School of Mathematics and Statistics

Wuhan University

Workshop on Advances in Boundary Element and Finite Element Methods and Their Applications

18 - 19 March 2017 • Wuhan University

Contents

Introduction

The purpose of the conference is to provide a forum for computational mathematicians in China to exchange their recent achievements and discuss the state of the art and new directions on boundary element and finite element methods and their applications.

Organizing Committee

Dehao Yu	中国科学院数学与系统科学研究院
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Sponsors

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School of Mathematics and Statistics, Wuhan University, China

Collaborative Innovation Center of Mathematics, Wuhan University, China

Computational Science Hubei Key Laboratory, Wuhan University, China

NSFC (the National Natural Science Foundation of China)

Registration Date & Venue

17 March 2017，武汉丰颐大酒店（武汉市武昌区八一路与广八路交叉口）

Conference Date, Venue & Time

18-19 March 2017，武汉大学数学与统计学院三楼报告厅

Time: March 18, 8:00-17:40.

March 19, 8:00 – 12:20.

Plenary Speakers

1 陈黄鑫（Huangxin Chen）	厦门大学(Xiamen University)
2 杜魁(Kui Du)	厦门大学(Xiamen University)
3 杜其奎(Qikui Du)	南京师范大学(Nanjing Normal University)
4 冯新龙(Xinlong Feng)	新疆大学(Xinjiang University)
5 何文明(Wenming He)	温州大学(Wenzhou University)
6 李剑(Jian Li)	陕西科技大学(Shaanxi University of Science & Technology)
7 康彤(Tong Kang)	中国传媒大学(Communication University of China)
8 毛士鹏(Shipeng Mao)	中国科学院数学与系统科学研究院(Academy of Mathematics and Systems Science, Chinese Academy of Sciences)
9 邱蔚峰(Weifeng Qiu)	香港城市大学(City University of Hong Kong)
10 邬吉明(Jiming Wu)	北京应用物理与计算数学研究所(Institute of Applied Physics and Computational Mathematics)
11 谢和虎(Hehu Xie)	中国科学院数学与系统科学研究院(Academy of Mathematics and Systems Science, Chinese Academy of Sciences)
12 姚昌辉(Changhui Yao)	郑州大学(Zhengzhou University)
13 杨肃煜（Suh-Yuh Yang）	国立中央大学（National Central University,台湾）
14 余德浩(Dehao Yu)	中国科学院数学与系统科学研究院(Academy of Mathematics and Systems Science, Chinese Academy of Sciences)
15 张晓平(Xiaoping Zhang)	武汉大学(Wuhan University)
16 郑权(Quan Zheng)	北方工业大学(North China University of Technology)

Schedule Overview (40 minutes each talk)

March 18, 2017(Saturday)

Session 1	
8:00 - 8:10	Opening
8:10 - 8:30	Group Photo & Coffee Break
Session 2	Chair: Huoyuan Duan
8:30 - 9:30	Dehao Yu
9:30 - 10:10	Qikui Du
10:10 - 10:30	Coffee Break
Session 3	Chair: Qikui Du
10:30 - 11:10	Xinlong Feng
11:10 - 11:50	Wenming He
11:50 – 14:00	Lunch
Session 4	Chair: Jiming Wu
14:00 - 14:40	Tong Kang
14:40 - 15:20	Quan Zheng
15:20 - 15:40	Coffee Break
Session 5	Chair: Xiaoping Zhang
15:40 - 16:20	Jian Li
16:20 - 17:00	Changhui Yao

17:00 – 17:40	Jiming Wu
17:40 -	Dinner

Schedule Overview (40 minutes each talk)

March 19, 2017(Sunday)

Session 1	Chair: Weifeng Qiu
8:00 - 8:40	Suh-Yuh Yang
8:40 - 9:20	Hehu Xie
9:20 - 10:00	Huangxin Chen
10:00 - 10:20	Coffee Break
Session 2	Chair: Quan Zheng
10:20 – 11:00	Shipeng Mao
11:00 - 11:40	Weifeng Qiu
11:40 -12:20	Kui Du
12:20 – 14:00	Lunch

Schedule with Titles of Talks

March 18, 2017 (Saturday)

8:00 - 8:10	**Opening**
8:10 - 8:30	**Group Photo**
8:30 – 9:30	**Dehao Yu (余德浩)** 我的数学人生
9:30 - 10:10	**Qikui Du（杜其奎）** 人工边界方法及应用
10:10 - 10:30	**Coffee Break**
10:30 - 11:10	**Xinlong Feng（冯新龙）** H1-Superconvergence of a Difference Finite Element Method for 3D Poisson Equation
11:10 - 11:50	**Wenming He（何文明）** 高次有限元方法的外推算法
11:50 - 14:00	**Lunch**
14:00 - 14:40	**Tong Kang （康彤）** Boundary data identification for an electromagnetic problem by means of the potential field method
14:40 - 15:20	**Quan Zheng （郑权）** 椭圆型方程外问题的人工边界条件法
15:20 - 15:40	**Coffee Break**
15:40 - 16:20	**Jian Li （李剑）** 不可压缩流动问题高效数值方法研究及应用
16:20 - 17:00	**Changhui Yao （姚昌辉）** The regularity problem of Magneto-heating coupling model with turbulent convection zone and the □ow elds
17:00 -17:40	**Jiming Wu （邬吉明）** 任意多边形网格上扩散问题的节点型线性精确格式
17:40-	**Dinner**

Schedule with Titles of Talks

March 19, 2017(Sunday)

8:00- 8:40	**Suh-Yuh Yang （杨肃煜）** An efficient stabilized linear finite element method for solving reaction-convection-diffusion equations
8:40 - 9:20	**Hehu Xie （谢和虎）** A multigrid method for nonlinear problems
9:20 - 10:00	**Huangxin Chen （陈黄鑫）** Reduced modeling for simulating the flow in fractured porous media
10:00 - 10:20	Coffee Break
10:20 - 11:00	**Shipeng Mao （毛士鹏）** Adaptive finite element method for incompressible magneto-hydrodynamics
11:00 – 11:40	**Weifeng Qiu （邱蔚峰）** Analysis of a Mixed Discontinuous Galerkin method for incompressible magneto-hydrodynamics
11:40 – 12:20	**Kui Du （杜魁）** Electromagnetic scattering from a cavity embedded in an impedance ground plane
12:20 - 14:00	Lunch

Titles and Abstracts

Reduced modeling for simulating the flow in fractured porous media

陈黄鑫

厦门大学

Abstract

In this talk we will introduce the discrete fracture model (DFM) to simulate the flow in the fractured porous media. The DFM is applied to model the fractures by one-dimensional fractures in a two-dimensional domain. Then an a posteriori error estimator for the Raviart-Thomas mixed finite element method will be introduced for single-phase Darcy flow in the fractured porous media. We derive a robust residual-based a posteriori error estimator for the problem with non-intersecting fractures. The reliability and efficiency of the a posteriori error estimator are established for the error measured in an energy norm. We will also introduce a two-scale reduced model for simulating the Darcy flow in the porous media with conductive fractures. We apply the approach motivated by the embedded fracture model (EFM) to simulate the flow on the coarse scale, and the effect of fractures on each coarse scale grid cell intersecting with fractures is represented by the DFM on the fine scale. Several numerical results will be shown to demonstrate the efficiency of the algorithms.

Electromagnetic scattering from a cavity embedded in an impedance ground plane

杜魁

厦门大学

Abstract

This talk is concerned with electromagnetic scattering from a cavity embedded in an impedance ground plane. The fillings (which may be inhomogeneous) do not protrude the cavity and the space above the ground plane is empty. This problem is obviously different from those considered in previous work where either perfectly conducting boundary conditions were used or the cavity was assumed to be empty. By employing the Green's function method, we reduce the scattering problem to a bounded domain (the cavity) problem, with impedance boundary conditions on the cavity walls and a nonlocal boundary condition, defined by an impedance-to-Dirichlet map, on the cavity aperture. Existence and uniqueness of the solution are proved for the reduced problem. We also propose a numerical method to calculate the radar cross section (RCS), which is a physical parameter of interest. Numerical experiments show that the proposed model and numerical method are efficient for the calculation of RCS from cavities. ation and spectral-Galerkin methods using Hermite functions to solve the problems in unbounded domains directly.

人工边界方法及应用

杜其奎

南京师范大学

Abstract

Not available

H1-Superconvergence of a Difference Finite Element Method for 3D Poisson Equation

冯新龙

新疆大学

Abstract

In this work, a difference finite element (DFE) method is presented for 3D Poisson equation on non-uniform meshes by using P_1-conforming element. This new method consists of combining the finite difference discretization based on P_1-element in the z-direction with the FE discretization based on P_1-element in the (x,y)-plane. First, under the regularity assumption of $u\in H^3(\O)\cap H^1_0(\O)$ and $\p_{zz}f\in L^2((0, L_3); H^{-1}(\o))$, the H^1-superconvergence of the discrete solution u_τ in the z-direction to the first-order interpolation function $I_\tau u$ is obtained, and the H^1-superconvergence of the second-order interpolation function $I^2_{2\tau} u_\tau$ in the z-direction to u is then provided. Moreover, the H^1-superconvergence of the DFE solution u_h to the H^1-projection R_hu_τ of u_τ is deduced and the H^1-superconvergence of the second-order interpolation function $I^2_{2\tau}I^2_{2h} u_h$ to u in the $((x,y),z)$-space is also established. Finally, numerical tests are presented to show the H^1-superconvergence results of the DFE method for the 3D Poisson equation under the above regularity assumption.

高次有限元方法的外推算法

何文明

温州大学

Abstract

本报告将针对常系数的二阶椭圆问题，讨论高次（三角或矩形））有限元方法的外推算法的导数与位移的局部超收敛性。

不可压缩流动问题高效数值方法研究及应用

李剑

陕西科技大学

Abstract

报告主要从以下三个方面介绍：

1. 低阶有限元方法/有限体积方法与之间优化阶数值结果比较；
2. 不可压缩流动问题耦合问题高效解耦方法研究；
3. 重油开采中的数值模拟。

Adaptive Boundary data identification for an electromagnetic problem by means of the potential

康彤、王然

中国传媒大学

Abstract

We give this talk on a boundary data identification for an electromagnetic problem by means of the potential field method (the A-- method). One part of the boundary is over-determined. The other part of the boundary is unreachable and has to be determined as a part of the problem. We design a constructive algorithm by the A-- formulation to solve this problem. The numerical scheme is based on the steepest descent method (SDM) for the minimization of a regularized cost functional, having its derivative determined via an adjoint method. We analyse the properties of the cost functional and prove the convergence of the minimization process. The method is supported by several numerical experiments.including flows in porous media and wave propagation in fractured media. This research is partially supported by the Hong Kong RGC General Research Fund (Project: 400813).

Adaptive finite element method for incompressible magnetohydrodynamics

毛士鹏

中国科学院数学与系统科学研究院

Abstract

We consider a mixed finite element method for the numerical discretization of a stationary incompressible magnetohydrodynamics problem in three dimensions with its velocity field is discretized using H^1 conforming elements and the magnetic field is approximated by curl-conforming Nédélec elements. Under the assumption that the original model has a unique solution pair, we derive a posteriori error estimates of the incompressible magnetohydrodynamic (MHD) equations with a sharp upper bound. Using these a posteriori error estimates, we construct an adaptive algorithm for computing the solution of 3D magnetohydrodynamics. Numerical experiments are carried out to show the performance of the adaptive finite element method.

Analysis of a Mixed Discontinuous Galerkin method for incompressible magneto-hydrodynamics

邱蔚峰

香港城市大学

Abstract

In this paper we propose and analyze a mixed DG method for the stationary Magnetohydrodynamics (MHD) equations. The numerical scheme is based a recent work proposed by Houston et. al. for the linearized MHD. With a novel discrete Sobolev embedding type estimate for the discontinuous polynomials, we provide a priori error estimates for the method on the nonlinear MHD equations. In the smooth case, we have optimal convergence rate for the velocity, magnetic field and pressure in the energy norm, the Lagrange multiplier only has suboptimal convergence order. With the minimal regularity assumption on the exact solution, the approximation is optimal for all unknowns. To the best of our knowledge, this is the first a priori error estimates of DG methods for nonlinear MHD equations.

任意多边形网格上扩散问题的节点型线性精确格式

邬吉明

北京应用物理与计算数学研究所

Abstract

针对任意多边形网格上各项异性扩散问题，我们提出了一簇节点型线性精确有限体积格式。这些格式的未知量定义在网格节点处，不需要引入辅助未知量。它们在对偶网格上满足局部守恒条件、精确捕捉线性解、导致对称正定线性系统、且在结构四边形网格上有九点模板。在一些弱的几何条件下，我们在任意网格尺度上严格分析了格式的强制性，稳定性和离散 H1 模误差估计。我们也讨论了它们与有限体积元格式的联系。数值试验表明，在多种典型的扭曲网格及多种扩散张量的情况下，该类格式可以达到最优收敛速度。

A multigrid method for nonlinear problems

谢和虎

中国科学院数学与系统科学研究院

Abstract

In this talk, we propose and discuss a multigrid method for nonlinear problems. This method is designed by the finite element method and the multilevel correction method. Compared with the normal multigrid method which needs bouned second order derivatives of the nonlinear terms, the proposed multigrid method needs the same regularity as the finite element discretization for the nonlinear terms. The corresponding convergence and efficiency will be discussed.

The regularity problem of Magneto-heating coupling model with turbulent convection zone and the flow fields

姚昌辉

郑州大学

Abstract

In this report, Magneto-heating coupling model with turbulent convection zone and the flow fields is established. Our main work is to analyze the well-posedeness of this model with the regularity techniques. For magnetic field with turbulent convection zone and the flow fields, we consider the space H(curl) \ H(div) and for the heat equation, we consider the space H10 (Ω). The we present the weak formula of magneto-heating coupling model and establish the regularity problem. Using Roth's method, monotone theories of nonlinear operator, weak convergent theories, we prove that the limits of the solutions from Roth's method converge to the solutions of the regularity problem with proper initial data. With the help of the spacial regularity technique, we derive the results of the well-posedness of the original problems when the regular parameter ϵ □! 0.

An efficient stabilized linear finite element method for solving reaction-convection-diffusion equations

Suh-Yuh Yang

National Central University, Taiwan

Abstract

In this talk, we will introduce an efficient stabilized linear finite element method (FEM) for solving reaction-convection-diffusion equations with arbitrary magnitudes of reaction and diffusion. The key feature of the method is that the test function in the stabilization term is taken in the adjoint-operator-like form $-\varepsilon \Delta v- ({\bf a}\cdot\nabla v)/\gamma+\sigma v$, where the parameter γ is appropriately designed to adjust the convection strength to achieve high accuracy and stability. We derive the stability estimates for the finite element solutions and establish the explicit dependence of L^2 and H^1 error bounds on the diffusivity, module of the convection field, reaction coefficient and the mesh size. The analysis shows that the proposed method is suitable for a wide range of mesh P\'{e}clet numbers and mesh Damk\"{o}hler numbers. More specifically, if the diffusivity ε is sufficiently small with $\varepsilon < \Vert{\bf a}\Vert h$ and the reaction coefficient σ is large enough such that $\Vert{\bf a}\Vert < \sigma h$, then the method exhibits optimal convergence rates in both L^2 and H^1 norms. However, for a small reaction coefficient satisfying $\Vert{\bf a}\Vert \ge \sigma h$, the method behaves like the well-known streamline upwind/Petrov-Galerkin formulation of Brooks and Hughes. Several numerical examples exhibiting boundary or interior layers are given to demonstrate the high performance of the proposed method. Moreover, we apply the developed method to time-dependent reaction-convection-diffusion problems and simulation results show the efficiency of the approach. This is joint work with Po-Wen Hsieh.

我的数学人生

余德浩

中国科学院数学与系统科学研究院

Abstract

Not available

椭圆型方程外问题的人工边界条件法

郑权

北方工业大学

Abstract

椭圆型方程外问题来源于声学、空气动力学、水动力学、电磁学、等离子体物理、地球物理学等学科领域，通常需要用某些方法恰当地把无限化为有限，再进行数值计算。本文主要介绍：1）各向异性椭圆型方程外问题的自适应耦合法，得到依赖于有限元网格大小、椭圆人工边界位置、级数截断项的先验误差估计，得到后验误差估计和后验误差指示子，给出一种 h-r 自适应耦合法；2）Helmholtz 方程外边值问题的修正的 DtN-有限元方法，得到 H1 范数和 L2 范数的误差估计。数值实验表明了两种方法的有效性及其误差分析的正确性。