深圳北理莫斯科大學
УНИВЕРСИТЕТ МГУ–ППИ В ШЭНЬЧЖЭНЕ
SHENZHEN MSU-BIT UNIVERSITY

2023

第一届分析与计算研讨会

The First MSU-BIT Workshop on Analysis and Computation

主办单位：深圳北理莫斯科大学

计算数学与控制系

2023 年 8 月 6-10 日 • 深圳

一、会议组织(Organization)

（一）会议目标(Objectives)

This workshop aims to bring together domestic scholars and researchers in the field of theoretical, applied and computational mathematics, and share the latest research progress and prospects in the relevant research areas. The Faculty of Computational Mathematics and Cybernetics, Shenzhen MSU-BIT University will host "The First MSU-BIT Workshop on Analysis and Computation" from August 6th to 10th, 2023.

（二）组织委员会(Organizing Committee)

刘宏宇	香港城市大学数学系	hongyu.liuip@gmail.com
张　晔	深圳北理莫斯科大学计算数学与控制系	ye.zhang@smbu.edu.cn
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汪贤超	哈尔滨工业大学数学学院	xcwang90@gmail.com

二、会议信息(Quick Information)

（一）会议时间（Time）：2023 年 8 月 6 日-8 月 10 日

日　期	会议内容	地点
8月6日	会议报到	深圳北理莫斯科大学主楼3楼
8月7日	会议报到、会议开幕式、会议主题报告、交流	深圳北理莫斯科大学3教206
8月8日	会议主题报告、交流	深圳北理莫斯科大学3教206
8月9日	会议主题报告、交流	深圳北理莫斯科大学3教206
8月10日	自由讨论	深圳北理莫斯科大学3教206

备注：具体安排见“会议日程”。

（二）会议地点（Conference Venue）

深圳北理莫斯科大学 3 教 206

会议注册(Registration): 8 月 6 日 15:00-17:30 **深圳北理莫斯科大学主楼 3 楼**

（三）会议餐饮（Meals）

深圳北理莫斯科大学一食堂三楼

（四）会议住宿(Accommodation)

8 月 6 日-8 月 9 日 深圳北理莫斯科大学 2B&3A&3B

（五）交通路线（Traffic routes）

地址：广东省深圳市龙岗区大运新城国际大学园路 1 号

三、会议日程(Program Schedule)

第一天(Day 1): Monday, Aug 07, 2023	
08:50-09:05	开幕式及合影(Opening Ceremony and Group Photo)
Morning Session Chair: Hongyu Liu	
09:05-09:30	Xia Ji A new method using C0IPG for the biharmonic eigenvalue problem
09:30-09:55	Daijun Jiang Variational source conditions for inverse Robin and flux problems by partial measurements
09:55-10:20	Jiaqing Yang Determining a penetrable obstacle with conductivity boundary conditions from the fixed frequency far-field measurements
10:20-10:50	**Tea break**
10:50-11:15	Yukun Guo Simultaneous recovery of source and scatterer from cauchy data
11:15-11:40	Zhiwen Zhang A data-driven and model-based accelerated Hamiltonian Monte Carlo method for Bayesian elliptic inverse problems
Afternoon Session Chair: Minghui Ding	
14:00-14:25	Lina Zhao A strongly mass conservative scheme for the coupled flow and transport
14:25-14:50	Chenchen Mou Minimal solutions of master equations for extended mean field games
14:50-15:15	Wenbin Li Data-driven studies for inverse problems in imaging
15:15-15:45	**Tea break**
15:45-16:10	Xinlin Cao The effective permittivity and permeability generated by a cluster of moderately contrasting nanoparticles
16:10-16:30	Zhiqiang Miao Near microscale hydrodynamic cloaking using electro-osmosis
16:30-16:50	Yu Gao A data-driven approach for inverse scattering problems with limited data using machine learning
16:50-17:10	Huipeng Gu Some optimally convergent algorithms for decoupling the computation of Biot's model

第二天(Day 2)：Tuesday, Aug 08, 2023	
Morning Session　Chair: Ye Zhang	
09:00-09:25	Heping Dong The cavity scattering problem for biharmonic wave
09:25-09:50	Huaian Diao Visibility, invisibility and unique recovery of inverse electromagnetic problems with conical singularities
09:50-10:15	Lu Chen Quantitative stability of Hardy-Littlewood-Sobolev inequality and fractional Sobolev inequality
10:15-10:45	**Tea break**
10:45-11:10	Haibing Wang Recovering the source function in a time-domain wave equation by injecting high contrast bubbles
11:10-11:35	Keji Liu Direct imaging of submerged inhomogeneities in the 3D ocean waveguide
Afternoon Session　Chair: Yueguang Hu	
14:00-14:25	Pinchao Meng A novel method for solving the inverse spectral problem with the incomplete data
14:25-14:50	Xiaoxu Xu Uniqueness in inverse diffraction grating problems with infinitely many plane waves at a fixed frequency
14:50-15:15	Lele Yuan Solving inverse problem of distributed-order time-fractional diffusion equations using boundary observations and L^2 regularization
15:15-15:45	**Tea break**
15:45-16:10	Jianbo Cui Wasserstein Hamiltonian Flow and its structure-preserving numerical schemes
16:10-16:35	Mengmeng Zhang Solving the inverse potential problem in the parabolic equation by the deep neural networks method
16:35-17:00	Chunlong Sun 几类光学成像问题的数学建模和理论分析
17:00-17:20	Shen Zhang Inverse problems for mean field games

第三天(Day 3)：Wednesday, Aug 09, 2023	
Morning Session Chair: Hongjie Li	
09:00-09:25	Youjun Deng 多层结构介质的理论与应用
09:25-09:50	Guanghui Zheng GFTG prior and Optimal transport for Bayesian inverse problems
09:50-10:15	Guozhi Dong Parametric polynomial preserving recovery of data on discretized manifolds and its applications
10:15-10:45	**Tea break**
10:45-11:10	Lei Zhang Scattering problem of electromagnetic waves in chiral media
11:10-11:35	Weishi Yin Contactless Reconstruction of 3D Human Body
Afternoon Session Chair: Chaohua Duan	
14:00-14:25	Shiqi Ma Fixed angle inverse scattering for sound speeds close to constant
14:25-14:50	Jiachuan Zhang Hierarchical basis a posteriori error estimator for Stokes problem
14:50-15:10	Catharine Lo Determining a parabolic system by its boundary data with biological applications
15:10-15:30	Minghui Ding On inverse problems for several coupled pde systems arising in Mathematical biology
15:30-16:00	**Tea break**
16:00-17:30	Discussion

四、与会专家名单(List of Participants)

（按姓名首字母顺序排序）

曹鑫林 Xinlin Cao	香港理工大学 The Hong Kong Polytechnic University
曹阳阳 Yangyang Cao	深圳北理莫斯科大学 Shenzhen MSU-BIT University
常燕 Yan Chang	哈尔滨工业大学 Harbin Institute of Technology
陈博超 Bochao Chen	东北师范大学 Northeast Normal University
陈露 Lu Chen	北京理工大学 Beijing Institute of Technology
崔建波 Jianbo Cui	香港理工大学 The Hong Kong Polytechnic University
邓又军 Youjun Deng	中南大学 Central South University
刁怀安 Huaian Diao	吉林大学 Jilin University
丁明慧 Minghui Ding	香港城市大学 City University of Hong Kong
董国志 Guozhi Dong	中南大学 Central South University
董和平 Heping Dong	吉林大学 Jilin University
段北平 Beiping Duan	深圳北理莫斯科大学 Shenzhen MSU-BIT University
段超华 Chaohua Duan	香港城市大学 City University of Hong Kong
范谢灵 Xieling Fan	中南大学 Central South University
费晓旭 Xiaoxu Fei	中南大学 Central South University
高杨 Yang Gao	中南大学 Central South University
高宇 Yu Gao	吉林大学 Jilin University

耿跃然 Yueran Geng	吉林大学 Jilin University
古惠鹏 Huipeng Gu	南方科技大学 Southern University of Science and Technology
郭玉坤 Yukun Guo	哈尔滨工业大学 Harbin Institute of Technology
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季霞 Xia Ji	北京理工大学 Beijing Institute of Technology
蒋代军 Daijun Jiang	华中师范大学 Central China Normal University
蒋演 Yan Jiang	吉林大学 Jilin University
孔令政 Lingzheng Kong	中南大学 Central South University
赖军将 Junjiang Lai	闽江学院 Minjiang University
李宏杰 Hongjie Li	香港中文大学 The Chinese University of Hong Kong
李景治 Jingzhi Li	南方科技大学 Southern University of Science and Technology
李善强 Shanqiang Li	福建理工大学 Fujian University of Technology
李文彬 Wenbin Li	哈尔滨工业大学(深圳) Harbin Institute of Technology, Shenzhen
历宇涵 Yuhan Li	香港城市大学 City University of Hong Kong
刘宏宇 Hongyu Liu	香港城市大学 City University of Hong Kong
刘可伋 Keji Liu	上海财经大学 Shanghai University of Finance and Economics

卢咏君 Catharine Lo	香港城市大学 City University of Hong Kong
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苗志强 Zhiqiang Miao	湖南大学 Hunan University
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全启蒙 Qimeng Quan	香港中文大学 The Chinese University of Hong Kong
时聪 Cong Shi	中山大学 Sun Yat-sen University
宋明辉 Minghui Song	哈尔滨工业大学 Harbin Institute of Technology
孙春龙 Chunlong Sun	南京航空航天大学 Nanjing University of Aeronautics and Astronautics
孙泽军 Zejun Sun	湖南大学 Hunan University
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王海兵 Haibing Wang	东南大学 Southeast University
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王丽丽 Lili Wang	湖南大学 Hunan University
汪贤超 Xianchao Wang	哈尔滨工业大学 Harbin Institute of Technology
王亚娟 Yajuan Wang	中南大学 Central South University
吴畏 Wei Wu	吉林大学 Jilin University
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张萌萌 Mengmeng Zhang	河北工业大学 Hebei University of Technology
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朱丽艳 Liyan Zhu	中南大学 Central South University

五、报告摘要(Abstracts)

（按姓名首字母顺序排序）

The effective permittivity and permeability generated by a cluster of moderately contrasting nanoparticles

Xinlin Cao
The Hong Kong Polytechnic University

Abstract: In a 3D bounded and $C^{1,\alpha}$-smooth domain Ω, 0<α<1, we distribute a cluster of nanoparticles enjoying moderately contrasting relative permittivity and permeability which can be anisotropic. We show that the effective permittivity and permeability generated by such cluster is explicitly characterized by the corresponding electric and magnetic polarization tensors of the fixed shape. The error of the approximation of the scattered fields corresponding to the cluster and the effective medium is inversely proportional to the dilution parameter $c_r = \delta/a$, where a is the maximum diameter of the nanoparticles and δ is the minimum distance between them. The constant of the proportionality is given in terms of a-priori bounds on the cluster of nanoparticles (i.e. upper and lower bounds on their permittivity and permeability parameters, upper bound on the dilution parameter c_r, the used incident frequency and the domain Ω).

Quantitative stability of Hardy-Littlewood-Sobolev inequality and fractional Sobolev inequality

Lu Chen
Beijing Institute of Technology

Abstract: In this talk, we will discuss the stability for the Hardy-Littlewood-Sobolev (HLS) inequality with the explicit lower bounds. By establishing the relation between the stability of HLS inequality and the stability of fractional Sobolev inequality, we also give the quantitative stability of the fractional Sobolev inequality, which extends the quantitative stability of Sobolev inequality established by Dolbeault, Esteban, Figalli, Frank and Loss [arXiv:2209.08651, 2022] to the fractional order case. Our proofs are based on the competing symmetry, the continuous Steiner symmetrization inequality for the HLS integral and the dual stability theory. This talk is based on the joint work with Prof. Lu from Connecticut University and Prof. Tang from Beijing Normal University.

Wasserstein Hamiltonian Flow and its structure-preserving numerical schemes

Jianbo Cui

The Hong Kong Polytechnic University

Abstract: We study discretizations of Hamiltonian systems on the probability density manifold equipped with the L2 -Wasserstein metric. Based on discrete optimal transport theory, several Hamiltonian systems on graph (lattice) with different weights are derived, which can be viewed as spatial discretizations to the original Hamiltonian systems. We prove the consistency and provide the approximate orders for those discretizations. By regularizing the system using Fisher information, we deduce an explicit lower bound for the density function, which guarantees that symplectic schemes can be used to discretize in time. Moreover, we show desirable long time behavior of these schemes, and demonstrate their performance on several numerical examples. This is a joint work with Prof. Haomin Zhou and Prof. Luca Dieci.

多层结构介质的理论与应用

Youjun Deng

Central South University

摘要：本报告将主要介绍多层材料结构的最新数学理论进展及其在构建等离子模式以及多层材料结构成像中的应用。

Visibility, invisibility and unique recovery of inverse electromagnetic problems with conical singularities

Huaian Diao

Jilin University

Abstract: Consider time-harmonic electromagnetic scattering in two scenarios, where the anomalous scatterer is either a pair of electromagnetic sources or an inhomogeneous medium, both with compact supports. In this talk, we are mainly concerned with the geometrical inverse scattering problem of recovering the support of the scatterer, independent of its physical contents, by a single far-field measurement. It is assumed that the support of the scatterer (locally) possesses a conical singularity. We establish a local characterisation of the scatterer when invisibility/transparency occurs, showing that its characteristic parameters must vanish locally around the conical point. Using this characterisation, we establish

several local and global uniqueness results for the aforementioned inverse scattering problems, showing that visibility must imply unique recovery. In the process, we also establish the local vanishing property of the electromagnetic transmission eigenfunctions around a conical point under the Hölder regularity or a regularity condition in terms of Herglotz approximation.

On inverse problems for several coupled pde systems arising in Mathematical biology

Minghui Ding

City University of Hong Kong

Abstract: In this talk, we discuss several inverse problems of identifying unknown coefficients for a class of coupled PDE systems by measuring the average flux data on part of the underlying boundary. In these coupled systems, we mainly consider the non-negative solutions of the coupled equations, which are consistent with realistic settings in biology and ecology. We develop a new and effective scheme to tackle the inverse problems and achieve unique identifiability results by properly controlling the injection of different source terms to obtain multiple sets of mean flux data. The approach relies on certain monotonicity properties which are related to the intrinsic structures of the coupled PDE system. We also connect our study to biological applications of practical interest.

Parametric polynomial preserving recovery of data on discretized manifolds and its applications

Guozhi Dong

Central South University

Abstract: Accuracy of numerical differentiation in general suffers from unboundedness of differential operators. In this talk, I will introduce some technique called parametric polynomial preserving recovery which is capable of improving the accuracy of gradient recovery for numerical data on discretized manifolds. Some applications will also be highlighted.

The cavity scattering problem for biharmonic wave

Heping Dong

Jilin University

Abstract: This talk concerns the cavity scattering problem in an infinite thin plate, where the out-of-plane displacement is governed by the two-dimensional biharmonic wave equation. We reduce the scattering problem into an equivalent coupled boundary value problem for the Helmholtz and modified Helmholtz equations. Then the well-posedness is established based on a system of boundary integral equations and an appropriate regularizer. Moreover, the error estimate and the convergence analysis are carried out for the semi- and full-discrete schemes of the boundary integral system by using the collocation method. Numerical results show that the proposed method is highly accurate for both smooth and nonsmooth examples.

A data-driven approach for inverse scattering problems with limited data using machine learning

Yu Gao

Jilin University

Abstract: In this presentation, we delve into the utilization of artificial neural networks to tackle inverse scattering problems. Our primary focus is on the challenging task of recovering a scattering object from data that may have limited aperture. Taking a data-driven approach, we meticulously examine the potential of feedforward neural networks (FNN) and convolutional neural networks (CNN) in addressing this inverse scattering problem, leveraging their respective strengths based on the data type at hand. Through extensive numerical analysis, we showcase the remarkable capabilities of our proposed method, which produces stunning reconstructions that validate its effectiveness.

Some optimally convergent algorithms for decoupling the computation of Biot's model

Huipeng Gu

Southern University of Science and Technology

Abstract: In this talk, we study numerical algorithms for solving Biot's model. Based on a three-field reformulation, we propose novel algorithms for decoupling the computation of Biot's model. Considering a uniform temporal discretization, these

algorithms solve the coupled model on the first time level. On the residual time level, one algorithm solves a reaction-diffusion subproblem first, and then solve a generalized Stokes subproblem. Another algorithm reverses the order of solving two subproblems. Our algorithms manage to decouple the numerical computation of the coupled system while retaining the convergence properties of the original coupled algorithm. Theoretical analysis is conducted to show that these algorithms are unconditionally stable and optimally convergent. Several numerical experiments are presented to show the efficiency and the accuracy of the proposed decoupled algorithms.

Simultaneous recovery of source and scatterer from cauchy data

Yukun Guo

Harbin Institute of Technology

Abstract: A numerical method is developed for recovering both the source locations and the obstacle from the scattered Cauchy data of the time-harmonic acoustic field. First, the incident and scattered components are decomposed from the Cauchy data by representing the single-layer potentials and the solution to the resulting linear integral system. As a consequence of this decomposition, the original problem of joint inversion is reformulated into two decoupled subproblems. Then, two sampling-type schemes are proposed to recover the shape of the obstacle and the source locations, respectively. The error estimates of the decoupling procedure are established. Numerical experiments are also conducted to verify the performance of the sampling schemes.

A new method using C0IPG for the biharmonic eigenvalue problem

Xia Ji

Beijing Institute of Technology

Abstract: The talk presents a new proof of the C^0 IPG method (C^0 interior penalty Galerkin method) for the biharmonic eigenvalue problem. Instead of using the proof following the structure of discontinuous Galerkin method, we rewrite the problem as the eigenvalue problem of a holomorphic Fredholm operator function of index zero. The convergence for C^0IPG is proved using the abstract approximation theory for holomorphic operator functions. We employ the spectral indicator method which is easy in coding to compute the eigenvalues. Numerical examples are presented to validate the theory.

Variational source conditions for inverse Robin and flux problems by partial measurements

Daijun Jiang

Central China Normal University

Abstract: This talk is devoted to the convergence analysis of the Tikhonov regularization for the inverse Robin and flux problems. Both inverse problems aim at recovering a respective physical quantity on an inaccessible part of the boundary through some measurement on a partial accessible boundary. The convergence and convergence rate in the desirable L2 -norm are derived based on two new logarithmic type stabilities (only in some weak norms, e.g., the negative Sobolev norms), which enable us to construct and rigorously verify the required variational source conditions.

Data-driven studies for inverse problems in imaging

Wenbin Li

Harbin Institute of Technology, Shenzhen

Abstract: We present our recent work in data-driven studies for inverse problems in imaging. The motivation is to deal with contaminations of random noises in imaging data, and the strategies of neural networks and learning approaches are considered. We will mainly talk about the work of uniformly convex neural networks and non-stationary iterated network Tikhonov (iNETT) method. The iNETT employs deep neural networks to build a data-driven regularizer for the solution of ill-posed inverse problems. To achieve theoretical convergence, we introduce uniformly convex neural networks to build the data-driven regularizer. Rigorous theories and detailed algorithms are proposed for the construction of convex and uniformly convex neural networks. Given a general neural network architecture, we prescribe sufficient conditions to achieve a trained neural network which is component-wise convex or uniformly convex; moreover, we provide concrete examples of realizing convexity and uniform convexity in the modern U-net architecture. With the tools of uniformly convex neural networks, the iNETT algorithm is developed and a rigorous convergence analysis is provided. Lastly, we show applications of the iNETT algorithm in 2D computerized tomography.

Direct imaging of submerged inhomogeneities in the 3D ocean waveguide

Keji Liu
Shanghai University of Finance and Economics

Abstract: The scattering problems of marine acoustics have attracted great attention in recent years since they have wide applications in identifications of submarines, mineral deposits, wreckages, reef, submerged scatterers, etc. In this talk, I will present the direct imaging method (DIM) for the ocean waveguide. The DIM can generate reliable initial estimates of submerged inhomogeneities, which advanced inversion methods can then utilize to accurately determine their physical properties. As corroborated by extensive numerical experiments, the DIM is computationally efficient and highly robust against noises, and the DIM can identify multiple sources and the scatterers of different shapes and locations from a few observation data.

Determining a parabolic system by its boundary data with biological applications

Catharine Lo
City University of Hong Kong

Abstract: We consider the inverse problem of determining some coefficients of the nonlinear terms of a coupled parabolic system, and discuss its biological applications.

Fixed angle inverse scattering for sound speeds close to constant

Shiqi Ma
Jilin University

Abstract: We study the fixed angle inverse scattering problem of determining a sound speed from scattering measurements corresponding to a single incident wave. The main result shows that a sound speed close to constant can be stably determined by just one measurement. Our method is based on studying the linearized problem, which turns out to be related to the acoustic problem in photoacoustic imaging. We adapt the modified time-reversal method from [P. Stefanov and G. Uhlmann, Thermoacoustic tomography with variable sound speed, Inverse Problems 25 (2009), 075011] to solve the linearized problem in a stable way, and we use this to give a local uniqueness result for the nonlinear inverse problem.

A novel method for solving the inverse spectral problem with the incomplete data

Pinchao Meng

Changchun University of Science and Technology

Abstract: This paper is concerned with the inverse spectral problem of the Dirichlet boundary in a bounded region. We construct a data-driven deep neural network using convolutional and residual layers. The key ingredient of the approach is to extract features from input data, while fully preserving the original features and preventing network degradation. Using incomplete eigenvalue data as input and the Fourier expansion coefficients of the bounded regions as output. The network parameters are updated based on the reciprocal of the error calculated by the smooth L1 function. The incomplete eigenvalues are used to achieve the high-precision inversion of the bounded regions. Numerical experiments demonstrate the effectiveness of our method in solving the inverse spectral problem in both two-dimensional and three- dimensional cases.

Near microscale hydrodynamic cloaking using electro-osmosis

Zhiqiang Miao

Hunan University

Abstract: In this paper, we develop a general mathematical framework for near hydrodynamic cloaking of electro-osmotic flow, which is governed by a coupled PDE system via the field-effect electro-osmosis. We first obtain the field asymptotic expansions and first order coupled system. We then establish the representation formula of the solution of the first order coupled system using the layer potential techniques. Based on asymptotic analysis, the first and second order near hydrodynamic cloaking conditions are derived for the control region with the cross-sectional shape of a slightly deformed annulus or confocal ellipses cylinder. Our theoretical findings are validated and supplemented by a variety of numerical results. The results in this paper also provide a mathematical foundation for more complex hydrodynamic cloaking.

Minimal solutions of master equations for extended mean field games

Chenchen Mou

City University of Hong Kong

Abstract: In an extended mean field game the vector field governing the flow of the

population can be different from that of the individual player at some mean field equilibrium. This new class strictly includes the standard mean field games. It is well known that, without any monotonicity conditions, mean field games typically contain multiple mean field equilibria and the well-posedness of their corresponding master equations fails. In this paper, a partial order for the set of probability measure flows is proposed to compare different mean field equilibria. The minimal and maximal mean field equilibria under this partial order are constructed and satisfy the flow property. The corresponding value functions, however, are in general discontinuous. We thus introduce a notion of weak-viscosity solutions for the master equation and verify that the value functions are indeed weak-viscosity solutions. Moreover, a comparison principle for weak-viscosity semi-solutions is established and thus these two value functions serve as the minimal and maximal weak-viscosity solutions in appropriate sense. In particular, when these two value functions coincide, the value function becomes the unique weak-viscosity solution to the master equation. The novelties of the work persist even when restricted to the standard mean field games. This is based on a joint work with Jianfeng Zhang.

几类光学成像问题的数学建模和理论分析

Chunlong Sun

Nanjing University of Aeronautics and Astronautics

摘要：考虑几类光学成像问题的数学模型构建，如扩散光学层析成像（DOT）、荧光层析成像（FDOT）和生物分子发光成像（BLT）等，数学上此类问题可以概括为由光测边界观测确定生物介质的光学特性（吸收系数和散射系数）或源项。基于扩散近似，我们给出几类光学成像问题易于计算的数学模型，考虑相应模型误差估计和反问题的唯一性。

Recovering the source function in a time-domain wave equation by injecting high contrast bubbles

Haibing Wang

Southeast University

Abstract: Consider the inverse source problem for the scalar wave equation. We show that we can reconstruct the spacetime dependent source function from the measurement of the wave, collected on a single point x and a large enough interval of time, generated by a small scaled bubble, enjoying large contrasts of its bulk modulus, injected inside the domain to image. Then, we extend this result to reconstruct not only the source function but also the variable wave speed. Indeed, from the measured waves, we first localize the internal values of the travel time

function by looking at the behavior of this collected wave in terms of time. Then from the Eikonal equation, we recover the wave speed. Second, we recover the internal values of the wave generated only by the background (in the absence of the small particles) from the same measured data by inverting a Volterra integral operator of the second kind. From this reconstructed wave, we recover the source function at the expense of a numerical differentiation.

Uniqueness in inverse diffraction grating problems with infinitely many plane waves at a fixed frequency

Xiaoxu Xu

Xi'an Jiaotong University

Abstract: In this talk, we focus on the inverse grating diffraction problem in two-dimensional case. We prove that a Dirichlet periodic curve can be uniquely determined by the near-field data of infinitely many incident plane waves with distinct directions at a fixed frequency. Our proof is based on Schiffer's idea which consists of two ingredients: the total fields incited by distinct incident directions are linearly independent; ii) there exist only finitely many linearly independent Dirichlet eigenfunctions in a bounded domain or in a closed waveguide under additional assumptions on the waveguide boundary. Based on the Rayleigh expansion, we show that the phased near-field data can be uniquely determined by the phaseless near-field data in a bounded domain, with the exception of a finite set of incident angles. Such a phase retrieval result leads to new uniqueness results using the near-field data without phase information. This talk is based on a joint work with Guanghui Hu, Bo Zhang, and Haiwen Zhang.

Hierarchical basis a posteriori error estimator for Stokes problem

Jiaqing Yang

Xi'an Jiaotong University

Abstract: Based on the auxiliary subspace techniques, a hierarchical basis a posteriori error estimator is proposed for the Stokes problem in two and three dimensions. For the error estimator, we need to solve only two global diagonal linear systems corresponding to the degree of freedom of velocity and pressure respectively, which reduces the computational cost sharply. The upper and lower bounds up to an oscillation term are shown without saturation assumption. Numerical simulations are performed to demonstrate the reliability of the a posteriori error estimator.

Contactless Reconstruction of 3D Human Body

Weishi Yin

Changchun University of Science and Technology

Abstract: In this talk, we introduce the use of point cloud data to build a 3D human body. Assuming that the human body is the L^2 source, using the fundamental solution method to calculate the far-field data corresponding to the human body, and then extract the human feature information data from the point cloud. A data-driven neural network model can be built. After the input of the human body feature data, the corresponding far-field data can be obtained through the neural network model, and then the 3D human body is constructed by using Fourier method. This method can make users have a better sense of involvement.

Solving inverse problem of distributed-order time-fractional diffusion equations using boundary observations and L^2 regularization

Lele Yuan

Liaocheng University

Abstract: This article investigates the inverse problem of estimating the weight function using boundary observations in a distributed-order time-fractional diffusion equation. We propose a method based on L^2 regularization to convert the inverse problem into a regularized minimization problem, and we solve it using the conjugate gradient algorithm. The minimization functional only needs the weight to have L^2 regularity. We prove the weak closedness of the inverse operator, which ensures the existence, stability, and convergence of the regularized solution for the weight in L^2(0,1). We propose a weak source condition for the weight in C[0,1] and, based on this, we prove the convergence rate for the regularized solution. In the conjugate gradient algorithm, we derive the gradient of the objective functional through the adjoint technique. The effectiveness of the proposed method and the convergence rate are demonstrated by two numerical examples in two dimensions.

Hierarchical basis a posteriori error estimator for Stokes problem

Jiachuan Zhang

Nanjing Tech University

Abstract: Based on the auxiliary subspace techniques, a hierarchical basis a posteriori error estimator is proposed for the Stokes problem in two and three dimensions. For

the error estimator, we need to solve only two global diagonal linear systems corresponding to the degree of freedom of velocity and pressure respectively, which reduces the computational cost sharply. The upper and lower bounds up to an oscillation term are shown without saturation assumption. Numerical simulations are performed to demonstrate the reliability of the a posteriori error estimator.

Scattering problem of electromagnetic waves in chiral media

Lei Zhang

Zhejiang University of Technology

Abstract: Chirality has played a critical role in studying optical activity, multiferroics, and superfluidity. This talk concerns a scattering problem with obliquely incident electromagnetic waves in a chiral medium. The left-circular polarization and right-circular polarization are used, and the model problem is reduced to a coupled boundary value problem of the Helmholtz equations. The potential operators are investigated to establish coupled boundary integral equations. The operators' properties are obtained in Sobolev spaces by splitting techniques to overcome the singularity of integral operators. Then we prove the existence and uniqueness results for the integral equations and develop an efficient and accurate method to solve the coupled system. Numerical experiments are presented to demonstrate the effectiveness and robustness of the proposed methods.

Solving the inverse potential problem in the parabolic equation by the deep neural networks method

Mengmeng Zhang

Hebei University of Technology

Abstract: In this work, we consider an inverse potential problem in the parabolic equation, where the unknown potential is a space-dependent function and the used measurement is the final time data. The unknown potential in this inverse problem is parameterized by deep neural networks (DNNs) for the reconstruction scheme. First, the uniqueness of the inverse problem is proved under some regularities assumption on the input sources. Then we propose a new loss function with regularization terms depending on the derivatives of the residuals for partial differential equations (PDEs) and the measurements. These extra terms effectively induce higher regularity in solutions so that the ill-posedness of the inverse problem can be handled. Moreover, we establish the corresponding generalization error estimates rigorously. Our proofs exploit the conditional stability of the classical linear inverse source problems, and the mollification on the noisy measurement data which is set to reduce the

perturbation errors. Finally, the numerical algorithm and some numerical results are provided. This work is joint with Prof. Zhidong Zhang.

Inverse problems for mean field games

Shen Zhang
City University of Hong Kong

Abstract: Mean Field Games (MFGs) are non-atomic differential games in which the goal is to study the behaviors of a large population of symmetric agents as the number of agents grows to infinity. We propose and study several inverse problems for the mean field games (MFG) system in different setup. Our focus is on recovering the running cost and/or the Hamiltonian within the MFG system by the associated boundary observation. We develop two mathematical strategies that can ensure the probability constraint as well as effectively tackle the inverse problems, which are respectively termed as high-order variation and successive linearisation. In particular, the high-order variation method is new to the literature, which demonstrates a novel concept to examine the inverse problems by nonnegative inputs only.

A data-driven and model-based accelerated Hamiltonian Monte Carlo method for Bayesian elliptic inverse problems

Zhiwen Zhang
The University of Hong Kong

Abstract: We propose a data-driven and model-based approach to accelerate the Hamiltonian Monte Carlo (HMC) method in solving large-scale Bayesian inverse problems. The key idea is to exploit (model-based) and construct (data-based) the intrinsic approximate low-dimensional structure of the underlying problem which consists of two components a training component that computes a set of data-driven basis to achieve significant dimension reduction in the solution space, and a fast-solving component that computes the solution and its derivatives for a newly sampled elliptic PDE with the constructed data-driven basis. Hence, we achieve an effective data and model-based approach for the Bayesian inverse problem and overcome the typical computational bottleneck of HMC -- repeated evaluation of the Hamiltonian involving the solution (and its derivatives) modeled by a complex system, a multiscale elliptic PDE in our case. We present numerical examples to demonstrate the accuracy and efficiency of the proposed method.

A strongly mass conservative scheme for the coupled flow and transport

Lina Zhao

City University of Hong Kong

Abstract: In this talk, I will present a viscosity robust scheme for solving coupled Brinkman-Darcy flow and transport. The staggered DG method and mixed finite element method are judiciously combined to yield a strongly conservative scheme, which is particularly important for practical applications. Moreover, the interface conditions are enforced without resorting to Lagrange multiplier, and the continuity of the normal velocity is also satisfied at the discrete level. The optimal convergence error estimates of the scheme for all the involved variables are rigorously proved. Several numerical experiments will be presented to verify the performance of the proposed scheme.

GFTG prior and Optimal transport for Bayesian inverse problems

Guanghui Zheng

Hunan University

Abstract: The Bayesian inference is widely used in many scientific and engineering problems, especially in the inverse problems in infinite dimensional setting where the unknowns are functions.In this talk, we discuss the imaging inverse problem by employing an infinite dimensional Bayesian inference method with a general fractional total variation-Gaussian (GFTG) prior and optimal transport technology. This novel hybrid prior is a development for the total variation-Gaussian (TG) prior, which is a combination of the Gaussian prior and a general fractional total variation regularization term, which contains a wide class of fractional derivative. Compared to the TG prior, the GFTG prior can effectively reduce the staircase effect, enhance the texture details of the images and also provide a complete theoretical analysis in the infinite dimensional limit similarly to TG prior. We give the well-posedness and infinite-dimensional approximation of the posterior measure of the Bayesian inverse problem based on the GFTG prior, and then the samples are extracted from the posterior distribution more effectively by using the independence sampler algorithm and optimal transport technology. Finally, we give several numerical examples of image reconstruction under linear and nonlinear models to illustrate the advantages of the proposed improved prior.