework via Mapping and Adjusting Regular Semialgebraic sets (MARS). Using MARS, we formally proved the second-order accuracy of Volume-of-Fluid methods, clarified many subtle issues such as the accuracy deterioration caused by local C1 discontinuities, and analyzed other explicit IT methods such as moment-of-Fluid methods and front-tracking methods. Also inspired by MARS, we proposed a new IT method which achieved 4th-, 6th-, and 8th-order accuracy for an arbitrary number of phases. For the classic vortex-shear tests, our new method achieves close to machine precision on a 128-by-128 grid. Finally, we showed under the framework of MARS that there exists a best estimation of curvature at any regular point of the interface, which can be easily obtained by our new eighth-order algorithms.

Modelling and Simulation for Anomalous and Non-ergodic Diffusion

邓伟华教授，兰州大学

摘要：For the particles undergoing the anomalous diffusion with different waiting time distributions for different internal states, we derive the Fokker-Planck and Feymann-Kac equations, respectively, describing positions of the particles and functional distributions of the trajectories of particles; in particular, the equations governing the functional distribution of internal states are also obtained. The dynamics of the stochastic processes are analyzed and the applications, calculating the distribution of the first passage time and the distribution of the fraction of the occupation time, of the equations are given. For the further application of the newly built models, we make very detailed discussions on the none-immediately-repeated stochastic process, e.g., the random walk of smart animals, and its boundary issues.

Decoupled Finite Element Methods for the 3D Primitive Equations of Ocean

何银年教授，西安交通大学

摘要：In this paper, two decoupled finite element methods are proposed for solving the 3D primitive equations of ocean. Based on the finite element approximation, optimal error estimates are given under the convergence condition. And the detailed algorithms are given in the section of numerical tests. Further, numerical calculations are implemented to validate the theoretical analysis and more calculations are implemented for a more meaningful problem. For both theoretical and numerical points of view, the proposed decoupled finite element methods are the effective strategies to solve the 3D primitive equations of ocean.

附件 2　　国家天元数学西北中心简介

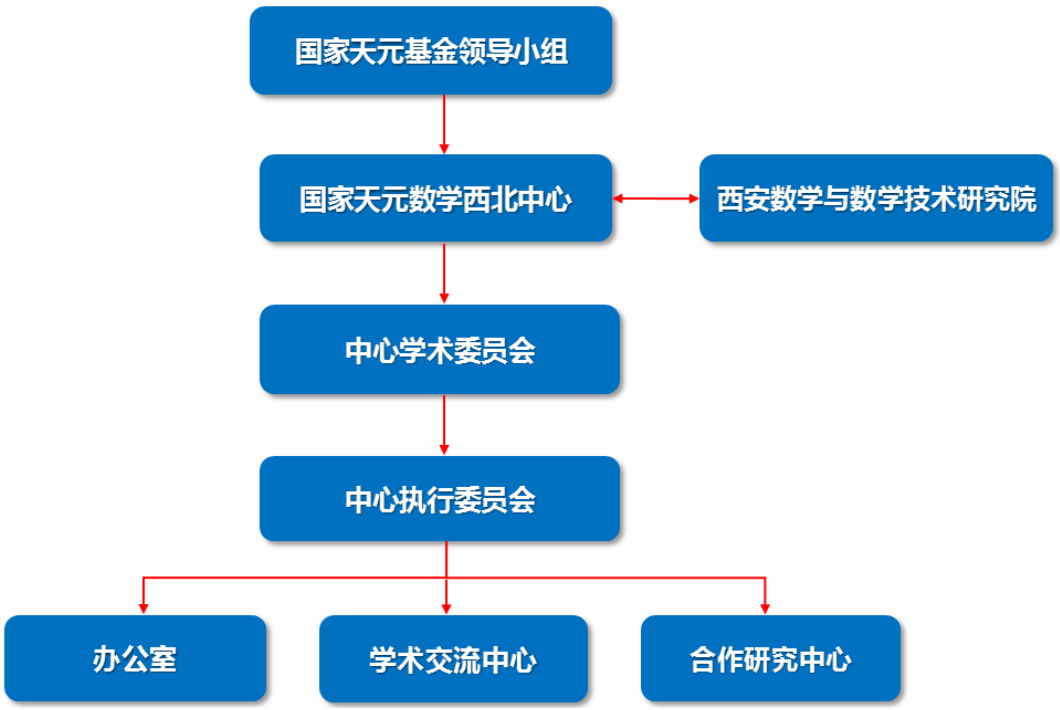
国家天元数学西北中心（以下简称“中心”）是国家自然科学基金委员会天元数学基金为推动中国数学率先赶上世界先进水平、推动中国数学区域、领域均衡发展而设立的数学研究机构（平台）。

中心的定位是：依托交大、立足西北、面向全国、放眼世界，建设数学工作者与其它学科领域学者深度交叉融合的学术交流中心和数学与数学技术研究中心。目标是：逐步将中心建设成为中国数学与其他学科交叉前沿研究基地、国家重大任务承接地、数学与数学技术研发基地与人才集聚地，新一代应用数学创新人才培养基地。

中心的主要任务包括：面向学科前沿开展学术交流，面向国家重大需求组织重大交叉问题研讨和重大课题研究；实施“天元学者/博士后”项目，促进数学研究与人才培养的地区平衡；策划并举办“全国应用数学暑期学校”及“全国大学数学教师暑期学校”，促进我国的应用数学发展及中西部地区大学数学教师队伍的培养。

中心依托西安交通大学，协同西北工业大学、兰州大学、西安电子科技大学、西北大学、陕西师范大学、新疆大学、西北师范大学、宁夏大学、青海师范大学等九所西部高校联合建设。中心支持各联建单位开展具有地域特色、符合各校情况的学术活动。

国家天元数学西北中心组织架构图



附件 3