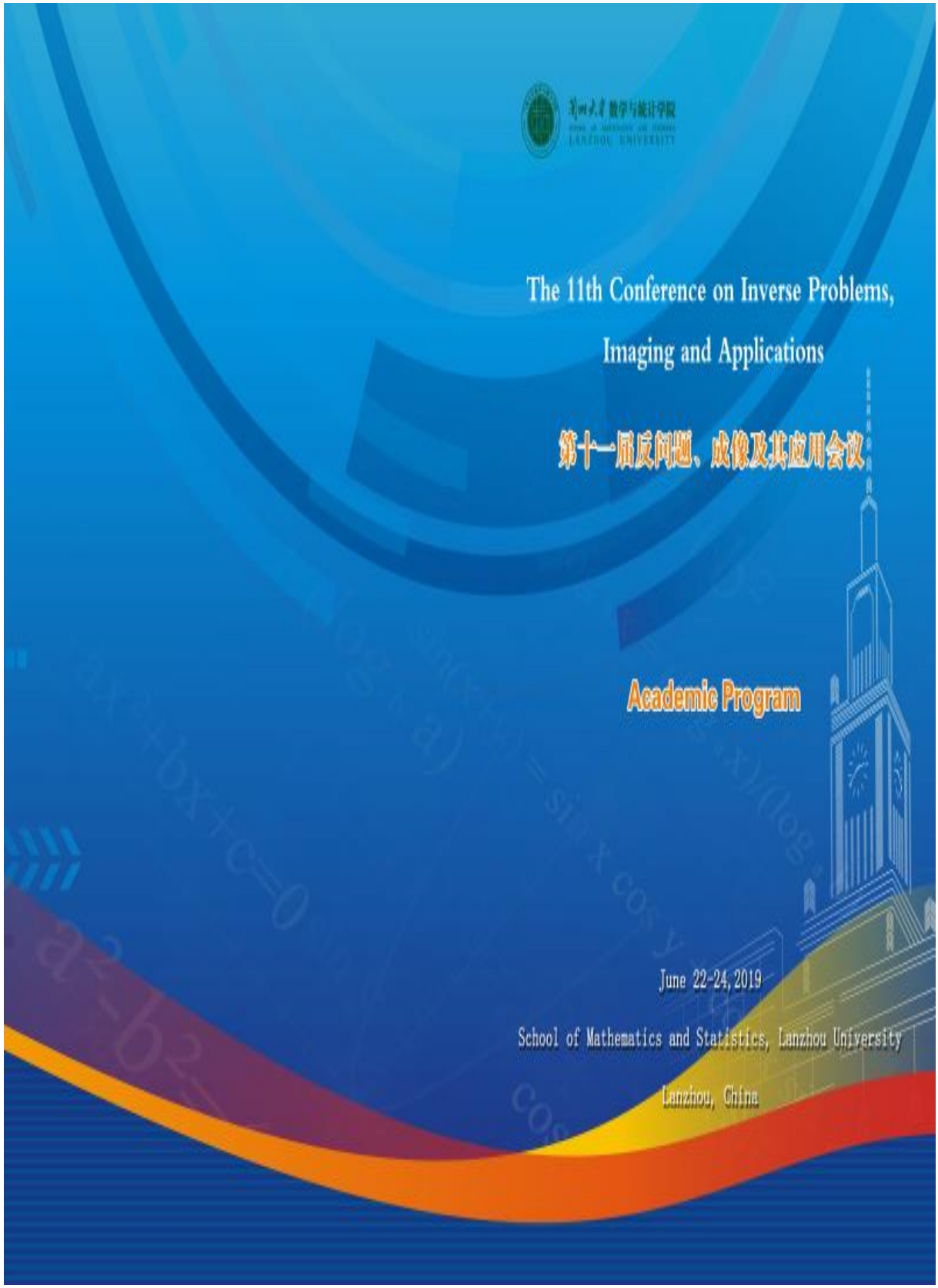
The 11th Conference on Inverse Problems,
Imaging and Applications
第十一届反问题、成像及其应用会议
Academic Program
June 22-24, 2019
School of Mathematics and Statistics, Lanzhou University
Lanzhou, China

The 11th Conference on Inverse Problems, Imaging and Applications

Conference in Lanzhou, China, June 22–24, 2019

Scientific committees:

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Organized by:

School of Mathematics and Statistics, Lanzhou University

Address: No.222, South Tianshui Road, Lanzhou, China, 730000

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The 11th Conference on Inverse Problems, Imaging and Applications

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1 Meals, venue information, map and general schedule

Meals

June 21 (Dinner): Buffet at Zugong Mansion, third floor;

June 22 (Lunch): Buffet at Zugong Mansion, third floor;

June 22 (Banquet): Table meal at Zugong Mansion, first floor;

June 23 (Lunch): Buffet at Zugong Mansion, third floor;

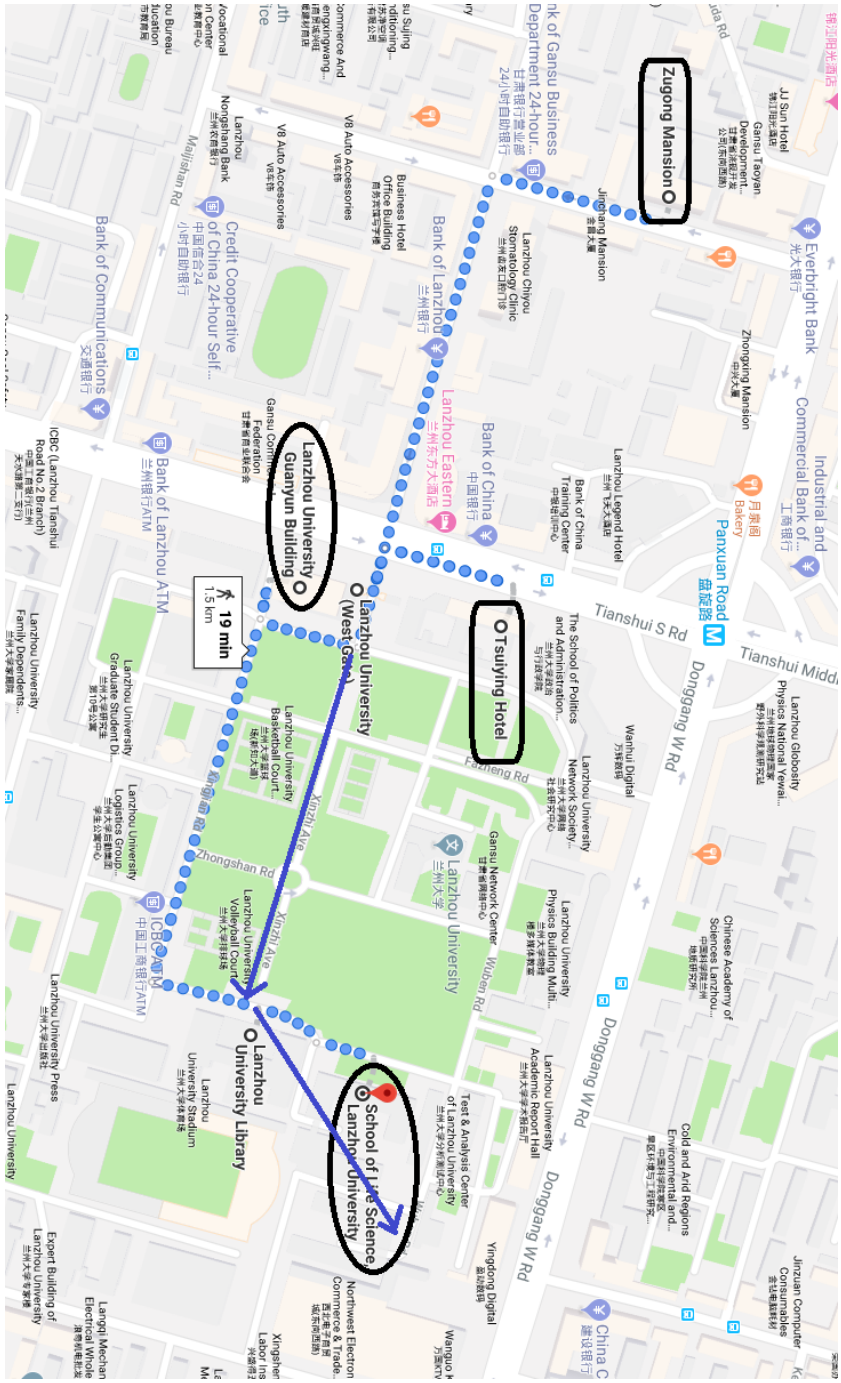
June 23 (Dinner): Buffet at Zugong Mansion, third floor;

June 24 (Lunch): Buffet at Zugong Mansion, third floor;

June 24 (Dinner): TBA.

Venue information

The Opening and plenary talks are scheduled at **Room 305, Yifu Shengwu Building, School of Life Science**, Lanzhou University. The minisymposia presentations are scheduled at **Rooms 501, 601, 603, 610, 703, Guanyun Building**, Lanzhou University.



Map of the Hotels & Conference rooms.

General schedule

	Fri, Jun. 21	Sat, Jun. 22	Sun, Jun. 23	Mon, Jun. 24	Tue, Jun. 25
08:00–09:00		**Opening** 08:30 - 09:10	**Bin Dong** 08:30 - 09:20	**M2-3, M3-3, M4-3** 08:00 - 10:00	
09:00–10:00	**Arrival & Registeration** 08:00 - 20:00	**Maarten V de Hoop** 09:10 - 10:00	**Xiaoqun Zhang** 09:20 - 10:10		**Departure** 08:00 - 18:00
		Tea Break 10:00 - 10:20	**Tea Break** 10:10 - 10:30	**Tea Break** 10:00 - 10:20	
10:00–11:00		**Jianliang Qian** 10:20 - 11:10	**Award Lecture I** 10:30 - 11:15	**M3-4, M6-2, M8-1** 10:20 - 12:20	
11:00–12:00		**Kui Ren** 11:10 - 12:00	**Award Lecture II** 11:15 - 12:00		
12:00–13:00		**Lunch Break** 12:20 - 13:30	**Lunch Break** 12:20 - 13:30	**Lunch Break** 12:30 - 14:00	
13:00–14:00					
14:00–15:00		**M1-1, M3-1, M4-1** 13:30 - 15:30	**M2-1, M5-1, M7-1** 13:30 - 15:30	**Discussion** 14:00 - 18:00	
15:00–16:00		**Tea Break** 15:30 - 15:50	**Tea Break** 15:30 - 15:50		
16:00–17:00		**M1-2, M3-2, M6-1** 15:50 - 17:50	**M2-2, M4-2, M7-2** 15:50 - 18:20		
17:00–18:00					
	Dinner 18:00 - 20:00	**Banquet** 18:00 - 20:30	**Dinner** 18:30 - 20:00	**Dinner** 18:00 - 20:00	

2 Plenary talks & award lectures

Inverse problems in anisotropic elasticity and seismology

Speaker:	Maarten V. de Hoop, *Rice Univeristy*
Scheduled:	Saturday, June 22, 9:10–10:00 at Room 305, Yifu Shengwu Building
Chair:	Gang Bao

Fast Algorithms for Direct and Inverse Problems in Mathematical Geophysics

Speaker:	Jianliang Qian, *Michigan State University*
Scheduled:	Saturday, June 22, 10:20–11:10 at Room 305, Yifu Shengwu Building
Chair:	Jin Cheng

Uncertainty Characterization in Model-Based Inverse and Imaging Problems

Speaker:	Kui Ren, *Columbia University*
Scheduled:	Saturday, June 22, 11:10–12:00 at Room 305, Yifu Shengwu Building
Chair:	Bo Zhang

Bridging Deep Neural Networks and Differential Equations for Image Analysis and Beyond

Speaker:	Bin Dong, *Beijing International Center for Mathematical Research & Peking University*
Scheduled:	Sunday, June 23, 08:30–09:20 at Room 305, Yifu Shengwu Building
Chair:	Fuming Ma

Variational image restoration: from sparsity to data driven approaches

Speaker:	Xiaoqun Zhang, *Shanghai Jiaotong University*
Scheduled:	Sunday, June 23, 09:20–10:10 at Room 305, Yifu Shengwu Building
Chair:	Peijun Li

Award lecture I

Scheduled:	Sunday, June 23, 10:30–11:15 at Room 305, Yifu Shengwu Building
Chair:	Jijun Liu

Award lecture II

Scheduled:	Sunday, June 23, 11:15–12:00 at Room 305, Yifu Shengwu Building
Chair:	Jiguang Sun

3 Minisymposia presentations

The minisymposia presentations are scheduled at **Rooms 501, 601, 603, 610, 703, Guanyun Building**, Lanzhou University.

3.1 List of Minisymposia

M1: Computational Inverse Problems
Organizer: Shuai Lu, Fudan University
M1-1: M1 Session 1; M1-2: M1 Session 2

M2: Inverse Problem for Diffusion Equation and Its Application
Organizers: Haibing Wang, Southeast University; Zewen Wang, East China University Of Technology
M2-1: M2 Session 1; M2-2: M2 Session 2; M2-3: M2 Session 3

M3: Imaging Theory and Algorithms for Inverse Scattering Problem
Organizers: Deyue Zhang, Jilin University; Guanghui Hu, Beijing Computational Science Research Center
M3-1: M3 Session 1; M3-2: M3 Session 2; M3-3: M3 Session 3; M3-4: M3 Session 4

M4: Visible and Invisible
Organizers: Yukun Guo, Harbin Institute of Technology; Xiaodong Liu, Chinese Academy of Sciences
M4-1: M4 Session 1; M4-2: M4 Session 2; M4-3: M4 Session 3

M5: Iterative Methods and Regularization Theory for Inverse Problems
Organizer: Rongfang Gong, Nanjing University of Aeronautics and Astronautics
M5-1: M5 Session 1

M6: Theory Analysis and Computation of Electromagnetic Scattering and Inverse Scattering Problems in Unbounded Domain
Organizers: Jiaqing Yang, Xi'an Jiaotong University; Lei Zhang, Heilongjiang University
M6-1: M6 Session 1; M6-2: M6 Session 2

M7: A3 Workshop
Organizer: Xiang Xu, Zhejiang University
M7-1: M7 Session 1; M7-2: M7 Session 2

M8: Contributed Talks
Organizer: TBA
M8-1: M8 Session 1

3.2 Detailed schedule for minisymposia presentations

M1: Computational Inverse Problems
Organizer: Shuai Lu

M1-1, 13:30-15:30, Saturday, Jun. 22, Room 501, Guanyun Building

- **Study of Three-dimensional Transient Inverse Heat Conduction Problems in the Enhanced Pool Boiling Heat Transfer**
  Yi Heng, *Sun Yat-sen University*
  Saturday, June 22, 13:30-14:00

- **A non-intrusive reduced basis EKI for time-fractional diffusion inverse problems**
  Liang Yan, *Southeast University*
  Saturday, June 22, 14:00-14:30

- **Variational Bayes' approach for functions and applications to some inverse problems**
  Junxiong Jia, *Xi'an Jiaotong University*
  Saturday, June 22, 14:30-15:00

- **A multiscale radial basis function method for severely ill-posed problems on spheres**
  Min Zhong, *Southeast University*
  Saturday, June 22, 15:00-15:30

M1-2, 15:50-17:50, Saturday, Jun. 22, Room 501, Guanyun Building

- **Regularization Methods for Recovering Conductivity**
  Xiliang Lu, *Wuhan University*
  Saturday, June 22, 15:50-16:20

- **Uniqueness analysis and numerical methods for an inverse source problem in a time-fractional diffusion-advection equation**
  Daijun Jiang, *Central China Normal University*
  Saturday, June 22, 16:20-16:50

- **Efficient implementations of multi-dimensional fractional Laplacians via spherical means**
  Boxi Xu, *Shanghai University of Finance and Economics*
  Saturday, June 22, 16:50-17:20

- **Determining a random Schrödinger equation with unknown source and potential**
  Jingzhi Li, *Southern University of Science and Technology*
  Saturday, June 22, 17:20-17:50

M2: Inverse Problem for Diffusion Equation and Its Application
Organizers: Haibing Wang & Zewen Wang

M2-1, 13:30-15:30, Sunday, Jun. 23, Room 501, Guanyun Building

- **On the simultaneous reconstruction of the reaction coefficient, source term and initial temperature**
  Kai Cao, *Southeast University*
  Sunday, June 23, 13:30-14:00

- **Regularization and convergence for ill-posed backward evolution equations in Banach spaces**
  Dehan Chen, *Central China Normal University*
  Sunday, June 23, 14:00-14:30

- **Inverse problems for degenerate parabolic equations**
  Zuicha Deng, *Lanzhou Jiaotong University*
  Sunday, June 23, 14:30-15:00

- **An inverse problem for parabolic equation with free boundary problem of ductal carcinoma in situ**
  Meibao Ge, *Hangzhou Medical College*
  Sunday, June 23, 15:00-15:30

M2-2, 15:50-18:20, Sunday, Jun. 23, Room 501, Guanyun Building

- **Backward Problem for a Time-Space Fractional Diffusion Equation**
  Junxiong Jia, *Xi'an Jiaotong University*
  Sunday, June 23, 15:50-16:20

- **Convergence analysis of LMM and DDMs for a parabolic inverse Robin problem**
  Daijun Jiang, *Central China Normal University*
  Sunday, June 23, 16:20-16:50

- **A hybrid inversion scheme for diffuse optical tomography with small inclusions**
  Yu Jiang, *Shanghai University of Finance and Economics*
  Sunday, June 23, 16:50-17:20

- **Unique continuation for the fractional diffusion-wave equation**
  Zhiyuan Li, *Shandong University of Technology*
  Sunday, June 23, 17:20-17:50

- **A Bayesian approach for inverse obstacle scattering with Poisson data**
  Xiaomei Yang, *Southwest Jiaotong University*
  Sunday, June 23, 17:50-18:20

M2-3, 08:00-10:00, Monday, Jun. 24, Room 501, Guanyun Building

- **Identification of initial condition in one-dimensional integer/fractional order diffusion equation by one point observation data**
  Zhousheng Ruan, *East China Institute Of Technology*
  Monday, June 24, 08:00-08:30

- **Some Inverse Boundary Value Problems for Parabolic Equations**
  Yuchan Wang, *Nanjing University of Information Science and Technology*
  Monday, June 24, 08:30-09:00

- **On the stability of recovering two sources and initial status simultaneously in a stochastic hyperbolic-parabolic system**
  Bin Wu, *Nanjing University of Information Science and Technology*
  Monday, June 24, 09:00-09:30

- **Application of Transmission Eigenvalues in penetrable Medium to Invisible Cloaking**
  Hansu Zhang, *Southeast University*
  Monday, June 24, 09:30-10:00

M3: Imaging Theory and Algorithms for Inverse Scattering Problem

Organizers: Deyue Zhang & Guanghui Hu

M3-1, 13:30-15:30, Saturday, Jun. 22, Room 601, Guanyun Building

- **The Wasserstein-Fisher-Rao Metric for Waveform Based Earthquake Location**
  Hao Wu, *Tsinghua University*
  Saturday, June 22, 13:30-14:00

- **Application of Optimal Transportation with Surrogate to Seismic Inverse Problems**
  Lingyun Qiu, *Tsinghua University*
  Saturday, June 22, 14:00-14:30

- **Convergence analysis for solving the Helmholtz equation in a layered medium by PML-BIE method**
  Jun Lai, *Zhejiang University*
  Saturday, June 22, 14:30-15:00

- **Determination of a transversely isotropic perturbation of elastic medium**
  Jian Zhai, *Hong Kong University of Science and Technology*
  Saturday, June 22, 15:00-15:30

M3-2, 15:50-17:50, Saturday, Jun. 22, Room 601, Guanyun Building

- **On the geometric structure of conductive transmission eigenfunctions and its application**
  Huai' an Diao, *Northeast Normal University*
  Saturday, June 22, 15:50-16:20

- **Time-Domain Analysis of an Acoustic–Elastic Interaction Problem**
  Yixian Gao, *Northeast Normal University*
  Saturday, June 22, 16:20-16:50

- **Uniqueness for phaseless inverse acoustic scattering with superposition of point sources**
  Deyue Zhang, *Jilin University*
  Saturday, June 22, 16:50-17:20

- **A simple method to reconstruct three dimensional time dependent point sources of acoustic waves**
  Bo Chen, *Civil Aviation University of China*
  Saturday, June 22, 17:20-17:50

M3-3, 08:00-10:00, Monday, Jun. 24, Room 610, Guanyun Building

- **Direct imaging methods for identifying multipolar sources with a single frequency**
  Yukun Guo, *Harbin Institute of Technology*
  Monday, June 24, 08:00-08:30

- **Potential reconstruction in nonlocal diffusion**
  Guanghui Zheng, *Hunan University*
  Monday, June 24, 08:30-09:00

- **Sparse Reconstructions of Acoustic Source for Inverse Scattering Problems in Measure Space**
  Hongpeng Sun, *Renmin University*
  Monday, June 24, 09:00-09:30

- **Inverse random source problems for time-harmonic acoustic and elastic waves**
  Jianliang Li, *Changsha University of Science and Technology*
  Monday, June 24, 09:30-10:00

M3-4, 10:20-12:20, Monday, Jun. 24, Room 610, Guanyun Building

- **Through Wall Detection of the Moving Paths and Vital Signs of Human Beings**
  Jiguang Sun, *Michigan Technological University*
  Monday, June 24, 10:20-10:50

- **Gradient Estimates for Solutions of Perfect Conductivity Problem**
  Yu Chen, *Beijng Normal University*
  Monday, June 24, 10:50-11:20

- **Fluorescence diffuse optical tomography using a cuboid approximation**
  Chunlong Sun, *Southeast University*
  Monday, June 24, 11:20-11:50

- **A data-driven inverse scattering problem with one incoming wave**
  Guanqiu Ma, *Beijing Computational Science Research Center*
  Monday, June 24, 11:50-12:20

M4: Visible and Invisible

Organizers: Yukun Guo & Xiaodong Liu

M4-1, 13:30-15:30, Saturday, Jun. 22, Room 610, Guanyun Building

- **Generalized polarization tensors for inhomogeneous medium and cloaking**
  Youjun Deng, *Central South University*
  Saturday, June 22, 13:30-14:00

- **A Bayesian level set approach for acoustic source identification using multiple frequency information**
  Zhiliang Deng, *University of Electronic Science and Technology*
  Saturday, June 22, 14:00-14:30

- **Direct and inverse scattering from a collection of small scatterers in the time domain**
  Guanghui Hu, *Beijing Computational Science Research Center*
  Saturday, June 22, 14:30-15:00

- **Fourier method for identifying electromagnetic sources with multi-frequency far-field data**
  Yukun Guo, *Harbin Institute of Technology*
  Saturday, June 22, 15:00-15:30

M4-2, 15:50-18:20, Sunday, Jun. 23, Room 601, Guanyun Building

- **A C0IP method of Transmission Eigenvalues for Elastic Waves**
  Xia Ji, *Chinese Academy of Sciences*
  Sunday, June 23, 15:50-16:20

- **Construction of weakly neutral inclusions of general shape**
  Xiaofei Li, *Zhejiang University of Technology*
  Sunday, June 23, 16:20-16:50

- **Uniqueness and stability for inverse source problems in acoustics**
  Chun Liu, *Chinese Academy of Sciences*
  Sunday, June 23, 16:50-17:20

- **Analysis of Fully Preconditioned Alternating Direction Method of Multipliers with Relaxation in Hilbert Spaces**
  Hongpeng Sun, *Renmin University*
  Sunday, June 23, 17:20-17:50

- **Extended Sampling Method for Inverse Elastic Scattering Problems**
  Juan Liu, *Jinan University*
  Sunday, June 23, 17:50-18:20

M4-3, 08:00-10:00, Monday, Jun. 24, Room 703, Guanyun Building

- **Localization and geometrization in plasmon resonances and geometric structures of Neumann-Poincare eigenfunctions**
  Yuliang Wang, *Hong Kong Baptist University*
  Monday, June 24, 08:00-08:30

- **Convergence of the perfectly matched layer for transient acoustic-elastic interaction above an unbounded rough surface**
  Changkun Wei, *Chinese Academy of Sciences*
  Monday, June 24, 08:30-09:00

- **Uniqueness in inverse scattering problems with phaseless far-field data at a fixed frequency**
  Xiaoxu Xu, *Chinese Academy of Sciences*
  Monday, June 24, 09:00-09:30

- **Multi-frequency iterative methods for the inverse medium scattering problem in elasticity**
  Fang Zeng, *Chongqing University*
  Monday, June 24, 09:30-10:00

M5: Iterative Methods and Regularization Theory for Inverse Problems

Organizer: Rongfang Gong

M5-1, 13:30-15:30, Sunday, Jun. 23, Room 601, Guanyun Building

- **Heuristic rule for the iteratively regularized Gauss-Newton method in Banach spaces**
  Qinian Jin, *Australian National University*
  Sunday, June 23, 13:30-14:00

- **Regularization of inverse problems by two point gradient methods with convex constraints**
  Min Zhong, *Southeast University*
  Sunday, June 23, 14:00-14:30

- **Logarithmic Stability for Coefficients Inverse Problem of Coupled Wave Equations**
  Fangfang Dou, *University of Electronic Science and Technology*
  Sunday, June 23, 14:30-15:00

- **A new class of accelerated regularization methods of solving inverse problems with application to bioluminescence tomography**
  Rongfang Gong, *Nanjing University of Aeronautics and Astronautics*
  Sunday, June 23, 15:00-15:30

M6: Theory Analysis and Computation of Electromagnetic Scattering and Inverse Scattering Problems in Unbounded Domain

Organizers: Jiaqing Yang & Lei Zhang

M6-1, 15:50-17:50, Saturday, Jun. 22, Room 610, Guanyun Building

- **Inverse acoustic-elastic interaction problem with phased or phaseless far-field data**
  Heping Dong, *Jilin University*
  Saturday, June 22, 15:50-16:20

- **Galerkin Method for the Scattering Problem of Strip Gratings**
  Enxi Zheng, *Dalian Maritime University*
  Saturday, June 22, 16:20-16:50

- **Approximately Recovering of Viscoelasticity of Living Body from MRE Data**
  Yu Jiang, *Shanghai University of Finance and Economics*
  Saturday, June 22, 16:50-17:20

- **Optimal Mesh Size for Inverse Medium Scattering Problems**
  Keji Liu, *Shanghai University of Finance and Economics*
  Saturday, June 22, 17:20-17:50

M6-2, 10:20-12:20, Monday, Jun. 24, Room 501, Guanyun Building

- **On a Novel Inverse Scattering Scheme Using Resonant Modes with Enhanced Imaging Resolution**
  Yuliang Wang, *Hong Kong Baptist University*
  Monday, June 24, 10:20-10:50

- **Recovering an Inclusion for the Inverse Stokes Problem by the Boundary Measurements**
  Meng Liu, *Xi'an Jiaotong University*
  Monday, June 24, 10:50-11:20

- **Near-field Imaging of an Unbounded Rough Surface by Elastic-wave Measurements**
  Tielei Zhu, *Xi'an Jiaotong University*
  Monday, June 24, 11:20-11:50

- **Time Domain Scattering Problems in Periodic Structures and Bi-periodic Structures**
  Jue Wang, *Harbin Engineering University*
  Monday, June 24, 11:50-12:20

M7: A3 Workshop
Organizer: Xiang Xu

M7-1, 13:30-15:30, Sunday, Jun. 23, Room 603, Guanyun Building

- **On inverse crack problems in conductive bodies by the enclosure method**
  Hiromichi Itou, *Tokyo University of Science*
  Sunday, June 23, 13:30-14:00

- **Existence of weakly neutral coated inclusions of general shape in two dimensions**
  Xiaofei Li, *Zhejiang University of Technology*
  Sunday, June 23, 14:00-14:30

- **Numerical unique continuation of two dimensional elliptic equations and estimate of confidence domain**
  Yu Chen, *Fudan University*
  Sunday, June 23, 14:30-15:00

- **An adaptive DtN finite element method for three-dimensional acoustic scattering problems**
  Bin Hu, *Zhejiang University*
  Sunday, June 23, 15:00-15:30

M7-2, 15:50-18:20, Sunday, Jun. 23, Room 603, Guanyun Building

- **Shape prior metal artifact reduction algorithm for industrial 3D cone beam**
  Chang-Ock LEE, *KAIST*
  Sunday, June 23, 15:50-16:20

- **Variational Model with the ℓ_q semi-norm for Impulse Noise Reduction**
  Taeuk JEONG, *Yonsei University*
  Sunday, June 23, 16:20-16:50

- **Asymptotic expansions for the diffusion equation with applications**
  Haibing Wang, *Southeast University*
  Sunday, June 23, 16:50-17:20

- **Unique continuation property with partial information for two-dimensional anisotropic elasticity systems**
  Yikan Liu, *The University of Tokyo*
  Sunday, June 23, 17:20-17:50

- **Carleman estimate for a time-fractional advection-diffusion equation and application to an inverse source problem**
  Xinchi Huang, *The University of Tokyo*
  Sunday, June 23, 17:50-18:20

M8: Contributed Talks
Organizer: TBA

M8-1, 10:20-12:25, Monday, Jun. 24, Room 703, Guanyun Building

- **Long Range Scattering Problem for the Maxwell-Schrödinger Equation without any Restriction on the Size of Data**
  Yang Liu, *Northeast Normal University & Shimane University*
  Monday, June 24, 10:20-10:45

- **REGINN iteration based on the non-stationary iterated Tikhonov method with general convex penalty terms**
  Zhenwu Fu, *Harbin Institute of Technology*
  Monday, June 24, 10:45-11:10

- **Recovery of non-smooth radiative coefficient from nonlocal observation by diffusion system**
  Mengmeng Zhang, *Southeast University*
  Monday, June 24, 11:10-11:35

- **A mixed strategy for efficient acousto-electric tomography based on complete electrode model**
  Changyou Li, *Northwest University of Technology*
  Monday, June 24, 11:35-12:00

- **An accelerated sequential subspace optimization method based on homotopy perturbation iteration for nonlinear ill-posed problems**
  Shanshan Tong, *Shaanxi Normal University*
  Monday, June 24, 12:00-12:25

4 Abstract of plenary talks and minisymposia presentations

4.1 Plenary talks & award lectures

Inverse problems in anisotropic elasticity and seismology

SPEAKER: Maarten V. de Hoop, *Rice Univeristy*

ABSTRACT: The basis for any seismological studies is the theory of wave propagation in models of elastic media adequate to the real Earth. Earth's (effective) elastic material properties are typically anisotropic and heterogeneous. We give an overview of recent results on determining these properties regionally and globally using different types of data using both active and passive, boundary and interior sources. Techniques from microlocal analysis and from Finsler geometry come into play.

Joint research with J. Ilmavirta, M. Lassas, T. Saksala, G. Uhlmann, A. Vasy and J. Zhai

Fast Algorithms for Direct and Inverse Problems in Mathematical Geophysics

SPEAKER: Jianliang Qian, *Michigan State University*

ABSTRACT: Geophysics has provided a rich source of problems for mathematicians to work on, starting from Hadamard's Cauchy problem of Laplace's equation to the famous Calderon problem of electrical impedance tomography. Since geophysical exploration is a multi-billion dollar industry, the geophysical community has always been open to new ideas, new tools, and new people. I will provide a bird's eye view of some problems arising from mathematical geophysics from the perspective of a computational mathematician. I will mainly cover some state-of-the-art fast algorithms for both direct and inverse problems of wave and potential fields, such as acoustic wave, elastic wave, gravity field, magnetic field, and electromagnetic field. I will illustrate these problems with computational results of both synthetic and field data.

Uncertainty Characterization in Model-Based Inverse and Imaging Problems

SPEAKER: Kui Ren, *Columbia University*

ABSTRACT: In model-based inverse and imaging problems, it is often the case that only a portion of the relevant physical quantities in the model can be reconstructed/imaged. The rest of the model parameters are assumed to be known. In practice, these parameters are often only known partially (up to a certain accuracy). It is therefore important to characterize the dependence of the inversion/imaging results on the accuracy of these parameters. This is an uncertainty quantification problem that is challenging due to the fact that both the map from the uncertainty parameters (the ones we assumed partially known) to the measured data and the map from the measured data to the quantities to be imaged are difficult to analyze. In this talk, we review some recent computational and mathematical results on such uncertainty characterization problems in nonlinear inverse problems for PDEs.

Bridging Deep Neural Networks and Differential Equations for Image Analysis and Beyond

SPEAKER: Bin Dong, *Beijing International Center for Mathematical Research & Peking University*

ABSTRACT: Deep learning continues to dominate machine learning and has been successful in computer vision, natural language processing, etc. Its impact has now expanded to many research areas in science and engineering. However, the model design of deep learning still lacks systematic guidance, and most deep models are seriously in lack of transparency and interpretability, thus limiting the application of deep learning in some fields of science and medicine. In this talk, I will show how we can tackle this issue by presenting some of our recent work on bridging numerical differential equation and deep convolutional architecture design. We can interpret some of the popular deep CNNs in terms of numerical (stochastic) differential equations, and propose new deep architectures that can further improve the prediction accuracy of the existing networks in image classification. We also show how to design transparent deep convolutional networks to uncover hidden PDE models from observed dynamical data and to predict the dynamical behavior accurately. We further applications of this perspective to various other problems in imaging and inverse problems will be discussed.

Variational image restoration: from sparsity to data driven approaches

SPEAKER: Xiaoqun Zhang, *Shanghai Jiaotong University*

ABSTRACT: Along with the rapid development of modern medical imaging technologies and computational resource, high dimensional images play more and more important roles in clinical application. However, there still present many modeling and computational challenges for restoring and processing medical images with high accuracy and efficiency in practice. In this talk, I will first introduce sparsity promoting and redundancy exploring approaches for some classes of image restoration problems, such as multi-modality image and dynamic images. Then I will present our recent data driven-type approaches: Bayesian Inversion and uncertainty quantification for image restoration and deep learning approaches, all in variational frameworks.

Adaptive Multi-fidelity surrogate modeling for Bayesian inference in inverse problems

SPEAKER: Liang Yan, *Southeast University*

ABSTRACT: Performing Bayesian inference via MCMC can be exceedingly expensive when posterior evaluations invoke the evaluation of a computationally expensive model, such as a system of PDEs. One strategy is to replace the forward model with a low-cost surrogate model; however, simply replacing the high-fidelity model with a low-fidelity model can lead to a lower approximation quality result. In this talk, we seek to address this challenge by introducing an adaptive procedure to construct a multi-fidelity polynomial chaos surrogate and explore the posterior simultaneously. More precisely, the new strategy starts with a low-fidelity surrogate model, and this surrogate will be adaptively corrected using online high-fidelity data. The key idea is to speed up the MCMC by combing, instead of replacing, the high-fidelity model with the low-fidelity model. We also introduce a multi-fidelity surrogate based on the deep Neural Networks to deal with problems with high dimensional parameters. Numerical experiments confirm that the proposed approach can obtain accurate posterior information with a limited number of forward simulations.

Solving forward and inverse elastic scattering problems based on the boundary integral equation method

SPEAKER: Jun Lai, *Zhejiang University*

ABSTRACT: Efficient algorithms for evaluating the elastic scattering are important in material science and seismic imaging. In this talk, we propose an efficient boundary integral method to solve the elastic equation based on Helmholtz decomposition. The advantage for our method over the conventional boundary integral method is that we avoid using the elastic Green's function, which is a second order tensor and difficult to compute. Meanwhile, it also provides a fast solver for the inverse elastic scattering problem. We will show its applications in the inverse elastic obstacle problem and inverse acoustic-elastic interaction problem with phased or phaseless data.

4.2 M1: Computational Inverse Problems

Study of Three-dimensional Transient Inverse Heat Conduction Problems in the Enhanced Pool Boiling Heat Transfer

SPEAKER: Yi Heng, *Sun Yat-sen University*

ABSTRACT: Inverse heat conduction problems (IHCP) have a variety of applications across different science and engineering disciplines. The development of their solution techniques has received more and more attention due to the mathematical difficulties and practical significance. Particularly, the fast and robust solution of transient and three-dimensional (3D) IHCP are still nontrivial due to the severe ill-posedness and the high computational cost. In the past few years, we have developed a series of numerical approaches for the efficient solution of benchmark 3D transient IHCP arising in pool boiling, including an iterative regularization method implemented by using conjugate gradient method together with the discrepancy principle, an enhanced Tikhonov regularization method and a multi-level adaptive mesh refinement strategy by means of a-posteriori error estimation. All of them are based on formulating and solving optimization problems. In this work, we focus on the benchmark 3D transient IHCP arising from pool boiling experiments for plain heating foils as well as heaters with micro/nano structured surfaces, which corresponds to the estimation of local surface heat fluxes from the transient temperature fields on the backside of the heaters. A radically different solution approach based on a new time-space adaptive mesh refinement strategy is proposed in this work. Instead of solving optimization problems constrained by 3D partial differential equations, the proposed method converts the inverse problem into an easy-to-solve direct problem and can provide an approximated solution. The accuracy and efficiency of the method have been validated by four practical case studies and applied to real experimental data. This work is considered as an important step forward towards the development of heat-flux soft sensors in many engineering problems.

A non-intrusive reduced basis EKI for time-fractional diffusion inverse problems

SPEAKER: Liang Yan, *Southeast University*

ABSTRACT: This talk studies an ensemble Kalman inversion (EKI) for the numerical solution of time-fractional diffusion inverse problems (TFDIPs). Computational challenges in the EKI arise from the need for repeated evaluations of the forward model. We address this challenge by introducing a non-intrusive reduced basis (RB) method for constructing surrogate models to reduce computational cost. In this method, a reduced basis is extracted from a set of full-order snapshots by the proper orthogonal decomposition (POD), and a doubly stochastic radial basis function (DSRBF) is used to learn the projection coefficients. The DSRBF is carried out in the offline stage with a stochastic leave-one-out cross-validation algorithm to select the shape parameter, and the outputs for new parameter values can be obtained rapidly during the online stage. Due to the complete decoupling of the offline and online stages, the proposed non-intrusive RB method – referred to as POD-DSRBF – provides a powerful tool to accelerate the EKI approach for TFDIPs. We demonstrate the practical performance of the proposed strategies through two nonlinear time-fractional diffusion inverse problems. The numerical results indicate that the new algorithm can achieve significant computational gains without sacrificing accuracy.

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

SPEAKER: Junxiong Jia, *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.

A multiscale radial basis function method for severely ill-posed problems on spheres

SPEAKER: Min Zhong, *Southeast University*

ABSTRACT: We propose and analyze a multiscale support vector approach (SVA) algorithm for solving a kind of severely ill-posed problems on spheres. To this end, the algorithm uses Wendland's radial basis functions with different scales and the Vapnik ϵ-intensive loss function to compute a regularized approximation at each step. We discuss the choice strategy for parameter choices and prove the convergence of the algorithm. Numerical simulations which support the theoretical results will be presented.

Regularization Methods for Recovering Conductivity

SPEAKER: Xiliang Lu, *Wuhan University*

ABSTRACT: In this talk we propose two regularization models for recovering conductivity. The first one is an H1 (or TV) regularization for Electrical Impedance Tomography (EIT). The second one is an L2 regularization for recovering a matrix coefficient. The existence and wellposedness of the regularization functional is proved. The finite element analysis is also provided, and several numerical examples are given to show the efficient of the proposed method.

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

SPEAKER: Daijun Jiang, *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.

Efficient implementations of multi-dimensional fractional Laplacians via spherical means

SPEAKER: Boxi Xu, *Shanghai University of Finance and Economics*

ABSTRACT: We develop efficient algorithms for computing the multi-dimensional fractional operator in hyper-singular form, where the operator is the so-called fractional Laplacian for $0 <$ alpha < 2. By introducing polar coordinates, we reduce the action of the multi-dimensional fractional operator to a function to that of the resulting one-dimensional fractional operator to the spherical mean of the underlying function. We propose two algorithms to compute spherical means of a given function: one by solving standard wave equations, and the other by solving Darboux's equations. We further apply a finite-difference quadrature approach to compute the one-dimensional fractional operator. Our methodology is equally applicable to computing the fractional Laplacian, the extended fractional Laplacian, and the Riesz potential operator. Numerical examples including algebraically decaying functions with varying regularity demonstrate the performance of our new algorithm. This is joint work with Jianliang Qian at MSU and Shingyu Leung at HKUST.

Determining a random Schrödinger equation with unknown source and potential

SPEAKER: Jingzhi Li, *Southern University of Science and Technology*

Abstract: This talk studies the direct and inverse scattering problem associated with a time-harmonic random Schrödinger equation with a Gaussian white noise source term. We establish the well-posedness of the direct scattering problem and obtain three uniqueness results in determining the variance of the source term, the potential and the mean of the source term, sequentially, by the corresponding far-field measurements. The first one shows that a single realization of the passive scattering measurement can uniquely recover the variance of the source term, without knowing the other two unknowns. The second shows that if active scattering measurement is further used, then a single realization can uniquely recover the potential function without knowing the source term. The last one shows that if full measurements are used, then both the potential and the random source can be uniquely recovered.

4.3 M2: Inverse Problem for Diffusion Equation and Its Application

On the simultaneous reconstruction of the reaction coefficient, source term and initial temperature

Speaker: Kai Cao, *Southeast University*

Abstract: In this talk, the space-dependent reaction coefficient, source component term and/or initial temperature of the inverse heat transfer problems were investigated from certain temperature measurements. The uniqueness of the inverse problem to simultaneously determine the reaction coefficient and initial status was established from the measured temperatures at time instants. And the existence and uniqueness of the problem to identify the reaction coefficient and source term was proved from integral temperature observations. The numerical reconstruction process was based on the conjugate gradient method (CGM) regularized by the discrepancy principle. Several examples have been studied to reveal the accuracy and stability of the numerical results.

Regularization and convergence for ill-posed backward evolution equations in Banach spaces

Speaker: Dehan Chen, *Central China Normal University*

Abstract: This talk is concerned with a mathematical study of ill-posed backward evolution equations associated with densely defined linear differential operators in Banach spaces. A general approach is presented to investigate the convergence and stability of a class of regularized solutions for ill-posed backward evolution equations associated with sectorial or half-strip operators. Generalized concepts of qualification pairs and index functions are introduced to characterize the explicit convergence rates of the concerned regularized solutions. Applications of our results to general backward evolution equations are also investigated.

Inverse problems for degenerate parabolic equations

Speaker: Zuicha Deng, *Lanzhou Jiaotong University*

ABSTRACT: We considered some inverse coefficient(s) problems for degenerate parabolic equations, including inverse initial value problems and multi-coefficients inversion problems. In the theoretical part, we study uniqueness and conditional stability of the solution for the inverse problem. Correspondingly, on the basis of Tikhonov regularization framework, the existence, uniqueness, stability and convergence for the solution of the optimal control problem are established. In the numerical part, the numerical solution for the forward problem is obtained by the finite difference method. Then, some iteration algorithms are proposed to numerically solve the inverse problem.

An inverse problem for parabolic equation with free boundary problem of ductal carcinoma in situ

SPEAKER: Meibao Ge, *Hangzhou Medical College*

ABSTRACT: In this paper we study an inverse problem for parabolic equation with free boundary problem model of ductal carcinoma in situ (DCIS) in order to investigate possible procedures of DCIS with clinical data. Based the characteristics of DCIS model, this paper presents an inverse problem of simultaneously determining nutrient concentration, unknown parameter and unknown boundary function under the conditions of incisional biopsy data at two times. The inverse problem was transformed into a problem of solving extreme value of a stable extensive function, which can be solved by Hook-Jeeves method to search the minimizer of the objective function. Algorithm and numerical simulation for the inverse problem are included to demonstrate the validity and accuracy of the method.

Backward Problem for a Time-Space Fractional Diffusion Equation

SPEAKER: Junxiong Jia, *Xi'an Jiaotong University*

ABSTRACT: In this talk, a backward problem for a time-space fractional diffusion process has been considered. For this problem, we propose to construct the initial function by minimizing data residual error in Fourier space domain with variable total variation (TV) regularizing term which can protect the edges as TV regularizing term and reduce staircasing effect. The well-posedness of this optimization problem is obtained under a very general setting. Actually, we rewrite the time-space fractional diffusion equation as an abstract fractional differential equation and deduce our results by using fractional operator semigroup theory, hence, our theoretical results can be applied to other backward problems for the differential equations with more general fractional operator. Then a modified Bregman iterative algorithm has been proposed to approximate the minimizer. The new features of this algorithm is that the regularizing term altered in each step and we need not to solve the complex Euler-Lagrange equation of variable TV regularizing term (just need to solve a simple Euler-Lagrange equation). The convergence of this algorithm and the strategy of choosing parameters are also obtained. Numerical implementations are provided to support our theoretical analysis to show the flexibility of our minimization model.

Convergence analysis of LMM and DDMs for a parabolic inverse Robin problem

SPEAKER: Daijun Jiang, *Central China Normal University*

ABSTRACT: We study the Levenberg-Marquardt method (LMM) for solving the highly nonlinear and ill-posed inverse problem of identifying the Robin coefficients in parabolic systems. The LMM transforms the Tikhonov regularized nonlinear non-convex minimizations into convex minimizations. And the quadratic convergence of the LMM is rigorously established for the nonlinear parabolic inverse problems for the first time, under a simple novel adaptive strategy for selecting regularization parameters during the LM iteration. Then the domain decomposition methods (DDMs) are used to solve the convex minimizations. The methods are completely local and the local minimizers have explicit expressions within the subdomains. Numerical experiments are presented to show the accuracy and efficiency of the methods, in particular, the convergence seems nearly optimal in the sense that the iteration number of the methods is independent on the mesh size.

A hybrid inversion scheme for diffuse optical tomography with small inclusions

SPEAKER: Yu Jiang, *Shanghai University of Finance and Economics*

ABSTRACT: Optical tomography is a typical non-invasive medical imaging technique, which aims to reconstruct geometric and physical properties of tissues by passing near infrared light through tissues for obtaining the intensity measurements. By analyzing the asymptotic behavior of the boundary measurements weighted by the fundamental solution of a backward diffusion equation as the diameters of inclusions go to zero, we developed a hybrid inversion scheme can not only find the locations of small inclusions but also the optical properties.

Unique continuation for the fractional diffusion-wave equation

SPEAKER: Zhiyuan Li, *Shandong University of Technology*

ABSTRACT: In this talk, the diffusion-wave equation with Caputo derivative is discussed. The Caputo derivative is inherently nonlocal in time with history dependence, which makes the crucial differences between fractional models and classical models. Is there any property retained from the parabolic equations? What about the unique continuation (UC)? There was not affirmative answer to this problem except for some special cases, see, e.g., Sakamoto-Yamamoto (2011) and Lin-Nakamura (2016) in which the homogeneous condition is imposed on the boundary value or on the initial value and a weak UC was obtained. In this talk, by using Phragman-Lindelof-Liouville argument, we will give a classical type unique continuation.

A Bayesian approach for inverse obstacle scattering with Poisson data

SPEAKER: Xiaomei Yang, *Southwest Jiaotong University*

ABSTRACT: This talk focuses on the obstacle reconstruction of the exterior acoustic scattering by the Poisson data of the far field pattern. The Poisson data usually arises in photonic imaging problems. The data consist of photon counts. In the obstacle scattering, the photons have interacted with the unknown obstacle. We try to use the Bayesian inference technique to recover the unknown obstacle. The well-posedness of the posterior distribution is given. The Metropolis-Hastings algorithm is used to generate samples of the posterior distribution.

Identification of initial condition in one-dimensional integer/fractional order diffusion equation by one point observation data

SPEAKER: Zhousheng Ruan, *East China Institute Of Technology*

ABSTRACT: In this report the backward problem for one-dimensional diffusion equation is considered. Firstly, we give the ill-posedness analysis for the backward problem. Then the uniqueness of the backward problem is proven by Laplace transformation technique and analytic continuation method. Next, the inverse problem is transformed into Tikhonov type optimization problems, and the conjugate gradient method is adopted to solve the optimization problem with the help of the variational adjoint technique. Several numerical examples are tested to show the efficiency and stability of the proposed method.

Some Inverse Boundary Value Problems for Parabolic Equations

SPEAKER: Yuchan Wang, *Nanjing University of Information Science and Technology*

ABSTRACT: The diffusion processes are quite popular in many engineering areas. Mathematically, the diffusion processes can be modeled by the initial boundary value problems for parabolic equations. In practical situations, not all the boundary values can be specified by direct measurements, and therefore some extra measurable data related to the diffusion system are required for reconstructing the unknown boundary ingredients for the completely determination of the diffusion process. We mainly consider the some inverse boundary value problems for parabolic equations. Firstly, we consider the reconstruction of the Robin coefficient from the time-average measurement, including conditional stability, regularization method and alternative iteration scheme. Secondly, we consider the simultaneous recovery of Robin coefficient and initial heat status, including uniqueness, regularization method and numerical realizations. Finally, we consider the reconstruction of non-smooth Robin coefficient, including uniqueness, regularization method and alternating iteration algorithm.

On the stability of recovering two sources and initial status simultaneously in a stochastic hyperbolic-parabolic system

SPEAKER: Bin Wu, *Nanjing University of Information Science and Technology*

ABSTRACT: Consider an inverse problem of determining two stochastic source functions and the initial data simultaneously in a stochastic thermoelastic system, which is constituted of two stochastic equations of different types, namely a parabolic equation and a hyperbolic equation. To establish the conditional stability for such a coupling system in terms some suitable norms revealing the stochastic property of the governed system, we first establish two Carleman estimates with regular weight function and two large parameters for stochastic parabolic equation and stochastic hyperbolic equation, respectively. By means of these two Carleman estimates, we finally prove the conditional stability for our inverse problem, provided the source in the elastic equation be known near the boundary and the solution be in a prior bound set. Due to the lack of information about the time derivative of wave field at final moment, the stability index with respect to the wave field at final time is found to be halved, which reveals the special characteristic of our inverse problem for the coupling system.

Application of Transmission Eigenvalues in penetrable Medium to Invisible Cloaking

SPEAKER: Hansu Zhang, *Southeast University*

ABSTRACT: This work concerned with the invisibility cloaking with acoustic wave scattering in a penetrable inhomogeneous medium. It is shown that an interior transmission eigenvalue problem arises in our study. By converting the non-self-adjoint problem into a quadric eigenvalue problem, we got an estimation of a characteristic of the distribution of eigenvalues. We demonstrate that it is feasible to achieve a mixed scattering field vanishing outside the medium numerically, the efficiency of the proposed scheme for solving the transmission eigenvalue problems is tested by solving the scattering problems of inhomogeneous medium with real eigenvalue as the wave number, which shows the property of scattering process for special incident wave related to the transmission eigenvalues. Finally, we use a secant-type iteration for solving the smallest real eigenvalues, the numerical result also gives a benchmark for the computation of interior transmission eigenvalue problems.

4.4 M3: Imaging Theory and Algorithms for Inverse Scattering Problem

The Wasserstein-Fisher-Rao Metric for Waveform Based Earthquake Location

SPEAKER: Hao Wu, *Tsinghua University*

ABSTRACT: In this work, the Wasserstein-Fisher-Rao (WFR) metric based on the unbalanced Optimal Transport (OT) theory is applied to the earthquake location problem. It introduces the wave amplitude as a new constraint, which overcomes the difficulty of the objective optimization functions degenerate since the wave signals are normalized by the balanced OT theory. Thus, we can expect more accurate location results from the WFR metric based earthquake location model under high-intensity noise.

Application of Optimal Transportation with Surrogate to Seismic Inverse Problems

SPEAKER: Lingyun Qiu, *Tsinghua University*

ABSTRACT: The cycle-skipping problem in the seismic inversion 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.

Convergence analysis for solving the Helmholtz equation in a layered medium by PML-BIE method

SPEAKER: Jun Lai, *Zhejiang University*

ABSTRACT: Helmholtz equation in a layered medium has important applications in submarine detection, meta-material design and many other inverse problems. Conventional numerical methods like finite difference and finite element with perfect matched layer (PML) truncation require discretizing the equation in the wholedomain. On the other hand, boundary integral method (BIE) would reduce the dimension by one and greatly reduce the computational cost. However, it suffers from the slow convergence for the Green's function evaluation in a layered medium. The hybrid PML-BIE method aims to take the advantage of both methods. In this talk, we will discuss the convergence analysis for the combination of PML and BIE methods. In particular, we show that for the source problem in a layered medium, the Helmholtz equation with PML layer is always well-posed and exponential convergence can be achieved when the PML thickness increases.

Determination of a transversely isotropic perturbation of elastic medium

SPEAKER: Jian Zhai, *Hong Kong University of Science and Technology*

ABSTRACT: We consider a linearized inverse boundary value problem for the elasticity system. We show that a transversely isotropic perturbation of a homogeneous isotropic elastic body can be uniquely determined from the linearized Dirichlet-to-Neumann map. Both the static and time-harmonic cases will be discussed. Joint work with Yang Yang.

On the geometric structure of conductive transmission eigenfunctions and its application

SPEAKER: Huai' an Diao, *Northeast Normal University*

ABSTRACT: This talk is concerned with the intrinsic geometric structures of conductive transmission eigenfunctions. The geometric properties of interior transmission eigenfunctions were first studied in [Blasten&Liu,JFA,2017]. It is shown in two scenarios that the interior transmission eigenfunction must be locally vanishing near a corner of the domain with an interior angle less than π. We significantly extend and generalize those results in several aspects. First, we consider the conductive transmission eigenfunctions which include the interior transmission eigenfunctions as a special case. The geometric structures established for the conductive transmission eigenfunctions in this paper include the results in [Blasten&Liu,JFA,2017] 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 π. That means, as long as the corner singularity is not degenerate, the vanishing property holds. Third, the regularity requirements on the interior transmission eigenfunctions in [Blasten&Liu,JFA,2017] 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 and the corresponding analysis is much more complicated than that in [Blasten&Liu,JFA,2017]. Finally, as interesting and practical applications of the obtained geometric results, we establish a unique recovery result for the inverse scattering problem by a single far-field measurement in simultaneously determining a polyhedral conductive obstacle and its surface conductivity.

Time-Domain Analysis of an Acoustic-Elastic Interaction Problem

SPEAKER: Yixian Gao, *Northeast Normal University*

ABSTRACT: In this talk, we concern the scattering of a time-domain acoustic plane wave by a bounded elastic obstacle which is immersed in a homogeneous air or fluid. . The well-posedness and stability are established for the reduced problem. A priori estimates with explicit time dependence are achieved for the pressure of the acoustic wave field and the displacement of the elastic wave field. In addition, a time-domain absorbing perfectly matched layer (PML) method is introduced to replace the nonlocal TBC by a Dirichlet boundary condition. A first order symmetric hyperbolic system is derived for the truncated PML problem. The well-posedness and stability are proved. This is based on joint work with Gang Bao and Peijun Li.

Uniqueness for phaseless inverse acoustic scattering with superposition of point sources

SPEAKER: Deyue Zhang, *Jilin University*

ABSTRACT: This talk is concerned with the uniqueness issue in inverse acoustic scattering problems with phaseless data. The essential technique underlying our proof 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.

A simple method to reconstruct three dimensional time dependent point sources of acoustic waves

SPEAKER: Bo Chen, *Civil Aviation University of China*

ABSTRACT: We are concerned about the numerical simulation of three dimensional time dependent inverse acoustic source problems. Both the reconstructions of stationary source points and a moving source point are considered. The proposed methods are based on the method of fundamental solutions, whereas new bases based on a time convolution are employed instead of the fundamental solutions to reconstruct the source points. For the case of a moving source point, moreover, the proposed method is simplified as a simple sampling method at each discrete time. Detailed numerical experiments are provided to show the effectiveness of the proposed methods.

Direct imaging methods for identifying multipolar sources with a single frequency

SPEAKER: Yukun Guo, *Harbin Institute of Technology*

ABSTRACT: This talk is concerned with the inverse source problem of locating multiple multipolar sources from boundary measurements for the Helmholtz equation and Maxwell system. We develop simple and effective sampling schemes for location recovery of the sources with a fixed wavenumber. Our algorithms are based on some novel indicator functions whose indicating behaviors could be used to identify multiple multipolar sources. The inversion schemes are totally "direct" in the sense that only simple integral calculations are involved in evaluating the indicator functions. Rigorous mathematical justifications of the indicating behaviors will be provided. Several numerical examples will be also presented to demonstrate the effectiveness, robustness and efficiency of the proposed methods.

Potential reconstruction in nonlocal diffusion

SPEAKER: Guanghui Zheng, *Hunan University*

ABSTRACT: Nonlocal models and nonlocal diffusion operators are widely applied in many fields, such as continuum mechanics, biology, jump process, graph theory, image analyses, machine learning, and phase transitions. The difference between the nonlocal model and the classical partial differential equation model is that in the latter case, the interaction between two regions occurs only because of contact, while in the former case, the interaction can occur at a certain distance. In this talk we are concerned with the potential reconstruction problems in nonlocal diffusion. The uniqueness theorems are established. Some hybrid algorithms are presented to recover the potential function, and capture the statistics information of potential. Finally, we give some numerical examples to show the effectiveness of the proposed algorithms. (Joint work with Ming-Hui Ding)

Sparse Reconstructions of Acoustic Source for Inverse Scattering Problems in Measure Space

SPEAKER: Hongpeng Sun, *Renmin University*

ABSTRACT: This paper proposes a systematic mathematical analysis of both the direct and inverse acoustic scattering problems given the source in Radon measure space. For the direct problem, we investigate the well-posedness including the existence, the uniqueness, and the stability by introducing a special definition of the weak solution, i.e. very weak solution. For the inverse problem, we choose the Radon measure space instead of the popular L1 space to build the sparse reconstruction, which can guarantee the existence of the reconstructed solution. The sparse reconstruction problem can be solved by the semismooth Newton method in the dual space. Numerical examples are included.

Inverse random source problems for time-harmonic acoustic and elastic waves

SPEAKER: Jianliang Li, *Changsha University of Science and Technology*

ABSTRACT: This paper concerns the random source problems for the time-harmonic acoustic and elastic wave equations in two and three dimensions. The goal is to determine the compactly supported external force from the radiated wave field measured in a domain away from the source region. The source is assumed to be a microlocally isotropic generalized Gaussian random function such that its covariance operator is a classical pseudo-differential operator. Given such a distributional source, the direct problem is shown to have a unique solution by using an integral equation approach and the Sobolev embedding theorem. For the inverse problem, we demonstrate that the amplitude of the scattering field averaged over the frequency band, obtained from a single realization of the random source, determines uniquely the principle symbol of the covariance operator. The analysis employs asymptotic expansions of the Green functions and microlocal analysis of the Fourier integral operators associated with the Helmholtz and Navier equations.

Through Wall Detection of the Moving Paths and Vital Signs of Human Beings

SPEAKER: Jiguang Sun, *Michigan Technological University*

ABSTRACT: Detection of human activities in complex environments such as through wall by UWB (ultra-wideband) radar has many important applications in security, vital rescue, etc. It is much more difficult to detect vital signs of moving human beings than static ones. We build a model for moving targets and apply the TDFEM (time domain finite element method) to simulate SIMO (single input multiple outputs) radar data. Human respiration is modeled by changing the body size and physical parameters. The background removal is performed for radar data. Then we use the back projection to reconstruct the consecutive target locations, which constitute the moving path, leading to a curve carrying vital signs in the radar image. Since SIMO radar data is multivariate, we use MEMD (multivariate empirical mode decomposition) and FFT to separate and extract the respiratory characteristic frequencies. The reconstructed frequency coincides with that in the original model. The result shows that the combination of SIMO radar and MEMD can effectively identify the moving path of the human being behind the wall and extract vital signs.

Gradient Estimates for Solutions of Perfect Conductivity Problem

SPEAKER: Yu Chen, *Beijng Normal University*

ABSTRACT: In this talk, we will talk about our recent results in the Perfect Conductivity problem. We derive the gradient estimates for solution to the perfect conductivity problem in the case where two perfectly conducting inclusions are located very closed to each other. The novelty of these estimates is that they reveal the relationship between the blowup rate of the gradient and the local geometry of the inclusions. When the smoothness of the inclusions is weakened from $C^{2,\alpha}$ to $C^{1,\alpha}$, more new difficulties need to be overcome. Here we take advantage of De Giorgi-Nash estimates and Campanato's approach to make up this gap.

Fluorescence diffuse optical tomography using a cuboid approximation

SPEAKER: Chunlong Sun, *Southeast University*

ABSTRACT: The time-domain fluorescence diffuse optical tomography (FDOT) is numerically investigated based on analytic expressions for the three space dimensional case. The emission light is analytically calculated by an initial boundary value problem for coupled diffusion equations in the half space. The inverse problem of FDOT is to recover the distribution of fluorophores in biological tissue, which is solved using the time-resolved measurement data on the boundary surface. We identify the location of a fluorescence target by assuming a cuboid. The aim of this paper is to propose a strategy for a reconstruction, which enables to obtain a stable reconstruction and accelerate the speed of convergence. Its effectivity and performance are tested numerically using simulated data and experimental data obtained from an ex vivo beef phantom.

A data-driven inverse scattering problem with one incoming wave

SPEAKER: Guanqiu Ma, *Beijing Computational Science Research Center*

ABSTRACT: Inspired by the factorization method by Kirsch (Inverse Problems, 1998), this paper designs a new indicator function to recover the position and shape of unknown obstacles and source supports. Our inversion scheme makes use of a priori far-field data of known obstacles (e.g. sound-soft disks and spheres with different radii and centers) and requires only a single far-field pattern corresponding to the unknown scatterer. We provide a rigorous mathematical theory for such data-driven imaging schemes and provide some numerical results.

4.5 M4: Visible and Invisible

Generalized polarization tensors for inhomogeneous medium and cloaking

SPEAKER: Youjun Deng, *Central South University*

ABSTRACT: In this talk, we shall introduce the notion of Generalized Polarization Tensors(GPTs) for inhomogeneous medium, which was previously defined for homogeneous medium. We shall also present some properties of the GPTs and then show its applications in super resolution imaging and cloaking.

A Bayesian level set approach for acoustic source identification using multiple frequency information

SPEAKER: Zhiliang Deng, *University of Electronic Science and Technology*

ABSTRACT: The spatial dependent unknown acoustic source is reconstructed according to noisy multiple frequency data on a remote closed surface. Assume that the unknown function is supported on a bounded domain. To determine the support, we present a Bayesian level set inversion algorithm. Several numerical examples show that the proposed method is effective.

Direct and inverse scattering from a collection of small scatterers in the time domain

SPEAKER: Guanghui Hu, *Beijing Computational Science Research Center*

Abstract: In this talk I shall introduce the Lax-Foldy formula for time-dependent wave scattering from a collection of point-like scatterers. This problem is also known as the dynamic point-interaction model in the time domain. An explicit representation of the total field is given in terms of the incident impulsive wave, positions of small scatterers and the charge density attached to each small scatterer. As an application to inverse problems, we shall justify the Kirsch-hoff migration scheme (total focusing method) for dynamically imaging a group of small scatterers in the born approximation case where the distance between each two scatterers is much larger than the incident wavelength.

Fourier method for identifying electromagnetic sources with multi-frequency far-field data

Speaker: Yukun Guo, *Harbin Institute of Technology*

Abstract: This talk is focused on the inverse problem of determining an unknown vectorial source current distribution associated with the homogeneous Maxwell system. We propose a novel non-iterative reconstruction method for solving this inverse problem from multi-frequency far-field measurements. The method is based on recovering the Fourier coefficients of the unknown source. A key ingredient of the method is to establish the relationship between the Fourier coefficients and the multi-frequency far-field data. Uniqueness and stability results are established for the proposed reconstruction method. Numerical experiments will be presented to illustrate the effectiveness and efficiency of the method.

A C0IP method of Transmission Eigenvalues for Elastic Waves

Speaker: Xia Ji, *Chinese Academy of Sciences*

Abstract: We develop a discontinuous Galerkin method to compute a few smallest elasticity transmission eigenvalues, which are of practical importance in inverse elastic scattering theory. For high-order problems, comparing with classical conforming finite element methods, discontinuous Galerkin methods use simpler basis functions which make the numerical implementation much easier. In this talk, we propose an interior penalty discontinuous Galerkin method using C0 Lagrange elements (C0IP) for the elastic transmission eigenvalue problem and prove the optimal convergence. Numerical examples are presented to validate its effectiveness. Both real and complex eigenvalues can be obtained.

Construction of weakly neutral inclusions of general shape

Speaker: Xiaofei Li, *Zhejiang University of Technology*

ABSTRACT: Upon insertion of an inclusion into an otherwise uniform field, if the field outside is not perturbed at all, then the inclusion is called a neutral inclusion. It is called a weakly neutral inclusion if the field is perturbed mildly. Inclusions neutral to multiple uniform fields are of circular or spherical shape if the background conductivity is isotropic, and of elliptic or ellipsoidal shape if the background conductivity is anisotropic. We consider in this paper the problem of constructing inclusions of general shape which are weakly neutral to multiple fields in two dimensions. We show that a simply connected domain satisfying a certain geometric condition can be realized as a weakly neutral inclusion to multiple fields by introducing an imperfect interface parameter on the boundary. The geometric condition on the domain and the imperfect interface parameter are determined by the first coefficient of the conformal mapping from the exterior of the unit disk onto the exterior of the domain. We provide some numerical examples to compare perturbations by weakly neutral inclusions and inclusions with perfect interfaces. They clearly show that the perturbation by weakly neutral inclusions is much weaker. In this talk, I will also briefly mention about the existence of weakly neutral inclusion of coated core-shell structure of general shape. This is a joint work with Hyeonbae Kang.

Uniqueness and stability for inverse source problems in acoustics

SPEAKER: Chun Liu, *Chinese Academy of Sciences*

ABSTRACT: This talk is concerned with uniqueness and stability in inverse acoustic source problems in the time domain. The source term is assumed to be a separable function, which is the product of a spatial function and a temporal function. Using the unique continuation for wave equations, we prove uniqueness of the spatial function without applying the Fourier transform. In the presence of an embedded sound-soft obstacle, we justify the unique determination of both the obstacle and the source term with dynamical boundary surface data over a finite time interval. This is a joint work with Prof. Bo Zhang and Guanghui Hu.

Analysis of Fully Preconditioned Alternating Direction Method of Multipliers with Relaxation in Hilbert Spaces

SPEAKER: Hongpeng Sun, *Renmin University*

ABSTRACT: Alternating direction method of multipliers is a powerful first order method for non-smooth optimization problems including various applications in inverse problems and imaging. However, there is no clear result on the weak convergence of alternating direction method of multipliers in infinite dimensional Hilbert spaces with relaxation. In this paper, by employing a kind of partial gap analysis, we prove the weak convergence of a general preconditioned and relaxed version in infinite dimensional Hilbert spaces, with preconditioning for solving all the involved implicit equations under mild conditions. We also give the corresponding ergodic convergence rates respecting to the partial gap function. Furthermore, the connections between certain preconditioned and relaxed alternating direction method of multipliers and the corresponding Douglas-Rachford splitting methods are discussed. Numerical tests show the efficiency of the proposed overrelaxation variants with preconditioning.

Extended Sampling Method for Inverse Elastic Scattering Problems

SPEAKER: Juan Liu, *Jinan University*

ABSTRACT: In this talk, we consider the inverse elastic scattering problems using the far field data due to one incident plane wave. A simple method is proposed to reconstruct the location and size of the obstacle using different components of the far field pattern. The method sets up linear ill-posed integral equations for sampling points in the domain of interrogation and uses the (approximate) solutions to compute indicators. Using the far field patterns of rigid disks as the kernels of the integral equations and moving the measured data to the right hand side, the method has the ability to process limited aperture data. Numerical examples show that the method can effectively determine the location and approximate the support of the obstacle with little a priori information.

Localization and geometrization in plasmon resonances and geometric structures of Neumann-Poincare eigenfunctions

SPEAKER: Yuliang Wang, *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.

Convergence of the perfectly matched layer for transient acoustic-elastic interaction above an unbounded rough surface

SPEAKER: Changkun Wei, *Chinese Academy of Sciences*

ABSTRACT: This topic is concerned with the time-dependent fluid-solid interaction problem associated with a bounded elastic body immersed in a homogeneous air or fluid above an unbounded rough surface. The well-posedness and stability of the problem are first established by using the Laplace transform and energy method. A perfectly matched layer (PML) is then introduced to truncate the interaction problem above a finite layer containing the elastic body, leading to a PML problem in a finite strip domain. We further establish the existence, uniqueness and stability estimate of solutions to the PML problem. Finally, we prove the exponential convergence about the thickness of the PML layer via establishing an error estimate between the DtN operator of the original problem and the DtN operator of the PML problem.

Uniqueness in inverse scattering problems with phaseless far-field data at a fixed frequency

SPEAKER: Xiaoxu Xu, *Chinese Academy of Sciences*

ABSTRACT: This talk is concerned with uniqueness in inverse acoustic scattering with phaseless far-field data at a fixed frequency.Firstly, by utilizing spectral properties of the far-field operator we proved for the first time that the obstacle and the index of refraction of an inhomogeneous medium can be uniquely determined by the phaseless far-field patterns generated by infinitely many sets of superpositions of two plane waves with different directions at a fixed frequency under the a priori assumption that the obstacle is known to be a sound-soft or non-absorbing impedance obstacle and the index of refraction of the inhomogeneous mediumis real-valued and greater or less than 1 in its compact support. Secondly, we remove the a priori assumption on the obstacle and the index of refraction of the inhomogeneous medium by adding a reference ball to the scattering system together with a simpler method of using Rellich's lemma and Green's representation formula for the scattering solutions. Further, our new method is also used to prove uniqueness in determining a locally rough surface from the phaseless far-field patterns corresponding to infinitely many sets of superpositions of two plane waves with different directions as the incident fields at a fixed frequency.This talk is based on a joint work with Bo Zhang and Haiwen Zhang.

Multi-frequency iterative methods for the inverse medium scattering problem in elasticity

SPEAKER: Fang Zeng, *Chongqing University*

ABSTRACT: This paper concerns the reconstruction of multiple elastic parameters (Lame parameters and density) of an inhomogeneous medium embedded in an infinite homogeneous isotropic background in R^2. The direct scattering problem is reduced to an equivalent system on a bounded domain by introducing an exact transparent boundary condition and the wellposedness of the corresponding variational problem is established. The Frechet differentiability of the near-field scattering map is studied with respect to the elastic parameters. Based on the multi-frequency measurement data and its phaseless term, two Landweber iterative algorithms are developed for the reconstruction of the multiple elastic parameters. Numerical examples, indicating that plane pressure incident wave is a better choice, are presented to show the validity and accuracy of our methods. This is a joint work with G. Bao and T. Yin.

4.6 M5: Iterative Methods and Regularization Theory for Inverse Problems

Heuristic rule for the iteratively regularized Gauss-Newton method in Banach spaces

SPEAKER: Qinian Jin, *Australian National University*

ABSTRACT: The iteratively regularized Gauss-Newton method is a prominent method for solving nonlinear inverse problems. Based on a modi- fied discrepancy principle, in this paper we propose for the IRGNM in Banach spaces a heuristic rule which is purely data driven and requires no information on the noise level. Under the tangential cone condition on the forward opera- tor and the variational source conditions on the sought solution, we obtain a posteriori error estimates for this heuristic rule. Under further conditions on the noisy data, we establish a general convergence result without using any source conditions. Numerical simulations are given to test the performance of the heuristic rule. This is a joint work with Z Fu, Z Zhang, B Han and Y Chen.

Regularization of inverse problems by two point gradient methods with convex constraints

SPEAKER: Min Zhong, *Southeast University*

ABSTRACT: In this talk, we propose and analyze a two-point gradient method for solving inverse problems in Banace spaces which is based on the Landweber iteration and an extrapolation strategy. The method allows to use non-smooth penalty terms,including the L^1 and the total variation-like penalty functionals, which are significant in reconstructing special features of solutions such as sparsity and piecewise constancy in practical applications. The design of the method involves the choices of the step sizes and the combination parameters which are carefully discussed. Numerical simulations are presented to illustrate the effectiveness of the proposed method.

Logarithmic Stability for Coefficients Inverse Problem of Coupled Wave Equations

SPEAKER: Fangfang Dou, *University of Electronic Science and Technology*

ABSTRACT: This talk investigates the identification of coefficients in two coupled wave equations with an observation on one component of the solution. Based on the the Carleman estimate for coupled wave equations and coupled heat equations, and the F.B.I. transform, a H?lder type stability for identifying three coefficients in the system simultanously is obtained, with the measurements only in a nonempty open subset of the domain where the equations evolved.

A new class of accelerated regularization methods of solving inverse problems with application to bioluminescence tomography

SPEAKER: Rongfang Gong, *Nanjing University of Aeronautics and Astronautics*

Abstract: In this talk we propose a new class of iterative regularization methods for solving ill-posed linear operator equations. The prototype of these iterative regularization methods is in the form of second order evolution equation with a linear vanishing damping term, which can be viewed not only as a extension of the asymptotical regularization, but also as a continuous analog of the Nesterov's acceleration scheme. New iterative regularization methods are derived from this continuous method in combination with damped symplectic numerical schemes. The regularization property as well as convergence rates and acceleration affects under the Holder-type source conditions of both continuous and discretized methods are proven. The second part of this talk is concerned with the application of the newly developed accelerated iterative regularization methods with a posteriori stopping rule to the diffusion based bioluminescence tomography. Several numerical examples, as well as a comparison with the state-of-the-art methods, are given to show the accuracy and the acceleration effect of the new method.

4.7 M6: Theory Analysis and Computation of Electromagnetic Scattering and Inverse Scattering Problems in Unbounded Domain

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

Speaker: Heping Dong, *Jilin University*

Abstract: This talk concerns an inverse acoustic scattering problem which is to determine the location and shape of an elastic obstacle from phased or phaseless far-field data for a single incident plane wave. By introducing Helmholtz decomposition, the model problem is reduced to a coupled boundary value problem of the Helmholtz equations. The jump relations for second derivatives of the single-layer potential are investigated to establish coupled boundary integral equations. Then we prove the existence and uniqueness results for the coupled boundary integral equations, and develop an efficient and accurate Nyström-type discretization to solve the coupled system. A nonlinear integral equations method is proposed for the inverse problem. In addition, we show that the modulus of far-field pattern is invariant under translations of the obstacle for plane wave as an incident field, which implies that the location of the obstacle cannot be uniquely recovered by the phaseless data. To overcome this difficulty, we introduce an elastic reference ball to the scattering system to break the translation invariance, and prove a uniqueness result for the inverse acoustic-elastic interaction problem with phaseless far-field pattern. A reference ball technique based nonlinear integral equations method is proposed for the inverse problem. Numerical experiments are presented to demonstrate the effectiveness and robustness of the proposed methods.

Galerkin Method for the Scattering Problem of Strip Gratings

Speaker: Enxi Zheng, *Dalian Maritime University*

ABSTRACT: In this talk, the diffraction problem of periodic strip gratings is considered. The previous study of this problem usually concentrated on the numerical method; however, we try to analyze this problem and the convergence of the numerical solution from the mathematical point of view in this work. By use of the Dirichlet to Neumann operator on the slit between two strips, we reformulate the problem to an operator equation. The well-posedness of the solution to the operator equation is proved. The Galerkin method is applied to solve this operator equation and the convergence result of the numerical solution is also derived. Finally, some numerical experiments are presented to show the effectiveness of our method and verify the theoretical convergence result.

Approximately Recovering of Viscoelasticity of Living Body from MRE Data

SPEAKER: Yu Jiang, *Shanghai University of Finance and Economics*

ABSTRACT: We will propose a new reconstruction scheme to identify the viscoelasticity of a living body from MRE measurements. The reconstruction scheme consists of application of the oscillating-decaying solution, Taylor expansion, complex geometric optics solutions, and an iterative method for solving the Cauchy problem for elliptic equations.

Optimal Mesh Size for Inverse Medium Scattering Problems

SPEAKER: Keji Liu, *Shanghai University of Finance and Economics*

ABSTRACT: An optimal mesh size of the sampling region can help to reduce computational burden in practical applications. In this work, we investigate optimal choices of mesh sizes for the identifications of medium obstacles from either the far-field or near-field data in two and three dimensions. The results would have applications in the reconstruction process of inverse scattering problems.

On a Novel Inverse Scattering Scheme Using Resonant Modes with Enhanced Imaging Resolution

SPEAKER: Yuliang Wang, *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.

Recovering an Inclusion for the Inverse Stokes Problem by the Boundary Measurements

SPEAKER: Meng Liu, *Xi'an Jiaotong University*

ABSTRACT: This talk is concerned with an inverse boundary value problem for determine an immersed inclusion in the stationary flow, which is governed by the Stokes equations. We proved that the shape and location of the inclusion can be uniquely recovered by the boundary measurements on the accessible exterior boundary. The method relied on reconstructing a well-posed coupled PDEs system by the solutions to the stokes equation in a sufficiently small domain near the boundary of the inclusion, and several key a priori estimates of the solutions in L^p space for $1 < p < 2$.

Near-field Imaging of an Unbounded Rough Surface by Elastic-wave Measurements

SPEAKER: Tielei Zhu, *Xi'an Jiaotong University*

ABSTRACT: Consider the two-dimensional inverse elastic wave scattering by an unbounded rough surface with a Dirichlet boundary condition. We propose a novel sampling-type method to locate the rough surface by taking near-field measurements in the sense that the surface could be reconstructed more fully as long as the auxiliary parameter $R > 0$ is chosen to be sufficiently large. Numerical experiments are carried out to illustrate the effectiveness of the method. This is a joint work with Prof. Jiaqing Yang.

Time Domain Scattering Problems in Periodic Structures and Bi-periodic Structures

SPEAKER: Jue Wang, *Harbin Engineering University*

ABSTRACT: Scattering problems in periodic structures has significant applications in many fields, such as optics, Electromagnetics. In this talk, we mainly focus on the time domain scattering problem in an unbounded periodic structure. A coordinate transformation is proposed to reduce equivalently the diffraction problem into an initial boundary value problem. The existence of unique weak solution of the reduced problem is proved by Galerkin method. Furthermore, the stability and a priori estimates with explicit time dependence are established for the weak solution by energy analysis method.

4.8 M7: A3 Workshop

On inverse crack problems in conductive bodies by the enclosure method

SPEAKER: Hiromichi Itou, *Tokyo University of Science*

ABSTRACT: In this talk, we consider a reconstruction problem for several linear cracks located on a line between two electric conductive plates from measured data which are an injecting direct current and the resulted voltage on the accessible side of the plate. This is a mathematical model for nondestructive evaluation of spot welds. For this problem, we introduce an extraction formula of the welding area from a single set of the data by means of the enclosure method, and some numerical implementations of the formula. This research is based on a joint work with Andreas Hauptmann (University College London), Masaru Ikehata (Hiroshima University) and Samuli Siltanen (University of Helsinki).

Existence of weakly neutral coated inclusions of general shape in two dimensions

SPEAKER: Xiaofei Li, *Zhejiang University of Technology*

ABSTRACT: A two dimensional inclusion of core-shell structure is neutral to multiple uniform fields if and only if the core and the shell are concentric disks, provided that the conductivity of the matrix is isotropic. An inclusion is said to be neutral if upon its insertion the uniform field is not perturbed at all. In this paper we consider inclusions of core-shell structure of general shape which are weakly neutral to multiple uniform fields. An inclusion is said to be weakly neutral if the field perturbation is mild. We show, by an implicit function theorem, that if the core is a small perturbation of a disk then we can coat it by a shell so that the resulting structure becomes weakly neutral to multiple uniform fields. This is a joint work with Hyeonbae Kang and Shigeru Sakaguchi.

Numerical unique continuation of two dimensional elliptic equations and estimate of confidence domain

SPEAKER: Yu Chen, *Fudan University*

ABSTRACT: The numerical method for unique continuation of two dimensional elliptic equations is investigated, which can be potentially applied to inverse problems and optimal design problems. The numerical computation of classical strong unique continuation for two dimensional elliptic equations can be realized by reconstruction of single layer potential. A stable algorithm is presented based on the conditional stability of the problem. The error estimation of the algorithm is provided, which can be applied to determine the confidence domain of reconstructed solutions. Numerical examples are given to illustrate the validity and effectiveness of the method. This is a joint work with Prof. Jin Cheng.

An adaptive DtN finite element method for three-dimensional acoustic scattering problems

SPEAKER: Bin Hu, *Zhejiang University*

ABSTRACT: In this paper, we are concerned with the acoustic wave scattering by an impenetrable obstacle in three dimensions. By introducing a transparent boundary condition, the physical domain is truncated into a computable bounded one for using the finite element method. Due to nonlocality of Direchlet-to-Neumann operator, an efficient algorithm is presented to adaptively choose the truncation parameter. Such approach is based on an a posteriori error estimate, which consists of the finite element approximation error and the truncation error of Direchlet-to-Neumann operator. The hierarchy geometry tree (HGT) is utilized to manage mesh grids. Numerical effectiveness of the presented adaptive method is shown by some numerical experiments.

Shape prior metal artifact reduction algorithm for industrial 3D cone beam

SPEAKER: Chang-Ock LEE, *KAIST*

ABSTRACT: Beam hardening effect is one of the main factors that decrease the contrast of CT images. Since the contrast degradation due to beam hardening effect causes misinterpretation of information about property and structure of a scanned object, a proper beam hardening correction algorithm is needed. In this talk, we propose a methodology to reduce beam hardening artifacts especially due to metallic objects by extending the method proposed in our previous work to three dimensional cone beam CT system. We develop a registration technique managing the three dimensional data in order to find segmentation regions needed in the proposed algorithm. Through numerical experiments, we verify that the proposed algorithm reduces beam hardening artifacts due to metallic objects successfully.

Variational Model with the ℓ_q semi-norm for Impulse Noise Reduction

SPEAKER: Taeuk JEONG, *Yonsei University*

ABSTRACT: We consider a variational model with the l_q semi-norm for reducing impulse noise. The impulse noise shows sparsity pattern especially when the noise level is low. The l_q semi-norm with $0 < q < 1$ has shown to capture sparsity pattern better than the l_1 norm. By exploiting these facts, we propose a new model for reducing impulse noise. The proposed model consists of the l_q semi-norm fidelity term of the difference between the observed and original images and total variation regularizer. Numerical results on images with different levels of impulsive noise indicate that the optimal value of q decreases as the noise level is declined.

Asymptotic expansions for the diffusion equation with applications

SPEAKER: Haibing Wang, *Southeast University*

Abstract: We show the asymptotic expansions of solutions to initial boundary value problems for the diffusion equation, as the size of the domain of interest (inclusion, cavity, etc.) goes to zero. More explicitly, we consider the following two model problems. First, for 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 close, and invertible, system of time domain integral equations of a second kind. As an application of these expansions, 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. Second, for the diffusion process by a finite number of small inclusions, we analyze the asymptotic behavior of the boundary measurements weighted by the fundamental solution of a backward diffusion equation. As an application, we derive an efficient non-iterative algorithm for locating small inclusions from finite boundary measurements.

Unique continuation property with partial information for two-dimensional anisotropic elasticity systems

Speaker: Yikan Liu, *The University of Tokyo*

Abstract: In this talk, we introduce a novel unique continuation property for two-dimensional anisotropic elasticity systems with partial information. More precisely, given a homogeneous elasticity system in a domain, we investigate the unique continuation by assuming only the vanishing of one component of the solution in a subdomain. Using the corresponding Riemann function, we prove that the solution vanishes in the whole domain provided that the other component vanishes at one point up to its second derivatives. Further, we construct several examples showing the possibility of further reducing the additional information of the other component. This result possesses remarkable significance in both theoretical and practical aspects because the required data is almost halved for the unique determination of the whole solution.

Carleman estimate for a time-fractional advection-diffusion equation and application to an inverse source problem

Speaker: Xinchi Huang, *The University of Tokyo*

Abstract: Recently introducing the time-fractional derivatives into the diffusion equation for a heterogeneous medium achieved great successes. This gives us a motivation to study the time-fractional diffusion equation (TFDE) intensively. In this talk, we consider a TFDE with a first-order time derivative. With the help of the first-order time derivative, we can prove a specific Carleman estimate by the idea of making a loop. Then we also obtain some stability inequality for an inverse source problem in terms of this Carleman estimate.

4.9 M8: Contributed Talks

Long Range Scattering Problem for the Maxwell-Schrödinger Equation without any Restriction on the Size of Data

SPEAKER: Yang Liu, *Northeast Normal University & Shimane University*

ABSTRACT: We consider the scattering theory for the Maxwell-Schrödinger equations under the Lorentz gauge conditions in three space dimensions.

$$\begin{cases} i\partial_t u = -(1/2)\Delta_A u + A_e u \\ \Box A = J \\ \Box A_e = J_0 \end{cases} \tag{1}$$

where (A, A_e) is an $\mathbb{R}^{3+1}$ valued function defined in space time $\mathbb{R}^{3+1}, \nabla_A = \nabla - iA$ and $\Delta_A = \nabla_A^2$ are the covariant gradient and covariant Laplacian respectively and $\Box = \partial_t^2 - \Delta$ is the d'Alembertian. $J = \mathrm{Im}\bar{u}\nabla_A u$ and $J_0 = |u|^2$. By the current conservation $\nabla \cdot J + \partial_t J_0 = 0$.

We prove the existence of modified wave operators for the Maxwell-Schrödinger system, without any restriction on the size of those data. To this end, we solve this system with prescribed asymptotic behaviour as $t \to \infty$, defined in terms of Schrödinger and Maxwell asymptotic data. This system belongs to the borderline between the short range case and the long range one, so that the prescribed asymptotic behaviour for the Schrödinger function includes a suitable phase correction. The method consists in partially solving the Maxwell equations for the potentials, substituting the result into the Schrödinger equation, which then becomes both nonlinear and nonlocal in time. The Schrödinger function is then parametrized in terms of an amplitude and a phase satisfying a suitable auxiliary system. Then we solve the Cauchy problem for this auxiliary system by an energy method.

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REGINN iteration based on the non-stationary iterated Tikhonov method with general convex penalty terms

SPEAKER: Zhenwu Fu, *Harbin Institute of Technology*

ABSTRACT: In this talk, we are in an effort to solve the inverse problem of the form

$$F(x) = y, \tag{2}$$

where $F : X \to Y$ is a nonlinear Frećhet differentiable operator with domain $\mathscr{D}(F) \subset X$ and X is a Banach space. Assuming that (2) has a solution x^* (which needs not be unique). The noisy data y^δ instead of exact data y which satisfies

$$\|y^\delta - y\| \leq \delta$$

is given for some $\delta > 0$. Due to the inherent ill-posedness of inverse problems, they need to be regularized to obtain reasonable approximation to x^*.
Many regularization methods have been developed during the last two decades to solve (2). Levenberg-Marquart method is one of the prominent methods and has been studied in Banach space, such as [1]. In [1], the regularization parameter α_n has to be calculated by solving an optimal problem which is time consuming. Since REGNN method has an advantage on the convergence speed [2,3], we thus combine it with a non-stationary iterated Tikhonov method to formulate a new version of Levenberg-Marquart method that proposed in [1]. The new method avoids the calculation of regularization parameter α_n in [1], therefore it has a higher convergence speed when terminated by discrepancy principle. Our REGINN method will go as following

$$\begin{aligned} x_{n,k+1} &:= \arg\min_{x\in X}\{\frac{1}{r}\|y^\delta - F(x_n) - F'(x_n)(x - x_n)\|^r + \alpha_n D_{\xi_{n,k}} R(x, x_{n,k})\} \\ \xi_{n,k+1} &= \xi_{n,k} + \frac{1}{\alpha_n} F'(x_n)^* J_r(y^\delta - F(x_n) - F'(x_n)(x_{n,k+1} - x_n)) \end{aligned} \tag{3}$$

where $x_{n,0} = x_n$, $\xi_{n,0} = \xi_n$ and α_n is given. We then define $x_{n+1} := x_{n,k_n}$ with k_n being the first integer satisfying

$$\|y^\delta - F(x_n) - F'(x_n)(x_{n,k_n} - x_n)\| < \mu\|y^\delta - F(x_n)\|$$

where $0 < \mu < 1$ is a preassigned number.
The convergence results of our REGINN method will be given under a tangential cone condition. In addition, we present some numerical simulations to test the performance of our REGINN method terminated by discrepancy principle. In the first example, we solve the Robin problem. The inverse potential problem will be considered in the second example.

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Recovery of non-smooth radiative coefficient from nonlocal observation by diffusion system

SPEAKER: Mengmeng Zhang, *Southeast University*

ABSTRACT: The heat conduction process in the composite medium can be modeled by a parabolic equation with discontinuous radiative coefficient. To detect the composite medium characterized by such a non-smooth radiative coefficient from measurable information about the heat distribution, we consider a nonlinear inverse problem for inhomogeneous parabolic equation, with the average measurement of temperature field in some time domain as the inversion input data. We firstly establish the uniqueness for this nonlinear inverse problem, based on the property of the direct problem and the known uniqueness result for linear inverse source problem. To solve this inverse problem from a nonlinear operator equation, the tangential condition of this nonlinear map is analyzed in some admissible set. An iterative process called two-point gradient method is proposed by minimizing data-fit term and the penalty term alternatively, with rigorous convergence analysis in terms of the tangential condition for the direct operator. Numerical simulations are presented to illustrate the effectiveness of the proposed method.

A mixed strategy for efficient acousto-electric tomography based on complete electrode model

SPEAKER: Changyou Li, *Northwest University of Technology*

ABSTRACT: A mixed strategy is proposed to combine the Dirichlet and complete electrode models to efficiently reconstruct the distribution of the conductivity. This method can eliminate the instability and the inefficiency arising from the numerical reconstruction based on complete electrode model via iteratively solving least-square minimization problems. These instability and inefficiency mainly come from the numerical difficulties of calculating the adjoint operators required in Levenberg-Marquardt or Gauss-Newton algorithms. Numerical reconstructions are used for evaluating the performance.

An accelerated sequential subspace optimization method based on homotopy perturbation iteration for nonlinear ill-posed problems

SPEAKER: Shanshan Tong, *Shaanxi Normal University*

ABSTRACT: Homotopy perturbation iteration is an effective and fast method for solving nonlinear ill-posed problems. It only needs approximately half the computation time of Landweber iteration to reach the similar recovery precision. In this talk, a Nesterov-type accelerated sequential subspace optimization method based on homotopy perturbation iteration is proposed for solving nonlinear inverse problems. The convergence analysis is provided under the general assumptions for iterative regularization methods. The numerical experiments on inverse potential problem and diffuse optical tomography(DOT) indicate that the proposed method dramatically reduce the total number of iteration and time consumption to obtain satisfying approximations, especially for the issues with costly solution of forward problem.