Analysis, Scientific computing and Applications of PDEs Workshop Programme

October 17-21, 2019

1 Intoduction

This workshop aims to bring together experts working on the analysis, scientific computing and applications of PDEs to exchange the latest research progress, discuss new research directions and foster research collaborations.

2 Organizing Committee

Xiaoming Wang 王晓明, Southern University of Science and Technology
Jingzhi Li 李景治, Southern University of Science and Technology
Hongyu Liu 刘宏宇, Hong Kong Baptist University
Fuming Ma 马富明, Southern University of Science and Technology

3 Time Table

Date	Event	Venue
17 October	Conference registration	Vienna Hotel Group (维也纳3好酒店(西丽南科大店))
18 October	Workshop talks	Room 415, Block 3, Wisdom Valley (慧园3栋415)
19 October	Workshop talks	Room 415, Block 3, Wisdom Valley (慧园3栋415)
20 October	Workshop talks	Room 415, Block 3, Wisdom Valley (慧园3栋415)
21 October	Workshop talks	Room 415, Block 3, Wisdom Valley (慧园3栋415)

4 Venue

Accommodation: **Vienna Hotel Group (维也纳3好酒店(西丽南科大店))**

- by taxi: 深圳市南山区西丽大学城学苑大道1153号，维也纳3好酒店(西丽南科大店)
- by metro: 深圳地铁5号线，塘朗地铁站
- by bus: 塘朗小学站(或中科院研究院站) , Line M369, 43, 74, 81

Workshop: **Room 415, Block 3, Wisdom Valley (慧园3栋415).**

- by taxi: 深圳市南山区西丽大学城学苑大道1088号，南方科技大学，慧园3栋

- by metro: 深圳地铁5号线，塘朗地铁站
- by bus: 南方科技大学站 , Line M369, 43, 74, 81

5 Meals

Breakfast 18 October	Vienna Hotel Group (维也纳3好酒店(西丽南科大店))
Lunch 18 October	ground floor, Faculty Dining Hall (教工餐厅)
Dinner 18 October	ground floor, Faculty Dining Hall (教工餐厅)
Breakfast 19 October	Vienna Hotel Group (维也纳3好酒店(西丽南科大店))
Lunch 19 October	ground floor, Faculty Dining Hall (教工餐厅)
Dinner 19 October	ground floor, Guest House 1 (专家公寓1栋)
Breakfast 20 October	Vienna Hotel Group (维也纳3好酒店(西丽南科大店))
Lunch 20 October	ground floor, Faculty Dining Hall (教工餐厅)
Dinner 20 October	ground floor, Faculty Dining Hall (教工餐厅)
Breakfast 21 October	Vienna Hotel Group (维也纳3好酒店(西丽南科大店))

Please check the map on the last page for these particular locations.

6 Assistant

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7 Workshop Program

Time	October 18, 2019 (Friday)	
Morning session Chair: Fuming Ma 马富明		
8:50–9:00	Opening session	
9:00–9:30	Deyue Zhang 张德悦	Uniqueness for phaseless inverse acoustic scattering with superposition of point sources
9:30–10:00	Xiaodong Liu 刘晓东	Inverse scattering problems with multi-frequency sparse data
10:00–10:30	Lei Zhang 张磊	The electromagnetic scattering and inverse scattering of an infinite cylinder in chiral medium
10:30–11:00	Tea break	
11:00–11:30	Yixian Gao 高忆先	Electromagnetic field enhancement in a subwavelength rectangular open cavity
11:30–12:00	Huaian Diao 刁怀安	On novel geometric structures of Laplacian eigenfunctions in R^3 and applications to inverse problems
12:00–12:30	Yuliang Wang 王玉亮	On a novel inverse scattering scheme using resonant modes with enhanced imaging resolution
12:30–14:00	Lunch	
Afternoon session Chair: Jingzhi Li 李景治		
14:00–14:30	Yukun Guo 郭玉坤	Inverse scattering based approaches for imaging moving point sources
14:30–15:00	Guanghui Zheng 郑光辉	Identification of the reaction coefficient in a time dependent nonlocal diffusion process
15:00–15:30	Dehan Chen 陈德汗	Variational source condition for the reconstruction of distributed fluxes
15:30–16:00	Wei Wu 吴畏	Introduction and outlook on research of metamaterial
16:00–16:30	Tea break	
16:30–17:00	Shizhong Du 杜式忠	On Bernstein Theorem of Affine Maximal Equation
17:00–17:30	Yue Zhao 赵越	Inverse source problems for wave propagation
17:30–18:00	Hongjie Li 李宏杰	Mathematical study on plasmon resonance beyond quasi-static approximation
18:00	Dinner	

Time	October 19, 2019 (Saturday)	
Morning session Chair: Youzi He 何酉子		
9:00–9:30	Xu Liu 柳絮	Controllability and observability of some coupled stochastic parabolic systems
9:30–10:00	Xiaoyu Fu 付晓玉	Lipschitz stability in an inverse problem for the beam equation
10:00–10:30	Fangfang Dou 窦芳芳	Logarithmic Stability for Coefficients Inverse Problem of Coupled Wave Equations
10:30–11:00	Tea break	
11:00–11:30	Zhiwen Zhang 张智文	An efficient multiscale method for semiclassical Schrodinger equation with multiscale and random potentials
11:30–12:00	Qi Ye 叶颀	Kernel-based Probability Measures for Data Analysis: A Deterministic or Stochastic Problem?
12:00–12:30	Youjun Deng 邓又军	On identifying magnetized anomalies using geomagnetic monitoring
12:30–14:00	Lunch	
Afternoon session Chair: Jiachuan Zhang 张佳川		
14:00–14:30	Lingyun Qiu 邱凌云	Application of Optimal Transportation to Seismic Inverse Problems
14:30–15:00	Jiaqing Yang 杨家青	An inverse boundary value problem for stokes equations
15:00–15:30	Wei Yang 杨伟	Time-domain metamaterial models and finite element simulations
15:30–16:00	Wangtao Lu 鲁汪涛	On wellposedness and convergence of UPML method for analyzing wave scattering in layered media
16:00–16:30	Tea break	
16:30–17:00	Daijun Jiang 蒋代军	Uniqueness analysis and numerical methods for an inverse source problem in a time-fractional diffusion-advection equation
17:00–17:30	Liuqiang Zhong 钟柳强	Two level methods for some classes of PDEs
17:30–18:00	Chong Chen 陈冲	Joint Image Reconstruction and Motion Estimation in Spatiotemporal Imaging
18:00	Banquet	

Time	**October 20, 2019 (Sunday)**	
Morning session Chair: Hongyu Liu 刘宏宇		
9:00–9:30	Qi Lu 吕琦	Carleman Estimate for Stochastic Partial Differential Equations
9:30–10:00	Haibing Wang 王海兵	Asymptotic analysis for the heat conduction problem by a cluster of small cavities with applications
10:00–10:30	Weifeng Qiu 邱蔚峰	On a class of generalized Monge-Ampere type equations
10:30–11:00	Tea break	
11:00–11:30	Rongliang Chen 陈荣亮	A Parallel Two-level Domain Decomposition Method for Simulating Blood Flows in Patient-Specific Arteries
11:30–12:00	Junxiong Jia 贾骏雄	Variational Bayes' approach for functions and applications to some inverse problems
12:00–12:30	Jian Lu 鲁坚	ℓ_0-minimization methods for image restoration problems
12:30–14:00	Lunch	
Afternoon session Chair: Hongjie Li 李宏杰		
14:00–14:30	Hui Liang 梁慧	The convergence of collocation solutions in continuous piecewise polynomial spaces for weakly singular Volterra integral equations
14:30–15:00	Heping Dong 董和平	An inverse acoustic-elastic interaction problem with phased or phaseless far-field data
15:00–15:30	Wenbin Li 李文彬	Joint inversion of gravity and traveltime data with a level-set structural approach
15:30–16:00	Congpei An 安聪沛	Regularized weighted least squares approximation by using Gauss points
16:00–16:30	Tea break	
16:30–17:00	Xianchao Wang 汪贤超	Fourier method for recovering acoustic sources from multi-frequency far-field data
17:00–17:30	Chun-Hsiang Tsou 鄒駿祥	On the inverse inclusion problems for sharp domains
17:30–18:00	Xinlin Cao 曹鑫林	On the geometric structures of conductive transmission eigenfunctions and its application
18:00	Dinner	

8 Titles and Abstracts (in alphabetical order)

Regularized weighted least squares approximation by using Gauss points

Professor Congpei An 安聪沛
Southwestern University of Finance and Economics

Abstract: We consider polynomial approximation over the interval $[-1, 1]$ by regularized weighted discrete least squares methods with ℓ_2- or ℓ_1-regularization, respectively. As the set of nodes we use Gauss quadrature points (which are zeros of orthogonal polynomials). The number of Gauss quadrature points is $N + 1$. For $2L \leq 2N + 1$, with the aid of Gauss quadrature, we obtain approximation polynomials of degree L in closed form without solving linear algebra or optimization problems. In fact, these approximation polynomials can be expressed in the form of the barycentric interpolation formula when an interpolation condition is satisfied. We then study the approximation quality of the ℓ_2-regularized approximation polynomial in terms of Lebesgue constants, and the sparsity of the ℓ_1-regularized approximation polynomial. Finally, we give numerical examples to illustrate these theoretical results and show that a well-chosen regularization parameter can lead to good performance, with or without contaminated data.

Variational source condition for the reconstruction of distributed fluxes

Professor Dehan Chen 陈德汗
Central China Normal University

Abstract: This talk is devoted to the inverse problem of recovering the unknown distributed flux on an inaccessible part of boundary using measurement data on the accessible part. We establish and verify a variational source condition for this inverse problem, leading to a logarithmic-type convergence rate for the corresponding Tikhonov regularization method under a low Sobolev regularity assumption on the distributed flux. Our proof is based on the conditional stability and Carleman estimates together with the complex interpolation theory on a proper Gelfand triplet.

On the geometric structures of conductive transmission eigenfunctions and its application

Professor Xinlin Cao 曹鑫林
Hong Kong Baptist Univeristy

Abstract: We are concerned with the intrinsic geometric structures of conductive transmission eigenfunctions. We significantly extend and generalize the results that the interior transmission eigenfunction must be locally vanishing near a corner of the domain with an interior angle less than in several aspects. First, we consider the conductive transmission eigenfunctions which include the interior transmission eigenfunctions as a special case. Second, the vanishing property of the conductive transmission eigenfunctions is established for any corner as long as its interior angle is not . That means, as long as the corner singularity is not degenerate, the vanishing property holds. Third, the regularity requirements on the interior transmission eigenfunctions are significantly relaxed in the present study for the conductive transmission eigenfunctions. In order to establish the geometric properties for the conductive transmission eigenfunctions, we develop technically new methods. Finally, as an interesting and practical application of the obtained geometric results, we

establish a unique recovery result for the inverse problem associated with the transverse electromagnetic scattering by a single far-field measurement in simultaneously determining a polygonal conductive obstacle and its surface conductive parameter.

Joint Image Reconstruction and Motion Estimation in Spatiotemporal Imaging

Professor Chong Chen 陈冲
AMSS, Chinese Academy of Sciences

Abstract: Image reconstruction becomes challenging in spatiotemporal medical imaging, such as tomographic imaging of the heart or lungs. As an example, accounting for the unknown motion of the organs is important in PET/CT cardiac imaging when data is acquired over a relatively long period of time (often in the range of minutes). We will introduce the general strategies for spatiotemporal image reconstruction, and propose a new variational model for joint image reconstruction and motion estimation, which is investigated along a general framework that we present with shape theory. This model consists of two components, one that conducts modified image reconstruction in a static setting and the other that estimates the motion by sequentially indirect image registration. For the latter, we generalize the large deformation diffeomorphic metric mapping framework into the sequentially indirect registration setting. The proposed model is compared theoretically against alternative approaches (optical flow based model and diffeomorphic motion models), and we demonstrate that the proposed model has desirable properties in terms of the optimal solution. This talk is concluded by some numerical examples in two-dimensional space + time tomography with very sparse and/or highly noisy data.

A Parallel Two-level Domain Decomposition Method for Simulating Blood Flows in Patient-Specific Arteries

Professor Rongliang Chen 陈荣亮
Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Abstract: Numerical simulation of blood flows in patient-specific arteries can be useful for the understanding of vascular diseases, as well as for surgery planning. In this talk, we simulate blood flows in the full cerebral artery of stroke patients. To accurately resolve the flow in this rather complex geometry with stenosis is challenging and it is also important to obtain the results in a short amount of computing time so that the simulation can be used in pre- and/or post-surgery planning. For this purpose, we introduce a highly scalable, parallel non-nested two-level domain decomposition method for the three-dimensional unsteady incompressible Navier-Stokes equations with an impedance outlet boundary condition. The problem is discretized with a stabilized finite element method on unstructured meshes in space and a fully implicit method in time, and the large nonlinear systems are solved by a preconditioned parallel Newton-Krylov method with a two-level Schwarz method. The key component of the method is a non-nested coarse problem solved using a subset of processor cores and its solution is interpolated to the fine space using radial basis functions. Numerical results show that the proposed method works well for realistic geometry and parameters of a full size cerebral artery of an adult stroke patient on a supercomputers with thousands of processor cores.

On identifying magnetized anomalies using geomagnetic monitoring

Professor Youjun Deng 邓又军
Central South University

Abstract: We propose and investigate the inverse problem of identifying magnetized anomalies beneath the Earth using the geomagnetic monitoring. Suppose a collection of magnetized anomalies presented in the shell of the Earth. The presence of the anomalies interrupts the magnetic field of the Earth, monitored above the Earth. Using the difference of the magnetic fields before and after the presence of the magnetized anomalies, we show that one can uniquely recover the locations as well as their material parameters of the anomalies. Our study provides a rigorous mathematical theory to the geomagnetic detection technology that has been used in practice.

On novel geometric structures of Laplacian eigenfunctions in R^3 and applications to inverse problems

Professor Huaian Diao 刁怀安
Northeast Normal University

Abstract: This is a continued development of our recent work [Cao et al. arXiv:1902.05798, 2019] on the geometric structures of Laplacian eigenfunctions and their applications to inverse scattering problems. We studied in [Cao et al. arXiv:1902.05798, 2019] the analytic behaviour of the Laplacian eigenfunctions at a point where two nodal or generalised singular lines intersect. The results reveal an important intriguing property that the vanishing order of the eigenfunction at the intersecting point is closely related to the rationality of the intersecting angle. In the current paper, we continue this development in three dimensions and study the analytic behaviours of the Laplacian eigenfunctions at places where nodal or generalised singular planes intersect. Compared with the two-dimensional case, the geometric situation is much more complicated, so is the analysis: the intersection of two planes generates an edge corner, whereas the intersection of more than three planes generates a vertex corner. We provide a systematic and comprehensive characterisation of the relation between the analytic behaviours of an eigenfunction at a corner point and the geometric quantities of that corner for all these geometric cases. Moreover, we apply our spectral results to establish some novel unique identifiability results for the geometric inverse problems of recovering the shape as well as the (possible) surface impedance coefficient by the associated scattering far-field measurements.

An inverse acoustic-elastic interaction problem with phased or phaseless far-field data

Professor Heping Dong 董和平
Jilin University

Abstract: Consider the scattering of a time-harmonic acoustic plane wave by a bounded elastic obstacle which is immersed in a homogeneous acoustic medium. This talk concerns an inverse acoustic-elastic interaction problem, which is to determine the location and shape of the elastic obstacle by using either the phased or phaseless far-field data. By introducing the Helmholtz decomposition, the model problem is reduced to a coupled boundary value problem of the Helmholtz equations. The jump relations are studied for the second derivatives of the single-layer potential in order to establish the corresponding boundary integral equations. The well-posedness is discussed for the solution of the coupled boundary integral equations. An efficient and high order Nyström-type discretization method is proposed for the integral system. A numerical method of nonlinear

integral equations is developed for the inverse problem. For the case of phaseless data, we show that the modulus of the far-field pattern is invariant under a translation of the obstacle. To break the translation invariance, an elastic reference ball technique is introduced. We prove that the inverse problem with phaseless far-field pattern has a unique solution under certain conditions. In addition, a numerical method of the reference ball technique based nonlinear integral equations is also proposed for the phaseless inverse problem. Numerical experiments are provided to demonstrate the effectiveness and robustness of the proposed methods.

On Bernstein Theorem of Affine Maximal Equation

Professor Shizhong Du 杜式忠
Shantou University

Abstract: This talk will present some known and new results for Bernstein type theorem of Affine Maximal Equation.

Logarithmic Stability for Coefficients Inverse Problem of Coupled Wave Equations

Professor Fangfang Dou 窦芳芳
University of Electronic Science and Technology of China

Abstract: We investigates the identification of three coefficients in a coupled hyperbolic system with an observation on one component of the solution. Based on the the Carleman estimate for coupled wave equations and coupled elliptic equations, and the Fourier–Bros–Iagolnitzer transform, a logarithmic type stability result is obtained, with the measurements only in a nonempty open subset of the domain where the equations evolved.

Lipschitz stability in an inverse problem for the beam equation

Professor Xiaoyu Fu 付晓玉
Sichuan University

Abstract: In this talk, we will discuss an inverse problem in determining a coefficient of the zeroth-order term for a structurally damped beam equation from boundary measurements, the damping depending on a positive parameter.We prove the local Lipschitz stability result for this inverse problem.

Electromagnetic field enhancement in a subwavelength rectangular open cavity

Professor Yixian Gao 高忆先
Northeast Normal University

Abstract: In this talk, we will consider the transverse magnetic polarization of the electromagnetic scattering of a plane wave by a perfectly conducting plane surface, which contains a two-dimensional subwavelength rectangular cavity. The enhancement is investigated fully for the electric and magnetic fields arising in such an interaction. The cavity wall is assumed to be a perfect electric conductor, while the cavity bottom is allowed to be either a perfect electric conductor or a perfect magnetic conductor. We show that the significant field enhancement may be achieved in both nonresonant and resonant regimes. The proofs are based on variational approaches, layer potential techniques, boundary integral equations, and asymptotic analysis. Numerical experiments are also presented to confirm the theoretical findings

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Inverse scattering based approaches for imaging moving point sources

Professor Yukun Guo 郭玉坤
Harbin Institute of Technology

Abstract: I will talk about some inverse scattering methods for determining the motion trajectory of the dynamic point charge from the collected electromagnetic field measurement data. The identification process is mathematically modelled as a dynamic inverse source problem for time-dependent Maxwell's equations. From a practical point of view, the point source should be assumed to move in an unknown inhomogeneous background medium, which models the surroundings. Moreover, the electromagnetic radiated data are usually collected in a limited aperture in practice. For the inverse problem, we develop a dynamic direct sampling method to effectively recover the motion trajectory. Theoretical justifications will be presented for the mathematical modelling and the proposed recovery methods. Numerical results will be shown to illustrate the promising features of the proposed recognition approaches.

Variational Bayes' approach for functions and applications to some inverse problems

Professor Junxiong Jia 贾骏雄
Xi'an Jiaotong University

Abstract: Bayesian approach as a useful tool for quantifying uncertainties has been widely used for solving inverse problems of partial differential equations (IPPDE). One of the key difficulties for employing Bayesian approach is how to extract information from the posterior probability measure. Variational Bayes' method (VBM) is one of the most activate research topics in the field of machine learning, which has the ability to extract posterior information approximately by using much lower computational resources compared with the sampling type method. In this talk, we generalize the usual finite-dimensional VBM to infinite-dimensional space, which makes the usage of VBM for IPPDE rigorously. General infinite-dimensional mean-field approximation theory has been established, and has been applied to abstract linear inverse problems with Gaussian and Laplace noise assumption. Finally, two numerical examples are given which illustrate the effectiveness of the proposed approach.

Uniqueness analysis and numerical methods for an inverse source problem in a time-fractional diffusion-advection equation

Professor Daijun Jiang 蒋代军
Central China Normal University

Abstract: In this study, we first establish a weak unique continuation property for time-fractional diffusion-advection equations. The proof is mainly based on the Laplace transform and the unique continuation properties for elliptic and parabolic equations. The result is weaker than its parabolic counterpart in the sense that we additionally impose the homogeneous boundary condition. As a direct application, we prove the uniqueness for an inverse problem on determining the spatial component in the source term by interior measurements. Numerically, we reformulate our inverse source problem as an optimization problem, and propose an iterative thresholding algorithm. Finally, several numerical experiments are presented to show the accuracy and efficiency of the algorithm. This is a joint work with Prof. Masahiro Yamamoto, Zhiyuan Li, Yikan Liu and Dongling Wang.

Mathematical study on plasmon resonance beyond quasi-static approximation

Professor Hongjie Li 李宏杰
The Chinese University of Hong Kong

Abstract: This talk discusses the mathematical progress made by our study on the plasmon resonances and their application to invisibility cloaking for optics and linear elasticity. First, I shall briefly discuss the major results obtained in the quasi-static regime. Then I shall focus on talking about our recent study beyond the quasi-static approximation for the Lame system.

Joint inversion of gravity and traveltime data with a level-set structural approach

Professor Wenbin Li 李文彬
Harbin Institute of Technology, Shenzhen

Abstract: This talk introduces an ongoing work in the inversion of potential-field data and seismic traveltime tomography. The potential-field data are modeled by a Fredholm integral equation of the first kind, and the traveltime data are modeled by the eikonal equation. The data inversion is performed by solving a PDE-constrained optimization problem, in which the level-set method plays an important role in depicting the interface structure of the recovered solution, and the adjoint state method is employed to solve the constrained optimization. We propose a novel approach to jointly invert gravity and traveltime data, so that the two data sets can complement each other in their interpretations and alleviate ill-posedness of their corresponding inverse problems. Numerical examples are included to demonstrate the inversion algorithm, as well.

The convergence of collocation solutions in continuous piecewise polynomial spaces for weakly singular Volterra integral equations

Professor Hui Liang 梁慧
Harbin Institute of Technology, Shenzhen

Abstract: Collocation solutions by globally continuous piecewise polynomials to second-kind Volterra integral equations (VIEs) with smooth kernels are uniformly convergent (as the mesh diameter tends to zero) only for certain sets of collocation points. In this talk,we study the analogous convergence properties of globally continuous piecewise polynomial collocation solutions for second-kind VIEs with weakly singular kernels, both with respect to uniform and graded meshes.

Inverse scattering problems with multi-frequency sparse data

Professor Xiaodong Liu 刘晓东
AMSS, Chinese Academy of Sciences

Abstract: The inverse scattering theory has been a fast-developing area for the past forty years. Majority of studies focuses on inverse time harmonic wave scattering problems at a fixed frequency. At the same time, the measurements should be taken all around the unkonwn objects. However, from the practical point of view, we have only limited aperture data. In particular, the measurements are only available at isolated directions/points. To make the inverse scattering problems solvable, measurements should be taken with multiple frequencies. This is practically relevant because it is easier to vary frequency than to use arrays of receivers/sources. We introduce some of our recent progress on the theory and numerical methods in this direction.

Controllability and observability of some coupled stochastic parabolic systems

Professor Xu Liu 柳絮
Northeast Normal University

Abstract: In this talk, the controllability and observability for some coupled stochastic parabolic systems are studied, respectively, through one control and observer. The Lebeau-Robbiano strategy and Carleman estimate method are utilized. Compared to deterministic coupled parabolic systems, the coupling appearing in diffusion terms in the stochastic case introduces a new phenomena. A counterexample is presented to show that the controllability of stochastic parabolic systems is not robust with respect to the coupling coefficient.

ℓ_0-minimization methods for image restoration problems

Professor Jian Lu 鲁坚
Shenzhen University

Abstract: In this talk we consider a class of ℓ_0-minimization and wavelet frame based models for image deblurring and denoising. Mathematically, they can be formulated as minimizing the sum of a data fidelity term and the ℓ_0-'norm' of the framelet coefficients of the underlying image, and we are particularly interested in three different types of data fidelity forms for image restoration problems. We first study the first-order optimality conditions for these models. We then propose a penalty decomposition (PD) method for solving these problems in which a sequence of penalty subproblems are solved by a block coordinate descent (BCD) method. Under some suitable assumptions, we establish that any accumulation point of the sequence generated by the PD method satisfies the

first-order optimality conditions of these problems. Moreover, for the problems in which the data fidelity term is convex, we show that such an accumulation point is a local minimizer of the problems. In addition, we show that any accumulation point of the sequence generated by the BCD method is a block coordinate minimizer of the penalty subproblem. Furthermore, under some convexity assumptions on the data fidelity term, we prove that such an accumulation point is a local minimizer of the penalty subproblem. Numerical simulations show that the proposed ℓ_0-minimization methods enjoy great potential for image deblurring and denoising in terms of solution quality and/or speed.

On wellposedness and convergence of UPML method for analyzing wave scattering in layered media

Professor Wangtao Lu 鲁汪涛
Zhejiang University

Abstract: For time-harmonic wave scattering problems, the perfectly matched layer (PML) method has been utilized extensively in the literature to truncate the unbounded domain due to its remarkable efficiency in terminatingoutgoing waves. This paper establishes the wellposedness and convergence theory of the uniaxial PML (UPML) method in solving a two-dimensional acoustic scattering problem due to a compactly supported source, where the medium consists of two layers separated by the horizontal axis. When PML is used to truncate the vertical variable only, the medium structure becomes a closed waveguide. The Green function due to a primary source point in this waveguide can be constructed explicitly based on variable separations and Fourier transformations. In the horizontal direction, by properly placing periodical PMLs and locating periodic source points imaged by the primary source point, the exciting waveguide Green functions by those imaging points can be assembled to construct the Green function due to the primary source point for the two-layer medium truncated by a UPML. Incorporated with Green's identities, this UPML Green function directly implies the unconditional wellposedness of the acoustic scattering problem with a UPML truncation; in other words, the UPML problem is unconditionally resonance free. In addition, we show that the layered Green's function with UPML truncation converges to the exact layered Green's function exponentially fast as absorbing strength of the PML increases, which in turn shows the exponential convergence for the UPML truncated scattering problem.

Carleman Estimate for Stochastic Partial Differential Equations

Professor Qi Lu 吕琦
Sichuan University

Abstract: In this talk, we present some recent results of Carleman estimate for stochastic partial differential equations. Applications to controllability problems, inverse problems and unique continuation problems are also given.

Application of Optimal Transportation to Seismic Inverse Problems

Professor Lingyun Qiu 邱凌云
Tsinghua University

Abstract: The cycle-skipping problem in full waveform inversion (FWI) is investigated. A novel approach is presented to generalize and impose the optimal transport (OT) metric on the seismic inversion problem. We advocate the use of the quadratic Wasserstein metric with an encoding procedure to measure the transport cost and a penalty term for the mass creation/destruction in the unbalanced mass case. This approach improves the convexity of the misfit function and mitigates the local minimum issue.

The new approach uses an encoding scheme with the softplus function to emphasize the phase information in the inversion. In our implementation of the adjoint state method, the adjoint source is calculated trace-wise based on the 1D Wasserstein distance. It results in an efficient and robust algorithm with a computational complexity proportional to the number of shots and receivers, and the length of the seismic records. Consequently, there is no substantially added cost to the FWI when compared to the conventional least-squares norm implementation. We demonstrate the effectiveness of our solution by using synthetic velocity models.

On a class of generalized Monge-Ampere type equations

Professor Weifeng Qiu 邱蔚峰
City University of Hong Kong

Abstract: We consider generalized solutions to the Dirichlet problem for a class of generalized Monge-Ampere equations. For such generalized solutions, we give a complete proof for the so-called comparison principle.

On the inverse inclusion problems for sharp domains

Chun-Hsiang Tsou 鄒駿祥
Hong Kong Baptist University

Abstract: In this talk, we will present our recent developments on inverse inclusion problems, which represent a special category in the classical Calderon problems and have relevant applications in imaging techniques. Our researches are concentrated on the inverse inclusion problems for sharp domains, i.e. polygons or domains with high curvature points. We have established the logarithmic stability estimate for those inverse problems of polygons under a single measurement. Moreover, this technique can be applied to the domains with high curvature points, we will discuss on the uniqueness of the inverse problems on this case. This is joint work with Prof. H. Liu at HKBU.

Asymptotic analysis for the heat conduction problem by a cluster of small cavities with applications

Haibing Wang 王海兵
Southeast University

Abstract: Consider the heat conduction problem by a cluster of many small cavities. We show that the dominating heat is a sum, over the number of the cavities, of the heats generated by each cavity after interacting with each other. This interaction is described through densities computable as solutions of a closed, and invertible, system of time domain integral equations of a second kind. As an

application of this expansion, we derive the effective heat conductivity which generates approximately the same heat as the cluster of cavities, distributed in a 3D bounded domain, with explicit error estimates in terms of that cluster.

Fourier method for recovering acoustic sources from multi-frequency far-field data

Xianchao Wang 汪贤超
Harbin Institute of Technology

Abstract: We consider an inverse source problem of determining a source term in the Helmholtz equation from multi-frequency far-field measurements. Based on the Fourier series expansion, we develop a novel non-iterative reconstruction method for solving the problem. A promising feature of this method is that it utilizes the data from only a few observation directions for each frequency. Theoretical uniqueness and stability analysis are provided. Numerical experiments are conducted to illustrate the effectiveness and efficiency of theproposed method in both two and three dimensions.

On a novel inverse scattering scheme using resonant modes with enhanced imaging resolution

Professor Yuliang Wang 王玉亮
Hong Kong Baptist University

Abstract: We develop a novel wave imaging scheme for reconstructing the shape of an inhomogeneous scatterer and we consider the inverse acoustic obstacle scattering problem as a prototype model for our study. There exists a wealth of reconstruction methods for the inverse obstacle scattering problem and many of them intentionally avoid the interior resonant modes. Indeed, the occurrence of the interior resonance may cause the failure of the corresponding reconstruction. However, based on the observation that the interior resonant modes actually carry the geometrical information of the underlying obstacle, we propose an inverse scattering scheme of using those resonant modes for the reconstruction. To that end, we first develop a numerical procedure in determining the interior eigenvalues associated with an unknown obstacle from its far-field data based on the validity of the factorization method. Then we propose two efficient optimization methods in further determining the corresponding eigenfunctions. Using the afore-determined interior resonant modes, we show that the shape of the underlying obstacle can be effectively recovered. Moreover, the reconstruction yields enhanced imaging resolution, especially for the concave part of the obstacle. We provide rigorous theoretical justifications for the proposed method. Numerical examples in 2D and 3D verify the theoretically predicted effectiveness and efficiency of the method.

Introduction and outlook on research of metamaterial

Professor Wei Wu 吴畏
Hong Kong Baptist University

Abstract: Metamaterial is the name of a vast category of man-made material with properties that never occur on natural materials. It consists of assemblies of multiple repeatedly aligned unit structures made of metal or plastics. By adjusting properties of unit structures, we could expect a remarkable change of corresponding metamaterial in the absorption, enhancement or refraction to incident wave, of which we could take advantage to develop new materials possessing specific physical properties. In this talk, three different forms of metamaterial will be introduced in detail: plasmonic metamaterial, double-negative metamaterial and tunable metamaterial. We will elaborate the mathematical principle behind them, and the actual phenomenon observed by physicists. We will also give an outlook of future of metamaterial by illustrating exotic properties of so-called hyperbolic metamaterial, a hot research topic recently.

An inverse boundary value problem for stokes equations

Professor Jiaqing Yang 杨家青
Xi'an Jiaotong University

Abstract: This talk is concerned with an inverse boundary value problem for the stokes equation in a bounded domain with an unknown inclusion inside. We show that the shape and location of the inclusion can be uniquely recovered by taking partial boundary measurements. This is a joint work with Dr. Meng Liu and Prof. Wenjing Yan.

Time-domain metamaterial models and finite element simulations

Professor Wei Yang 杨伟
Xiangtan University

Abstract: In this talk, we first introduce the development history of mematerials and give some time-domain mathematical model in metamaterials. Then, we focus on the time-domain cloaks model. The explicit expressions of the cloak parameters without the contour curve expressions of the objects and 2d arbitrary shape cloak model are established. A new time-domain finite element scheme is developed to solve the governing equations, and it's stability is also provided. Numerical results are presented to confirm the theoretical analysis and the effectiveness of our cloak model and FETD method.

Kernel-based Probability Measures for Data Analysis: A Deterministic or Stochastic Problem?

Professor Qi Ye 叶颀
South China Normal University

Abstract: In the talk, we introduce a concept of kernel-based probability measures on Banach spaces to solve a deterministic problem by a stochastic approach such as collocations and interpolations. We combine the theory of numerical analysis, regression analysis, and stochastic analysis to renew the classical kernel-based approximation methods for data analysis and machine learning. The kernel-based probability measures give a numerical tool to construct and analyze the kernel-based estimators based on the generalized data including kernel-based algorithms and error analysis.

Uniqueness for phaseless inverse acoustic scattering with superposition of point sources

Professor Deyue Zhang 张德悦
Jilin University

Abstract: This talk is concerned with the uniqueness issue in inverse acoustic scattering problems with phaseless data. The key technique underlying our analysis is the superposition of point sources as the incident waves. First, we proved that the location and shape of the obstacle as well as its boundary condition or the refractive index can be uniquely determined by the modulus of far-field patterns. Then, we establish the uniqueness for inverse scattering problem of bounded scatterers with limited-aperture phaseless near-field data. Finally, some similar results for the phaseless inverse scattering from locally perturbed half-plane and cavities will be also discussed.

The electromagnetic scattering and inverse scattering of an infinite cylinder in chiral medium

Professor Lei Zhang 张磊
Heilongjiang University

Abstract: In this talk, we consider the scattering of an obliquely incident electromagnetic wave by an infinitely long impedance cylinder which is embedded in a homogeneous chiral medium. We show that the scattering problem can be modeled as a second-order elliptic system with generalized oblique derivative boundary conditions. The unique solvability of the direct scattering problem and the complex analyticity of its solution are proved. We are concerned with a corresponding inverse scattering problem, and prove that the cross-section and the impedance function of the cylinder can be uniquely determined from the far-field measurements.

An efficient multiscale method for semiclassical Schrodinger equation with multiscale and random potentials

Professor Zhiwen Zhang 张智文
The University of Hong Kong

Abstract: In this talk, we propose an efficient multiscale method to solve semiclassical Schrodinger equations, where we construct multiscale basis functions using an optimization method and the proper orthogonal decomposition method in the physical space and employ the quasi-Monte Carlo method in the random space. Our method is verified to be efficient: the spatial mesh size is only proportional to the semi-classical parameter and the number of samples in the random space is inversely proportional to the same parameter. Several theoretical aspects of the proposed method, including how to determine the number of samples in the construction of multiscale reduced basis and convergence analysis, are studied with numerical justification. In addition, we investigate the Anderson localization phenomena for the Schrodinger equation with correlated random potentials in both 1D and 2D space.

Inverse source problems for wave propagation

Professor Yue Zhao 赵越
Central China Normal University

Abstract: In this talk, I will present some of our recent results on inverse source problems in both frequency domain and time domain. Specifically, in the first part of this talk, I will talk about increasing stability for the inverse source problems in time-harmonic elastic and electromagnetic waves; in the second part of this talk, I will talk about some uniqueness and stability results on acoutic and electromagnetic waves in the time domain. Finally, I will talk about some ongoing work and future directions.

Identification of the reaction coefficient in a time dependent nonlocal diffusion process

Professor Guanghui Zheng 郑光辉
Hunan University

Abstract: This talk will focus on the inverse reaction coefficient problem for a time dependent nonlocal diffusion equation by utilizing the nonlocal flux measurement from an accessible part of region. Firstly, we prove the nonlocal flux data can uniquely determine the reaction coefficient. The variational regularization method is proposed to overcome the ill-posedness of inverse problem. Based on the hierarchical Bayesian model, an alternating iteration method is adopted to automatically select regularization parameters. Furthermore, we use Laplace approximation method to capture the statistics information of the solution. In particular, we prove the convergence rate estimation of the approximate posterior distribution constructed by Laplace approximation method to the actual posterior in the sense of Hellinger distance, and the lower bound of confidence width is rigorously estimated to characterize the reliability of the method. Finally, numerical results indicate that the proposed method could yield an accurate estimate and efficient uncertainty quantification of the solution.

Two level methods for some classes of PDEs

Professor Liuqiang Zhong 钟柳强
South China Normal University

Abstract: Frist, we develop and analyze a preconditioning technique and an iterative solver for the linear systems resulting from the discretization of second order elliptic problems by the symmetric interior penalty discontinuous Galerkin methods. Secondly, for nonsymmetric or indefine linear elliptic PDEs, we obtain the first error estimate in L^2-norm for the classical two-grid method, then design and analysis an improved two-grid method by adding one more correction on the coarse space to the classical two-gird method. Thirdly, for semilinear elliptic PDEs, we design and analyze a new finite element discretization technique based on iterative two-grid methods. At last, we develop several two-grid methods and two-level additive preconditioners for the Nedelec edge finite element approximation of the time-harmonic Maxwell equations.

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9 The list of participants

Congpei An 安聪沛 (Southwestern University of Finance and Economics)
Xinlin Cao 曹鑫林 (Hong Kong Baptist University)
Chong Chen 陈冲 (Academy of Mathematics and Systems Science, Chinese Academy of Sciences)
Rongliang Chen 陈荣亮 (Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences)
Dehan Chen 陈德汗 (Central China Normal University)
Youjun Deng 邓又军 (Central South University)
Huaian Diao 刁怀安 (Northeast Normal University)
Heping Dong 董和平 (Jilin University)
Fangfang Dou 窦芳芳 (University of Electronic Science and Technology of China)
Shizhong Du 杜式忠 (Shantou University)
Xiaoxu Fei 费晓旭 (Northeast Normal University)
Xiaoyu Fu 付晓玉 (Sichuan University)
Yixian Gao 高忆先 (Northeast Normal University)
Yukun Guo 郭玉坤 (Harbin Institute of Technology)
Youzi He 何酉子 (Hong Kong Baptist University)
Junxiong Jia 贾骏雄 (Xi'an Jiaotong University)
Daijun Jiang 蒋代军 (Central China Normal University)
Shanqiang Li 李善强 (Harbin University Of Science And Technology)
Hongjie Li 李宏杰 (The Chinese University of Hong Kong)
Jinhong LI 李金红 (Qilu University of Technology)
Wenbin Li 李文彬 (Harbin Institute of Technology, Shenzhen)
Hui Liang 梁慧 (Harbin Institute of Technology, Shenzhen)
Xiaodong Liu 刘晓东 (Academy of Mathematics and Systems Science, Chinese Academy of Sciences)
Xu Liu 柳絮 (Northeast Normal University)
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Qi Lu 吕琦 (Sichuan University)
Xiaowei Pang 庞晓伟 (Jilin University)
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Wei Yang 杨伟 (Xiangtan University)
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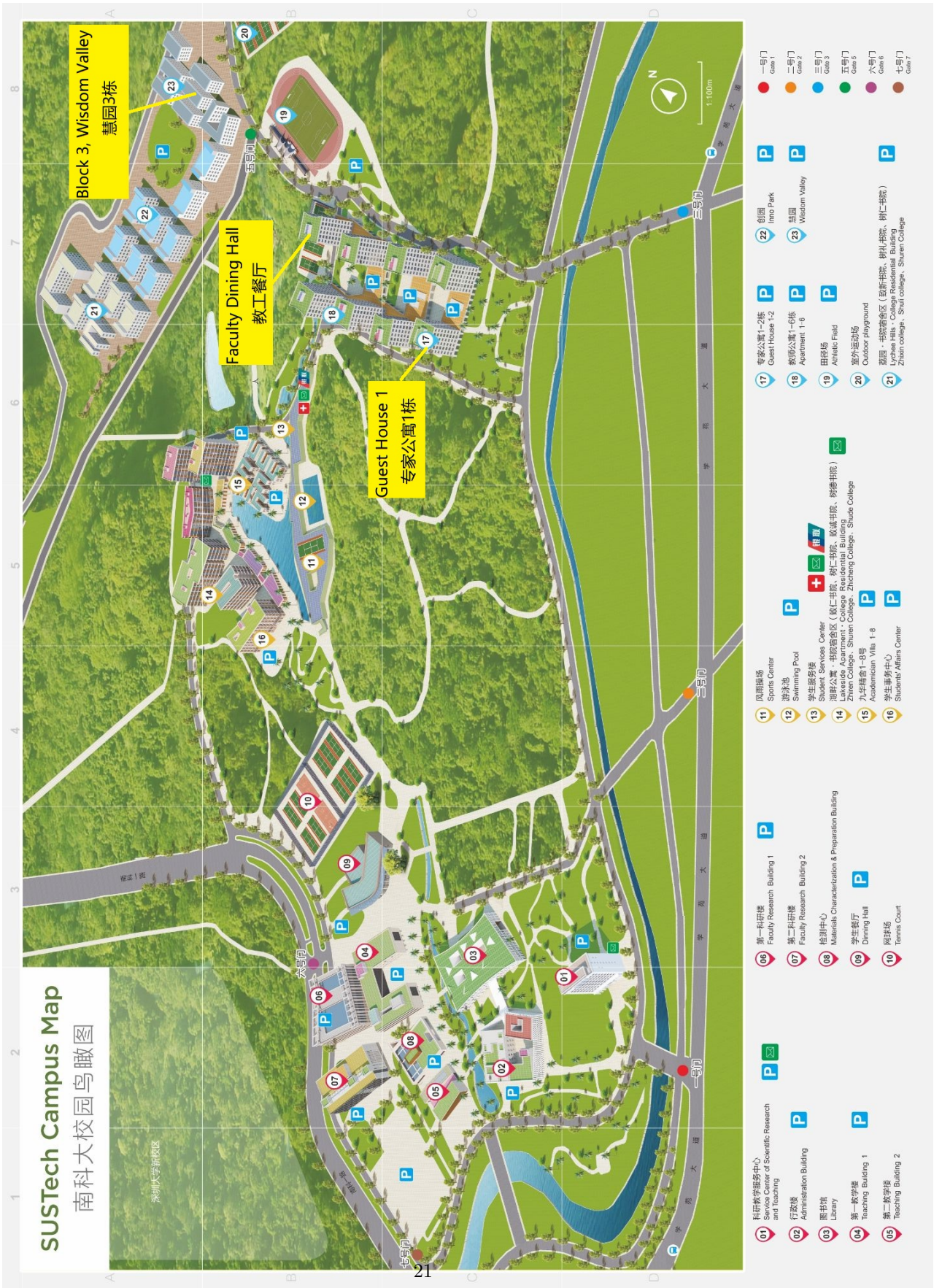
Qinghua Yu 于清华 (Northeast Normal University)

Deyue Zhang 张德悦 (Jilin University)
Lei Zhang 张磊 (Heilongjiang University)
Zhiwen Zhang 张智文 (The University of Hong Kong)
Yue Zhao 赵越 (Central China Normal University)
Guanghui Zheng 郑光辉 (Hunan University)
Liuqiang Zhong 钟柳强 (South China Normal University)

10 Campus map

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