会议名称：科学计算进展研讨会

会议时间：2023 年 2 月 10 日-11 日

会议地点：北京师范大学珠海校区励教楼 A103

内容简介：邀请科学计算方向的优秀学者进行学术交流，探讨科学计算方向的学术前沿问题以及新方法、新进展。

科学计算进展会议日程

2 月 10 日，星期五	
8:25-8:30	开幕式
8:30-9:00	Chair: 孙伟伟（北京师范大学珠海校区） Speaker: 高华东（华中科技大学） 报告 1: 超导模型中 Ginzburg-Landau 方程的最低阶混合元的误差分析
9:00-9:30	Chair: 高华东（华中科技大学） Speaker: 李东方（华中科技大学） 报告 2: relaxation Runge-Kutta methods: construction, analysis and applications
9:30-10:00	Chair: 李东方（华中科技大学） Speaker: 单丽（汕头大学） 报告 3: Fast ensemble methods for dual-porosity-Stokes model
茶歇（30 分钟）	
10:30-11:00	Chair: 单丽（汕头大学） Speaker: 史峰（哈尔滨工业大学深圳分校） 报告 4: Numerical schemes for some non-divergence PDEs of second order based on PPR techniques

11:00-11:30	Chair: 史峰（哈尔滨工业大学深圳分校） Speaker: 司智勇（河南理工大学） 报告 5: Unconditional stability and error estimates of FEMs for the electro-osmotic flow in micro-channels
11:30-12:00	Chair: 司智勇（河南理工大学） Speaker: 陈升（北京师范大学珠海校区） 报 告 6: An efficient spectral method and its applications
14:00-17:00	交流讨论

2 月 11 日，星期六	
8:30-9:00	Chair: 陈升（北京师范大学珠海校区） Speaker: 杜魁（厦门大学） 报告 7: Regularized randomized iterative algorithms for factorized linear systems
9:00-9:30	Chair: 杜魁（厦门大学） Speaker: 张继伟（武汉大学） 报告 8: Do we need decay-preserving error estimate for solving parabolic equations with the initial singularity?
9:30-10:00	Chair: 张继伟（武汉大学） Speaker: 张晓平（武汉大学） 报告 9: Learning Green’s Functions of Linear Reaction-Diffusion Equations with Application to Fast Numerical Solver
茶歇（30 分钟）	
10:30-11:00	Chair: 张晓平（武汉大学） Speaker: 郑海标（华东师范大学） 报告 10: Domain decomposition methods for the Stokes-Darcy-type couple Models

11:00-11:30	Chair: 郑海标（华东师范大学） Speaker: 蔡晓峰（北京师范大学珠海校区） 报告 11: 守恒型半拉格朗日间断有限元方法及其在 Vlasov 模型中的应用
14:00-17:00	交流讨论

[1] **超导模型中 Ginzburg-Landau 方程的最低阶混合元的误差分析**

高华东 华中科技大学

摘要：This talk is concerned with new error analysis of a lowest-order backward Euler Galerkin-mixed finite element method for the time-dependent Ginzburg-Landau equations. The method is based on a commonly-used non-uniform approximations, in which linear Lagrange element, the lowest order Nedelec edge element and Raviart-Thomas face element are used for the order parameter ψ, the magnetic field $curl \mathbf{A}$ and the magnetic potential $\mathbf{A}$, respectively. This mixed method has been widely used in practical simulations due to its low cost and ease of implementation. In the Ginzburg-Landau model, the order parameter ψ is the most important variable, which indicates the state of the superconductor. An important feature of the method is the inconsistency of the approximation orders. A crucial question is how the first-order approximation of $(curl \mathbf{A}, \mathbf{A})$ influences the accuracy of ψ_h. The main purpose is to establish the second-order accuracy for the order parameter in spatial direction, although the accuracy for $curl \mathbf{A}, \mathbf{A}$ is in the first order only. Previous analysis only gave the first order convergence for all three variables due to certain artificial pollution involved in analysis. Our analysis is based on a nonstandard quasi-projection for ψ and the corresponding more

precise estimates, including in H^{-1}-norm. With the quasi-projection, we prove that the lower-order approximation to $curl \mathbf{A}, \mathbf{A}$ does not pollute the accuracy of ψ_h. Our numerical experiments confirm the optimal convergence of ψ_h. The approach can be extended to many other multi-physics models.

[2] relaxation Runge-Kutta methods: construction, analysis and applications

李东方 华中科技大学

摘要： Spatial discretizations of time-dependent partial differential equations usually result in a large system of semi-linear and stiff ordinary differential equations. Taking the structures into account, we develop a family of linearly implicit and high order accurate schemes for the time discretization, using the idea of some linearlized methods and the relaxation techniques. The proposed schemes are monotonicity preserving/conservative for the original problems, while the previous linearized methods are usually not. Numerical experiments on several typical models are presented to confirm the effectiveness of the proposed methods.

[3] Fast ensemble methods for dual-porosity-Stokes model

单丽 汕头大学

摘要： Uncertainty quantification (UQ) has been a hot research topic recently. In this talk, we focus on the fast simulation for the evolutionary dual-porosity-Stokes system with random input parameters. We propose several decoupled ensemble algorithms and provide there error estimations. Besides, the numerical tests verify our theoretical results.

[4]Numerical schemes for some non-divergence PDEs of second order based on PPR techniques

史峰 哈尔滨工业大学深圳分校

摘要：In the talk, we review a systematic method to generate finite difference and finite element schemes on unstructured meshes. Such method is based on recovery technique in the finite element community. The computed solutions can own the same superconvergence (or ultraconvergence) property as recovered gradient and Hessian.

[5] Unconditional stability and error estimates of FEMs for the electro-osmotic flow in micro-channels

司智勇 河南理工大学

摘要：In this paper, we will provide the the finite element method for the electro-osmotic flow in micro-channels, in which a convection diffusion type equation is given for the charge density $\rhoˆe$. A time-discrete method based on the backward Euler method is designed. The theoretical analysis shows that the numerical algorithm is unconditionally stable and has optimal convergence rates. To show the effectiveness of the proposed model, some numerical results for the electro-osmotic flow in the T-junction micro-channels and in rough micro-channels are provided. Numerical results indicate that the proposed numerical method is suitable for simulating electro-osmotic flows.

[6]An efficient spectral method and its applications

陈升 北京师范大学珠海校区

摘要：In this talk, an efficient spectral method will be proposed for solving singular problems and singularly perturbed problems. Based on

the Log mapping to Laguerre, the new bases are capable of exponentially approximating one-point singular functions and some boundary layer functions. The related Log spectral methods are applied to some fundamental singular problems and singularly perturbed problems, respectively. The numerical experiments are demonstrated to verify the high-efficiency of the new method

[7] Regularized randomized iterative algorithms for factorized linear systems

杜魁 厦门大学

摘要：Randomized iterative algorithms for solving the factorized linear system, ABx = b with A ∈ Rˆ{m×l}, B ∈ Rˆ{l×n}, and b ∈ Rˆm, have recently been proposed. They take advantage of the factorized form and avoid forming the matrix C = AB explicitly. However, they can only find the minimum norm (least squares) solution. In contrast, the regularized randomized Kaczmarz (RRK) algorithm can find solutions with certain structures from consistent linear systems. In this work, by combining the randomized Kaczmarz algorithm or the randomized Gauss-Seidel algorithm with the RRK algorithm, we propose two new regularized randomized iterative algorithms to find (least squares) solutions with certain structures of ABx = b. We prove linear convergence of the new algorithms. Computed examples are given to illustrate that the new algorithms can find sparse (least squares) solutions of ABx = b and can be better than the existing randomized iterative algorithms for the corresponding full linear system Cx = b with C = AB.

[8] Do we need decay-preserving error estimate for solving parabolic equations with the initial singularity?

张继伟 武汉大学

摘要：The solutions with weakly initial singularity arises in a wide variety of equations, for example, diffusion and subdiffusion equations. When the well-known L1 scheme is used to solve subdiffusion equations with weak singularity, numerical simulations show that this scheme can produce various convergence rates for different choices of model parameters. This elusive phenomenon can be found in other numerical methods for reaction-diffusion equations such as the backward Euler (IE) scheme, Crank-Nicolson (C-N) scheme, and BDF2 scheme. The current theory in the literatures cannot explain why there exists two different convergence regimes, which has been puzzling us for a long while, and motivating us to study this inconsistence between the standard convergence theory and numerical experiences. In this talk, we begin with the alpha-robust estimates for L1 and Alikhanov's schemes on general nonuniform meshes, and then provide a general methodology to systematically obtain error estimates that incorporate the exponential decaying feature of the solution. We call this novel error estimate decay-preserving error estimate and apply it to aforementioned IE, C-N, and BDF2 schemes. Our estimates reveal that the various convergence rates are caused by the trade-off between the two components in different model parameter regimes.

[9]Learning Green's Functions of Linear Reaction-Diffusion Equations with Application to Fast Numerical Solver

张晓平 武汉大学

摘要：In this talk, we introduce a novel neural network method, "GF-Net", for learning the Green's functions of the classic linear reaction-diffusion equation with Dirichlet boundary condition in the unsupervised fashion, inspired by the rapidly growing impact of deep learning techniques. The proposed method overcomes the numerical

challenges for finding the Green's functions of the equations on general domains by utilizing the physics-informed neural network and the domain decomposition approach. As a consequence, it also leads to a fast numerical solver for the target equation subject to arbitrarily given sources and boundary values without network retraining. We numerically demonstrate the effectiveness of the proposed method by extensive experiments with various domains and operator coefficients.

[10]Domain decomposition methods for the Stokes-Darcy-type couple Models

郑海标 华东师范大学

摘要：Domain decomposition methods for the Stokes-Darcy-type couple Models are discussed, which can decouple the Stokes-Darcy-type systems into some smaller sub-physics problems naturally and reduce the size of the linear systems and allow parallel computation of the those sub-physics problems. For the Stokes-Darcy model with a random hydraulic conductivity tensor, we propose the efficient ensemble domain decomposition algorithm. The ensemble idea can result in a common coefficient matrix for all realizations at each iteration step solving the linear systems much less expensive while maintaining comparable accuracy. For the Stokes-dual-permeability fluid flow model, a parallel domain decomposition method is proposed to use the existing well-developed solvers or codes in a flexible way to solve two single dual-permeability equations and a single Stokes equation in parallel. Mesh-independent convergence rates of the algorithms are rigorously derived by choosing suitable Robin parameters.

[11] 守恒型半拉格朗日间断有限元方法及其在 Vlasov 模型中的应用。

蔡晓峰 北京师范大学珠海校区

摘要：半拉格朗日方法的特点是其解沿着流体运动轨迹追踪，使得算法能够突破

时间步长的限制。近年来，半拉氏方法的发展尤为迅速，也被应用与等离子体物理等领域。半拉氏算法发展的核心困难在于求解高维（二维及以上）问题时，以往的算法难以兼顾高阶精度、质量守恒和大时间步长。为了克服这一困难，本报告将讲述一种真正高维的守恒型半拉氏间断有限元方法（简称高维 SLDG 算法）。这一方法继承了间断有限元的高精度、质量守恒、有利于并行实现等众多优点，同时，可允许使用大时间步长的显式计算，且无维数分裂误差。进一步，我们将所提出的高维 SLDG 算法与一类李群高精度时间积分算法结合，得到一种求解实际应用中的非线性 Vlasov 模型的非线性 SLDG 算法。最后，我们通过一系列标准的数值算例的测试，验证了所提出算法的高精度、质量守恒、大时间步长等优势。