反问题分析与计算研讨会

Workshop on Analysis and Computation of Inverse Problems

哈尔滨工业大学　　数学学院

School of Mathematics, Harbin Institute of Technology

中国 · 哈尔滨

2022 年 5 月 14-15 日

目 录

一、会议简介

  反问题是现代数学物理和计算数学中的一个十分活跃的重要研究领域，在近半个世纪内，一直受到了国内外众多的数学家、物理学家以及工程技术专家的广泛关注。近些年，关于反问题的理论不断被发展与完善，相关的数学理论和数值方法研究在科学计算中日益活跃，其研究内容越来越丰富，相关应用已经遍及医学成像、雷达探测、地质勘探、光学、材料和控制等众多重要的科学技术领域。因此，从数学理论和计算方法角度，对反问题给予必要的基础研究，对物理现象的定性解释和定量预测都显得至关重要，相关研究不仅具有重要的科学意义，而且部分研究成果能够直接促进工业生产与发展。

  为了探讨反问题领域的最新发展和前景，加强研究机构和高校在反问题研究领域的学术交流与合作，拟定于2022年5月14-15日在线举办 "反问题分析与计算研讨会"。会议主题包括：反问题和不适定问题的理论和正则化方法、偏微分方程和反问题数值方法、统计反问题和求解反问题的机器学习技术等。

会议时间：

  2022年5月14日—5月15日

组织委员会：

  马坚伟 韩波 陈勇 郭玉坤 汪贤超

联系人：

  郭玉坤 邮箱：ykguo@hit.edu.cn
  汪贤超 邮箱：xcwang@hit.edu.cn

二、邀请报告人

（按姓氏首字母排序）

邓志亮	电子科技大学	宋义壮	山东师范大学
董和平	吉林大学	孙鸿鹏	中国人民大学
高忆先	东北师范大学	王海兵	东南大学
龚荣芳	南京航空航天大学	王 薇	嘉兴学院
蒋代军	华中师范大学	许伯熹	上海财经大学
季 霞	北京理工大学	徐 翔	浙江大学
贾骏雄	西安交通大学	殷 涛	中科院
赖 俊	浙江大学	袁晓凯	吉林大学
刘 娟	暨南大学	张德悦	吉林大学
刘可仮	上海财经大学	张 磊	浙江工业大学
陆 帅	复旦大学	张植栋	中山大学
邱凌云	清华大学	钟 敏	东南大学

三、会议日程表

2022年5月14日，周六上午

腾讯会议　链接：https://meeting.tencent.com/dw/7HuBdulJ1P3a
会议号：　606-840-341　密码：0514

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08:30-08:40	开幕式：数学学院院长马坚伟教授致辞	郭玉坤
08:40-09:10	Non-line-of-sight Imaging 邱凌云　清华大学	马坚伟
09:10-09:40	Numerical method for the Elasticity Transmission Eigenvalues 季　霞　北京理工大学	
09:40-10:10	A spectral solver for the elastic scattering problems in three dimensions 赖　俊　浙江大学	
10:10-10:20	休　息	
10:20-10:50	无限维变分贝叶斯推断及其应用 贾骏雄　西安交通大学	赖俊
10:50-11:20	Inverse obstacle scattering for elastic waves in the time domain 董和平　吉林大学	
11:20-11:50	Study of bioluminescence tomography based on a new time-dependent diffusion equation 龚荣芳　南京航空航天大学	
11:50-14:00	午　休	

三、会议日程表

2022年5月14日，周六下午

腾讯会议　链接： https://meeting.tencent.com/dw/7HuBdulJ1P3a
会议号： 606-840-341　**密码：0514**

时间	报告信息	主持人
14:00-14:30	Data assimilation from a viewpoint of regularization theory 陆 帅　**复旦大学**	张德悦
14:30-15:00	Convergence of some numerical methods for parabolic inverse Robin problems 蒋代军　**华中师范大学**	
15:00-15:30	Acousto-electric tomography imaging model and algorithm based on two-point gradient θ Method 钟 敏　**东南大学**	
15:30-15:40	**休 息**	
15:40-16:10	腔体边界与内部点源的共同反演 张德悦　**吉林大学**	陆帅
16:10-16:40	On the asymptotical regularization with convex constraints for inverse problems 王 薇　**嘉兴学院**	
16:40-17:10	Uniqueness and numerical inversion in the time-domain fluorescence diffuse optical tomography 张植栋　**中山大学**	

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08:30-09:00	A Bayesian level set method for an inverse medium scattering problem in acoustics 邓志亮　电子科技大学	王海兵
09:00-09:30	Inverse problems for the DCIS model with asymmetric free boundaries 刘可仮　上海财经大学	
09:30-10:00	Theory and calculation of scattering and composite scattering from rough surfaces 张 磊　浙江工业大学	
10:00-10:10	休 息	
10:10-10:40	A new approach to an inverse source problem for the wave equation 王海兵　东南大学	张磊
10:40-11:10	Modal approximation for time-domain elastic scattering from metamaterial quasiparticles 高忆先　东北师范大学	
11:10-11:40	Convergence and stability analysis of an MREIT reconstruction algorithm based on a single measurement 宋义壮　山东师范大学	
11:40-14:00	午 休	

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14:30-15:00	A preconditioned difference of convex algorithm for truncated quadratic regularization with application to imaging 孙鸿鹏　中国人民大学	徐翔
15:00-15:30	An adaptive finite element DtN method for the elastic wave scattering problem in three dimensions 袁晓凯　吉林大学	徐翔
15:30-16:00	解弹性波反散射问题的混合迭代法 刘　娟　暨南大学	徐翔
16:00-16:10	休　息	
16:10-16:40	Inverse problems for piezoelectric equations 徐　翔　浙江大学	陈勇
16:40-17:10	Boundary integral equation methods for elastic open-surface problems 殷　涛　中国科学院数学与系统科学研究院	陈勇
17:10-17:30	Levenberg–Marquardt method with general convex penalty for nonlinear inverse problems 付振武　哈尔滨工业大学	陈勇
17:30-17:50	Direct imaging for the moment tensor point sources of elastic waves 汪贤超　哈尔滨工业大学	陈勇
17:50-18:00	会　议　闭　幕	汪贤超

四、报告摘要

1 邓志亮　　电子科技大学

题目： A Bayesian Level Set Method for An Inverse Medium Scattering Problem in Acoustics

摘要： In this talk, we are interested in the determination of the shape of the scatterer for the two-dimensional time harmonic inverse medium scattering problems in acoustics. The scatterer is assumed to be a piecewise constant function with a known value inside inhomogeneities, and its shape is represented by the level set functions for which we investigate the information using the Bayesian method. In the Bayesian framework, the solution of the geometric inverse problem is defined as a posterior probability distribution. The well-posedness of the posterior distribution is discussed, and the Markov chain Monte Carlo (MCMC) method is applied to generate samples from the posterior distribution. Numerical experiments are presented to demonstrate the effectiveness of the proposed method.

2 董和平　　吉林大学

题目： Inverse obstacle scattering for elastic waves in the time domain

摘要： This talk concerns an inverse elastic scattering problem which is to determine a rigid obstacle from time domain scattered field data for a single incident plane wave. By using the Helmholtz decomposition, we reduce the initial boundary value problem for the time domain Navier equation to a coupled initial-boundary value problem for wave equations, and prove the uniqueness of the solution for the coupled problem by employing the energy method. The retarded single layer potential is introduced to establish a set of coupled boundary integral equations, and uniqueness is discussed for the solution of these boundary integral equations. Based on the convolution quadrature method for time discretization, the coupled boundary integral equations are reformulated into a system of boundary integral equations in the *s*-domain, and then a convolution quadrature based nonlinear integral equation method is proposed for the inverse problem. Numerical experiments are presented to show the feasibility and effectiveness of the proposed method.

3 高忆先　　东北师范大学

题目： Modal approximation for time-domain elastic scattering from metamaterial quasiparticles

摘要： This talk aims at quantitatively understanding the elastic wave scattering due to negative metamaterial structures under wide-band signals in the time domain. Specifically, we establish the modal expansion for the time-dependent field scattered by metamaterial quasiparticles in elastodynamics. By Fourier transform, we first analyze the modal expansion in the time-harmonic regime. With the presence of quasiparticles, we validate such an expansion in the static regime via quantitatively analyzing the spectral properties of the Neumann-Poincaré operator associated with the elastostatic system. We then approximate the incident field with a finite number of modes and apply perturbation theory to obtain such an expansion in the perturbative regime. In addition, we give polariton resonances as simple poles for the elastic system with non-zero frequency. Finally, we show that the low-frequency part of the scattered field in the time domain can be well approximated by using the resonant modal expansion with sharp error estimates.

4 龚荣芳　　南京航空航天大学

题目： Study of bioluminescence tomography based on a new time-dependent diffusion equation

摘要： In this talk, we consider inverse source problems arising in bioluminescence tomography (BLT). Mathematically, BLT is an under-determined inverse source problem which leads to no solution uniqueness. Particularly, one cannot distinguish between a strong source over a small region and a weak source over a large region. Therefore, it is particularly important to know the support Ω_s of the underlining light source p_* so that its strength could be reconstructed accurately. In the literature, Ω_s is assumed to be given. Practically, we only get an approximation Ω_s of it, known from some a priori information. The accuracy of Ω_s affects largely the one in approximate solutions of p_*. Therefore, in this talk, a new time-dependent coupled model is proposed motivated by the solution uniqueness. Some theoretical and numerical results are reported for the verification of the new model and methods.

5 蒋代军　　华中师范大学

题目： Convergence of some numerical methods for parabolic inverse Robin problems

摘要： We study in this talk some numerical methods for solving the highly nonlinear and ill-posed inverse problem of identifying the Robin coefficients in parabolic systems. We first apply the Levenberg-Marquardt method (LMM) to transform 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. We also propose some semismooth Newton type algorithms when the Robin coefficients have

sparse structure. Local superlinear convergence of the proposed algorithms are rigorously proved under the reasonable Small Residual Assumption.

6 季 霞   北京理工大学

题目： Numerical method for the Elasticity Transmission Eigenvalues

摘要： We develop a discontinuous Galerkin method computing a few smallest elasticity transmission eigenvalues, which are of practical importance in inverse scattering theory. For high order problems, DG methods are competitive since they use simple basis functions, the numerical implementation is much easier compared with classical conforming finite element methods. In this talk, we propose an interior penalty discontinuous Galerkin method using C0 Lagrange elements (C0IP) for the transmission eigenvalue problem for elastic waves and prove the optimal convergence. The method is applied to several examples and its effectiveness is validated.

7 贾骏雄   西安交通大学

题目： 无限维变分贝叶斯推断及其应用

摘要： 贝叶斯方法作为反问题不确定性量化的理论框架，近年来获得了广泛的关注。贝叶斯方法在大规模反问题求解方面的一个核心困难问题是如何快速且精准的获得后验测度的统计信息，例如：后验均值、后验方差等。这个核心困难问题同样出现在大规模机器学习的研究中，为了克服这一困难，学者提出了系列变分贝叶斯理论，并大量用于机器学习模型的不确定性量化研究。在偏微分方程反问题领域，变分贝叶斯方法的相关研究还较少（反问题通常定义在无限维空间，还少有无限维空间变分贝叶斯方法的理论），在本报告中，将简述变分贝叶斯方法的基本思想，构造无限维空间上基于平均场逼近的变分贝叶斯方法、基于粒子演化的 Stein 变分贝叶斯方法、以及基于深度学习的变分逆网络方法。

8 赖 俊   浙江大学

题目： A spectral solver for the elastic scattering problems in three dimensions

摘要： The scattering problems for elastic waves have attracted considerable attention due to the significant applications in diverse scientific areas such as nondestructive testing, medical imaging, and seismic exploration. This talk concerns the time-harmonic elastic scattering problem of a rigid obstacle embedded in a homogeneous and isotropic elastic medium in three dimensions. A novel boundary integral equation is formulated and a high order spectral accurate algorithm is proposed for the obstacle scattering problem based on the Galerkin method. By making use of the Helmholtz decomposition, we reduce the model problem to a coupled boundary value problem consisted of acoustic and Maxwell equations. The uniqueness of the coupled system is proved under certain conditions and a novel boundary integral equation is formulated based on the potential theory. By employing the surface differential operator and Stokes theorem, we reduce the strongly singular operators to weakly singular ones. A spectral

accurate discretization scheme is proposed by the spherical harmonic basis. Numerical experiments are provided for various geometries to demonstrate the spectral accuracy and high efficiency (in terms of complexity and computational time) of the algorithm.

9 刘 娟 暨南大学

题目：解弹性波反散射问题的混合迭代法

摘要：对于利用单入射波下的远场重构散射体的弹性波反散射问题，我们可通过已有的 Extend sampling method 等算法确定散射体的大致位置，而为了进一步确定散射体形状，我们引入了一种被称为 Hybrid method 的迭代算法，它基于边界信息实现对散射体形状的迭代重构。由于该算法在迭代过程中无需求解正问题，因此即使在边界条件缺失的情况下，仍能通过构造"边界信息"达到形状重构的效果。多个实验结果表明了该算法的有效性。

10 刘可伋 上海财经大学

题目：Inverse problems for the DCIS model with asymmetric free boundaries

摘要：We shall present the DCIS model with asymmetric free boundaries and the corresponding direct problem. And an effective iterative finite difference method of approximate second-order accuracy would be presented for the direct problem. Moreover, we shall state a related inverse problem of the DCIS model and the corresponding uniqueness analysis. An efficient reconstruction method would be exhibited for the inverse problem. Finally, some numerical experiments are shown to verify the accuracy and effectiveness of the proposed methods, and the numerical simulations may help to determine whether the atypical hyperplasia of DCIS would become malignant or not.

11 陆 帅 复旦大学

题目：Data assimilation from a viewpoint of regularization theory

摘 要：Inverse problems are ubiquitous in real applications. Understanding of algorithms for their solution has been greatly enhanced by a deep understanding of the linear inverse problem. In the applied communities ensemble-based filtering methods have recently been used to solve inverse problems by introducing an artificial (continuous) dynamical system. This opens up the possibility of using a range of other filtering methods, such as 3DVAR, Kalman-Bucy filter (online) and 4DVAR (offline), to solve inverse problems, again by introducing an artificial dynamical system. The aim of this talk is to understand these methods in the context of the regularization theory under the framework of linear inverse problems.

12 邱凌云　　清华大学

题目： Non-line-of-sight Imaging

摘要： Non-line-of-sight imaging aims at recovering obscured objects from multiple scattered light. It has recently received widespread attention due to its potential applications such as autonomous driving, rescue operations, and remote sensing. However, in cases with high measurement noise, obtaining high-quality reconstructions remains a challenging task. In this work, we establish a unified regularization framework, which can be tailored for different scenarios, including indoor and outdoor scenes with substantial background noise under both confocal and non-confocal settings. The proposed regularization framework incorporates sparseness and non-local self-similarity of the hidden objects as well as smoothness of the measured signals. We show that the estimated signals, albedo, and surface normal of the hidden objects can be estimated reconstructed robustly even with high measurement noise under the proposed framework. Reconstruction results on synthetic and experimental data show that our approach recovers the hidden objects faithfully and outperforms state-of-the-art reconstruction algorithms in terms of both quantitative criteria and visual quality.

13 宋义壮　　山东师范大学

题目： Convergence and stability analysis of an MREIT reconstruction algorithm based on a single measurement

摘要： Magnetic resonance electrical impedance tomography (MREIT) is an imaging modality that is capable of reconstructing a high spatial resolution conductivity image of the human body using partial information of magnetic flux densities measured through an MRI scanner. However, its temporal resolution is quite low due to the hardware limit of the MRI scanner. To accelerate the imaging speed, recently we propose an iterative reconstruction algorithm, called the single current harmonic Bz algorithm which can produce a conductivity image using only half of the time compared with the traditional reconstructions. In this talk, we will present the convergence and stability analysis of the single current harmonic Bz algorithm. We will also provide numerical and phantom experiments to validate the proposed theory.

14 孙鸿鹏　　中国人民大学

题目： A preconditioned difference of convex algorithm for truncated quadratic regularization with application to imaging

摘要： We consider the minimization problem with the truncated quadratic regularization, which is a nonsmooth and nonconvex problem. We cooperated the classical preconditioned iterations for linear equations into the nonlinear difference of convex functions algorithms with extrapolation. Especially, our preconditioned framework can deal with the large linear system efficiently which is usually expensive for computations. Global convergence is guaranteed and local linear convergence rate is given based on the analysis of the Kurdyka-Lojasiewicz exponent of the

minimization functional. The proposed algorithm with preconditioners turns out to be very efficient for image restoration and is also appealing for image segmentation.

15 王海兵　　东南大学

题目：　A new approach to an inverse source problem for the wave equation

摘要：　Consider an inverse problem of reconstructing a source term from boundary measurements for the wave equation. We propose a novel approach to recover the unknown source through measuring the wave fields after injecting small particles, enjoying a high contrast, into the medium. For this purpose, we first derive the asymptotic expansion of the wave field, based on the time-domain Lippmann-Schwinger equation. The dominant term in the asymptotic expansion is expressed as an infinite series in terms of the eigenvalues of the Newtonian operator (for the pure Laplacian). Such expansions are useful under a certain scale between the size of the particles and their contrast. Second, we observe that the relevant eigenvalues appearing in the expansion have non-zero averaged eigenfunctions. By introducing a Riesz basis, we reconstruct the wave field, generated before injecting the particles, on the center of the particles. Finally, from these (internal values of these) last fields, we reconstruct the source term (by numerical differentiation for instance). A significant advantage of our approach is that we only need the measurements for a single point away from the support of the source.

16 王 薇　　　嘉兴学院

题目：　On the asymptotical regularization with convex constraints for inverse problems

摘要：　We investigate the method of asymptotical regularization for solving ill-posed problems in Hilbert spaces. A general uniformly convex functional has been embedded in the evolution equations which is allowed to be non-smooth, thus the algorithm can be applied for sparsity and discontinuity reconstruction. We establish the convergence and stability of the method. Under variational source conditions on the sought solution, we derive the convergence rates.

17 许伯熹　　上海财经大学

题目：Linearized inverse problems at a high frequency

摘要：We investigate recovery of the potential and conductivity function from many boundary measurements at a high frequency for linear/nonlinear equations. By considering such a linearized form, we obtain Hölder type stability which is a big improvement over logarithmic stability in low frequencies. Increasing stability bounds for these coefficients contain a Lipschitz term with a factor growing polynomially in terms of the frequency, a Hölder term, and a logarithmic term which decays with respect to the frequency as a power. Based on the linearized problem, a reconstruction algorithm is proposed aiming at the recovery of sufficiently many Fourier modes of the

potential or conductivity function. By choosing the high frequency appropriately, the numerical evidence shed light on the influence of the growing frequency and confirms the improved resolution.

This is the joint work with Prof. Victor Isakov, Prof. Shuai Lu and Prof. Mikko Salo.

18 徐 翔   浙江大学

题目： Inverse problems for piezoelectric equations

摘要： In this talk, recent progress on inverse problems for piezoelectric equations is discussed. We show a uniqueness result on recovering coefficients of piecewise homogeneous piezoelectric equations from a localized Dirichlet-to-Neumann map on partial boundaries. Assume the bounded domain can be divided into finite subdomains, in which the unknown coefficients including elastic tensor, piezoelectric tensor and dielectric tensor are constants. Two different cases are considered: the subdomains are either known and Lipschitz, or unknown and subanalytic. For both cases, the unknown coefficients can be uniquely determined from a given localized Dirichlet-to-Neumann map. Moreover, for a specific hexagonal piezoelectric equation, we obtained a first order perturbation formula for the phase velocity of Bleustein-Gulyaev (BG) waves, which expresses the shift in the velocity from its comparative value, caused by the perturbation of the elasticity tensor, the piezoelectric tensor and of the dielectric tensor.

19. 殷 涛   中国科学院数学与系统科学研究院

题目： Boundary integral equation methods for elastic open-surface problems

摘要： This talk will present some of our recent works on the boundary integral equation methods, including Nystrom-type methods and spectral Galerkin methods, for solving the elastic open-surface scattering problems, as well as the corresponding mathematical analysis of the integral operators. The certain edge singularities of potentials are explicitly considered in our methods. Moreover, theoretical properties of elastic Calderón formulas defined on a two-dimensional open-arc will be shown to provide some rigorous theoretical basis for the preconditioning. Numerical examples in both 2D and 3D will be presented to demonstrate the accuracy and robustness of the proposed methods.

20 袁晓凯   吉林大学

题目： An adaptive finite element DtN method for the elastic wave scattering problem in three dimensions

摘要： Consider the elastic scattering of an incident wave by a rigid obstacle in three dimensions, which is formulated as an exterior problem for the Navier equation. By constructing a Dirichlet-to-Neumann (DtN) operator and introducing a transparent boundary condition, the scattering problem is reduced equivalently to a boundary value problem in a bounded domain. The discrete problem with the truncated DtN operator is solved by using the a posteriori error estimate based adaptive finite element method.

The estimate takes account of both the finite element approximation error and the truncation error of the DtN operator, where the latter is shown to converge exponentially with respect to the truncation parameter. Moreover, the generalized Woodbury matrix identity is utilized to solve the resulting linear system efficiently. Numerical experiments are presented to demonstrate the superior performance of the proposed method.

21. 张德悦 　吉林大学

题目： 腔体边界与内部点源的共同反演

摘要： 针对利用测量的总场数据确定腔体边界与相应的入射点源位置的共同反演问题，提出利用单层位势方法解耦入射场与散射场，并通过优化方法与直接采样方法来分别重构腔体形状与确定点源的位置。所提出算法在传统数值方法单一测量曲线的基础上,增加了一条测量曲线,即本算法采用双测量曲线进行数据采集,确保了问题解的唯一性,且所提出算法是一种定性方法与定量方法的结合,也不需要求解正问题或迭代,因此计算量不大且易于实现。同时,我们从数学上分析了数据带有噪声时的逼近性质,从而为算法的鲁棒性奠定了理论基础。本报告还将展示若干数值算例来验证所提出算法的有效性。

22. 张磊 　浙江工业大学

题目： Theory and calculation of scattering and composite scattering from rough surfaces

摘要： This talk is concerned with the scattering and inverse scattering problems for an incident wave by an obstacle embedded in a two-layered background medium. It is a nontrivial extension of the previous theoretical work on the inverse obstacle scattering in an unbounded structure. We consider two different cases: the time domain and time-harmonic wave scattering. I will briefly introduce theoretical results based on the boundary integral equation and the variational methods. Finally, we will submit our ongoing research work.

23 张植栋 　中山大学

题目： Uniqueness and numerical inversion in the time-domain fluorescence diffuse optical tomography

摘要： This work considers the time-domain fluorescence diffuse optical tomography (FDOT). We recover the distribution of fluorophores in biological tissue by the boundary measurements. With the Laplace transform and the knowledge of complex analysis, we build the uniqueness theorem of this inverse problem. After that, the numerical reconstructions are considered. We introduce a non-iterative inversion strategy by peak detection and an iterative inversion algorithm under the framework of regularizing scheme, then give several numerical examples in three-dimensional space

illustrating the performance of the proposed inversion schemes.

24 钟 敏　　东南大学

题目： Acousto-electric tomography imaging model and algorithm based on two-point gradient θ method

摘要： We study the numerical reconstruction problem in acousto-electric tomography of recovering the conductivity distribution in a bounded domain from interior power density data. We propose a numerical method for recovering discontinuous conductivity distributions, by utilizing the two point gradient method, the piecewise constant conductivity can be efficiently reconstructed. Extensive numerical experiments are presented to illustrate the feasibility of the proposed approach.

25 付振武　　哈尔滨工业大学

题目： Levenberg–Marquardt method with general convex penalty for nonlinear inverse problems

摘要： We consider a Levenberg–Marquardt method for solving nonlinear inverse problems in Hilbert spaces. The proposed method uses general convex penalty terms to reconstruct nonsmooth solutions of inverse problems. Instead of an a priori choice, the regularization parameter in each iteration is chosen by solving an equation which depends on the residual. We utilize the discrepancy principle to terminate the iteration and give the convergence results. In addition, numerical simulations are presented to test the performance of the method.

26 汪贤超　　哈尔滨工业大学

题目： Direct imaging for the moment tensor point sources of elastic waves

摘要： We investigate an inverse source problem of the time-harmonic elastic wave equation. Some novel sampling-type numerical schemes are proposed to identify the moment tensor point sources in the Lamé system from near-field measurements. Rigorous theoretical justifications are provided to show that the locations and moment tensors of the elastic sources can be uniquely determined from the multi-frequency displacement data. Several numerical examples are also presented to illustrate the validity and robustness of the proposed method.

五、学院简介

哈尔滨工业大学数学学院前身是创建于 1958 年的计算数学专业，1981 年开始培养基础数学和计算数学专业硕士，1986 年获得基础数学博士学位授予权（是国内最早的两所工科院校之一），1987 年成立数学系，2019 年成立数学学院。2001 年建立了数学学科博士后流动站，2005 年数学学科成为一级学科硕士学位授权点，2010 年数学学科成为一级学科博士授权点，2011 年统计学成为一级学科博士授权点。基础数学是省重点学科（2001 年）和国防科工委重点学科（2002 年）；应用数学是省重点学科（2001 年）。数学学科 2011 年成为省一级重点学科。2013 年基础数学和应用数学成为工信部重点学科。1997 年入选教育部首批七个"工科基础课程（数学）教学基地"之一；2020 年数学类专业入选教育部强基计划和基础学科拔尖学生培养计划 2.0 基地；2020 年获批成立黑龙江应用数学中心。

在教育部第四轮学科评估中，哈尔滨工业大学数学学科位列 A-，统计学位列 B。在 2020 年 10 月《美国新闻和世界报导》(US News)发布的世界大学数学专业排名中，我校数学学科排名全球第 80 位，在内地高校 45 个机构中位于第 14 位。在 2021 年发布的世界大学学科排名（QS World University Rankings）中，我校数学学科排名全球第 126 位，在内地高校 36 个机构中位于第 8 位；统计学排名全球第 101-150 位，在内地高校 17 个机构中并列第 7 位。在最新的 ARWU 排名中，数学学科位列全球第 76-100 位，在内地高校 93 个机构中并列第 5 位。哈尔滨工业大学数学学科自 2013 年 5 月始终保持全球前 1%行列。