2023 International Conference on Mathematics and the Applications (Shenzhen)

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Shenzhen, China
October 18-23, 2023

深圳北理莫斯科大学计算数学与控制研究中心

Совместный научно-исследовательский центр вычислительной математики и управления МГУ-ППИ

2023 数学与应用国际会议（深圳）会议通知

尊敬的　　　　：

2023 数学与应用国际会议（深圳）将于 2023 年 10 月 19 日—23 日在广东深圳举行。19 日—21 日会场设在深圳北理莫斯科大学，22 日—23 日会场设在南方科技大学。本次会议由深圳北理莫斯科大学主办，南方科技大学杰曼诺夫数学中心、南方科技大学数学系共同举办。会议旨在交流数学与应用数学各研究方向的最新学术进展及其应用成果，展开广泛的学术交流和讨论。本次会议学术形式包括大会邀请报告、主题讨论会、论坛等。

热忱欢迎广大国内外从事数学与应用数学及相关领域研究的同行，踊跃参加本次会议。期待十月与您相会鹏城深圳！

现将本次会议有关事项通知如下：

1. 会议时间：2023 年 10 月 19 日—23 日，10 月 18 日报到。

2. 会议地点：深圳市

3. 会议报到地点：

报到地点：深圳北理莫斯科大学

地址：广东省深圳市龙岗区国际大学园路 1 号

4. 注册、食宿：本次会议不收取注册费，住宿将由主办方承担，用餐需自理。

深圳北理莫斯科大学

计算数学与控制研究中心

2023 年 10 月 16 日

第零天 (Day 0): 2023 年 10 月 18 日 星期三（Wednesday, Oct. 18, 2023）	
08:30-18:00	Registration
18:00-20:00	Icebreaker / TAB
20:00	Bus to Hotels
第一天 (Day 1): 2023 年 10 月 19 日 星期四（Thursday, Oct. 19, 2023） 深圳北理莫斯科大学 SMBU	
开幕式及合影 (Opening Ceremony & Group Photo) Chair: 施塔列夫 Shtarev D.S.	
9:00-10:15	Speech of Rector Hezhang Li / 李和章校长致辞
9:15-9:30	Speech of First Vice-rector Ivanchenko S.N. / 伊万琴科校长致辞
9:30-9:45	Speech of Ilin A.V. / 伊利英院士致辞
9:45-11:45	Other events + Acad. Kabanikhin S.I. (RAS, Novosibirsk) "Novosibirsk State University and the International Mathematical Center in Akademgorodok"
11:45-12:00	合影 / Group photo
12:00-14:00	午餐&讨论（Lunch & discussion）
会议下午场（Afternoon Session） 大会主席 Chair: 张晔 Ye Zhang	
14:00-14:50	Acad. Ilin A.V. (MSU&SMBU) "Inversion of the dynamical system with delay"
14:50-15:40	Prof. Shishlenin M.A. (Sobolev Institute of Mathematics) "Applied inverse problems for parabolic equations"
15:40-16:00	茶歇（Tea break）
16:00-16:50	Prof. Hui Liang (HIT Shenzhen) "A general collocation analysis for weakly singular Volterra integral equations with variable exponent"
16:50-17:40	Prof. Fomichev V.V. (MSU) "Definition of relative degree for MIMO systems"
18:00-20:00	晚餐&讨论（Dinner & discussion）

第二天 (Day 2): 2023 年 10 月 20 日星期五（Friday, Oct.20, 2023） 深圳北理莫斯科大学 SMBU	
会议上午场（Morning Session）大会主席 Chair: 布达克 Budak B.A.	
09:00-10:00	Acad. Tyrtyshnikov E.E. (MSU) “Tensor methods in mathematics and applications”
10:00-10:20	茶歇（Tea break）
10:20-11:10	Prof. Yuping Tian (Hangzhou Dianzi University) “Time synchronization over networks with random delays”
11:10-12:00	Prof. Jijun Liu (Southeast University/Nanjing Center for Applied Mathematics) “On the reconstruction of medium conductivity by integral equation method based on the Levi function”
12:00-14:00	午餐&讨论（Lunch & discussion）
会议下午场（Afternoon Session） 大会主席 Chair: 张晔 Ye Zhang	
14:00-14:40	Prof. Korolev V.Yu. (MSU) “Quasi-exponentiated normal random variables and their distributions”
14:40-15:20	Prof. Khokhlov Yu.S. (MSU) “On a family of multidimensional distributions with heavy tails”
15:20-16:00	茶歇（Tea break）
16:00-16:40	Prof. Shevtsova I.G. (MSU) “Convergence rate estimates of mixed Poisson random sums to normal variance-mean mixtures”
16:40-17:20	Prof. Zakharov V.A. (MSU) “Program obfuscation: 25 years of efforts”
17:20-18:00	Prof. Ye Zhang (SMBU) “Generalized asymptotical regularization for linear inverse problems”
18:00-20:00	晚餐&讨论（Dinner & discussion）

第三天(Day 3): 2023 年 10 月 21 日星期六（Saturday, Oct. 21, 2023） 深圳北理莫斯科大学 SMBU	
会议上午场（Morning Session）　大会主席 Chair: 布达克 Budak B.A.	
09:00-10:00	Acad. Vassilevski Yu.V. (MSU) “Diastolic state of reconstructed aortic valve: from mechanical experiment to surgery”
10:00-10:20	茶歇（Tea break）
10:20-11:10	Prof. Jun Hu (Beijing Institute of Technology) “KLR Algebras and Categorifications”
11:10-12:00	Prof. Hongyu Liu (City University of Hong Kong) “Spectral geometry of Neumann-Poincare operators and applications to localized resonances”
12:00-14:00	午餐&讨论（Lunch & discussion）
会议下午场（Afternoon Session）　大会主席 Chair: 张晔 Ye Zhang	
14:00-14:50	Prof. Rongfang Gong (Nanjing University of Aeronautics and Astronautics) “The coupled complex boundary methods for inverse problems of partial differential equations”
14:50-15:40	Prof. Lukyanenko D.V. (MSU) “Accounting for round-off errors when using gradient minimization methods in solving linear ill-posed problems”
15:40-16:00	茶歇（Tea break）
16:00-16:50	Prof. Fursov A.S. (MSU) “Some theoretical aspects of the neurocontrollers’ construction for the switched interval systems’ stabilization”
16:50-17:40	Prof. Hai Zhang (HKUST) “A Mathematical Theory of Computational Resolution Limit”
18:00-20:00	晚餐&讨论（Dinner & discussion）

第四天(Day 4): 2023 年 10 月 22 日星期日（Sunday, Oct. 22, 2023） 南方科技大学 SUSTech	
开幕式及合影 2 (Opening Ceremony and Group Photo) 大会主席 Chair: Kurganov A.A.	
09:20-09:30	Speech of Acad. Zelmanov E.I. (SUSTech)
09:30-10:00	合影&茶歇 / Group photo & Tea break
会议上午场（Morning Session） 大会主席 Chair: Kurganov A.A.	
10:00-11:00	Acad. Tao Tang (HKBU United International College) “Deep adaptive sampling for numerical PDEs”
11:00-11:50	Acad. Kabanikhin S.I. (RAS, Novosibirsk) “Inverse Problems: Theory and Numerics”
12:00-14:00	午餐&讨论（Lunch & discussion）
会议下午场（Afternoon Session） 大会主席 Chair: 李景治 Jingzhi Li	
14:30-15:20	Acad. Tyrtyshnikov E.E. (MSU) “Tensor methods in mathematics and applications”
15:20-16:10	Acad. Vassilevski Yu.V. (MSU) “Diastolic state of reconstructed aortic valve: from mechanical experiment to surgery”
16:10-16:40	茶歇（Tea break）
16:40-17:20	Prof. Kurganov A.A. (SUSTech) “Low-Dissipation Central-Upwind Schemes”
17:20-18:00	Prof. Bangti Jin (CUHK) “Conductivity Imaging using Deep Neural Networks”
18:00-20:00	晚餐&讨论（Dinner & discussion）

第五天(Day 5): 2023 年 10 月 23 日星期一（Monday, Oct. 23, 2023） 南方科技大学 SUSTech	
会议上午场（Morning Session） 大会主席 Chair: Kurganov A.A.	
10:00-11:00	Prof. Yanfei Wang (CAS) “Model-driven and data-driven inverse problems with applications”
11:00-12:00	Acad. Ilin A.V. (MSU&SMBU) “Inversion of the dynamical system with delay”
12:00-14:00	午餐&讨论（Lunch & discussion）
会议下午场（Afternoon Session） 大会主席 Chair: 李景治 Jingzhi Li	
14:00-14:50	Prof. KailiangWu (SUSTech) “Geometric Quasi-Linearization (GQL) for Bound-Preserving Schemes”
14:50-15:40	Prof. Korolev V.Yu. (MSU) “Quasi-exponentiated normal random variables and their distributions”
15:40-16:00	茶歇（Tea break）
16:00-16:50	Prof. Fomichev V.V. (MSU) “Definition of relative degree for MIMO systems”
18:00-20:00	晚餐&讨论（Dinner & discussion）

Convergence rate estimates of mixed Poisson random sums to normal variance-mean mixtures

Shevtsova I.G. (Lomonosov Moscow State University)

The class of normal variance-mean mixtures is very wide and contains, in particular, generalized hyperbolic and generalized variance gamma distributions, which proved be very adequate models of statistical data arising in plasma turbulence, meteorology, financial mathematics, and many other fields. In (Korolev, 2013) a limit theorem on convergence of distributions of random sums of independent identically distributed random variables was proved justifying the choice and explaining the high adequacy of normal variance-mean mixtures in the analysis of various statistical data. In the talk, estimates of the rate of convergence in this limit theorem will be presented.

Some theoretical aspects of the neurocontrollers' construction for the switched interval systems' stabilization

Fursov A.S. (Lomonosov Moscow State University)

The problem of stabilization of a switched interval linear system with slow switching unavailable for observation is considered. The solution is proposed to be found in the class of variable structure regulators. To ensure the operability of such a controller, it is necessary to build a switching signal observer. This report is devoted to some theoretical aspects related to the use of a neural network as such an observer.

Quasi-exponentiated normal random variables and their distributions

Korolev V.Yu. (Lomonosov Moscow State University)

In mid-80s of the past century Yu. V. Prokhorov suggested that the distributions of all odd powers of the normal random variable with zero mean belong to the class of normal scale mixtures. The validity of this suggestion was proved in the PhD thesis of E. Bagirov, PhD student of Yu. V. Prokhorov. However, the corresponding mixing distributions were not specified there.
Some recent results concerning the properties of normal mixtures and related topics made it possible to give an extended solution of Prokhorov's suggestion and more or less complete description of the mixture properties of the distributions of real powers of the normal random variables with zero mean. To be formally correct, we have to speak of `quasi-powers', since the normal random variables take values of both signs.
It is this description the present communication deals with.

Tensor methods in mathematics and applications

Tyrtyshnikov E.E. (Lomonosov Moscow State University)

Tensor decompositions have become a powerful tool for the treatment of multidimensional data. In the talk I plan to present a brief survey of modern tensor nethods and some recent achievments.

Definition of relative degree for MIMO systems

Fomichev V.V. (Lomonosov Moscow State University)

The problem of determining the relative order for linear MIMO-controlled systems is considered.

It is shown that the classical definition may not be shared. An algorithm for reducing the system to a form with relative order is proposed. A generalization of the concept of relative order to a hyper-output system (when the dimension of the output is greater than the dimension of the input) is proposed.

Inversion of dynamic systems with delay.

Ilin A.V. (Lomonosov Moscow State University & Shenzhen MSU-BIT University)

The problem of inversion of dynamic systems is one of the classical problems of the modern mathematical theory of automatic control. The problem of handling delays will be considered. The peculiarity of the problem formulation is that the delays will be assumed to be commensurate.

On a family of multidimensional distributions with heavy tails

Khokhlov Yu.S. (Lomonosov Moscow State University & Shenzhen MSU-BIT University)

The role of multidimensional normal distribution in many applied statistical studies is well known. This is due, in particular, to the fact that it has the following good properties. The density of this distribution is written out explicitly, which makes it possible to use the maximum likelihood method to estimate the parameters. Its characteristic function is also easily written out explicitly, which makes it easy to write out its numerical characteristics, for example, the average of each component and the covariance matrix. Any linear combination of coordinates will be a distribution of the same type. This makes it easy to find the distribution of a single coordinate, the distribution of the sum of coordinates, the conditional distribution of one coordinate provided for the sum of all coordinates. But the tails of such a distribution decrease very quickly, which is often not done in many specific tasks. In our report, we consider a certain family of multidimensional distributions that has all the properties listed above, but, unlike a multidimensional normal distribution, the tails of such distributions decrease in a power-law manner, i.e. they are heavy. Some variant of such family has been considered earlier. But our definition is more general and we investigate it using a new method when these distributions are considered both as densities and as characteristic functions at the same time. In addition, their close connection with limit distributions for multidimensional geometric random sums is shown.

Diastolic state of reconstructed aortic valve: from mechanical experiment to surgery

Vassilevski Yu.V. (Lomonosov Moscow State University)

Reconstruction of the heart valve from the patient's tissues is becoming an increasingly attractive surgical solution for patients with significant aortic stenosis or regurgitation of the aortic valve. During the operation, a part of the patient's pericardium (autopericardium) is cut out, it is chemically treated, new cusps are cut out of it according to the template of Dr. S. Ozaki and sewn into the position of the native aortic valve cusps. The template offers an excessive size of the valves, so optimizing the template based on CT images of the patient's heart before surgery will ensure the optimal diastolic condition of the valve for the patient and reduce the operation time by avoiding the procedure of measuring intercomissural distances. The personalized model of aortic valve closure should take into account the individual features of the anatomy of the patient's aortic root, the line of suturing of the cusps, as well as the variability of the mechanical properties of the treated autopericardium. It was previously shown that to study the characteristics of valve cusp coaptation, it is sufficient to simulate deformation of the aortic valve cusp under the action of diastolic pressure without taking into account blood flow.
The closed state of the reconstructed aortic valve can be calculated by both a membrane and a shell model of deformation of cusps consisting of any hyperelastic material. Both models show

approximately the same coaptation zones despite different billowings of the cusps, which is caused by different accounting of sewing the cusps to the aortic root.
Unfortunately, there is currently no sufficiently reliable experimental data even on the physiological average properties of the human pericardium (chemically untreated and processed). Therefore, the creation of a Medical Decision Support System for the reconstruction of the aortic valve by the Ozaki method requires a experimental study of the properties of the human pericardium. In the laboratory of experimental biomechanics at Sirius University, installations have been created for such studies.
A combination of biomechanical experiments, personalized mathematical models of the diastolic state of the aortic valve, advanced technologies for creating a graphical interface will allow us to develop a Medical Decision Support System for the reconstruction of the aortic valve by the Ozaki method.

Accounting for round-off errors when using gradient minimization methods in solving linear ill-posed problems

Lukyanenko D.V. (Lomonosov Moscow State University)

A method for taking into account rounding errors when constructing stopping criterion for the iterative process in gradient minimization methods in solving ill-posed problems will be discussed. The main motivation of the talk is the development of methods for improving the quality of solving real applied inverse problems, the solution of which requires significant amounts of calculations and, as a result, can be sensitive to accumulating rounding errors. However, the talk will also demonstrate that the developed approach can also be useful in solving computationally small problems. The main ideas of the talk will be demonstrated using one of the possible implementations of the conjugate gradient method for solving an overdetermined system of linear algebraic equations with a dense matrix.

A general collocation analysis for weakly singular Volterra integral equations with variable exponent

Hui Liang (Harbin Institute of Technology Shenzhen)

Piecewise polynomial collocation of weakly singular Volterra integral equations (VIEs) of the second kind has been extensively studied in the literature, where integral kernels of the form $(t-s)^{-\alpha}$ for some constant $\alpha \in (0,1)$ are considered. Variable-order fractional-derivative differential equations currently attract much research interest, and in Zheng and Wang SIAM J. Numer. Anal. 2020 such a problem is transformed to a weakly singular VIE whose kernel has the above form with variable $\alpha = \alpha(t)$, then solved numerically by piecewise linear collocation, but it is unclear whether this analysis could be extended to more general problems or to polynomials of higher degree. In the present paper the general theory (existence, uniqueness, regularity of solutions) of variable-exponent weakly singular VIEs is developed, then used to underpin an analysis of collocation methods where piecewise polynomials of any degree can be used. This error analysis is also novel — it makes no use of the usual resolvent representation, which is a key technique in the error analysis of collocation methods for VIEs in the current research literature. Furthermore, all the above analysis for a scalar VIE can be extended to certain nonlinear VIEs and to systems of VIEs. The sharpness of the theoretical error bounds obtained for the collocation methods is demonstrated by numerical examples.

Inverse Problems: Theory and Numerics

Kabanikhin (ICM&MG SB RAS, Novosibirsk State University)

In this talk, I will briefly review the basic mathematical theory of general inverse problems. I will also recall some conventional numerical algorithms for stable solution of ill-posed problems.

Applied inverse problems for parabolic equations

Shishlenin M.A. (ICM&MG SB RAS, Novosibirsk State University, Sobolev Institute of Mathematics SB RAS)

Currently, many papers have been published on the problem of finding the coefficients of parabolic equations in the case when the data of the inverse problem is given in the form of non-local information (integral in time or space) or the data is given on a given curve [1-3]. Similar inverse problems arise in heat transfer, thermoelasticity, non-destructive testing, chemical kinetics, medicine, sociology, etc.
In this talk, algorithms for solving coefficient inverse problems of parabolic equations based on the inversion method of the difference scheme and the gradient method are proposed. The results of numerical calculations are presented.
The work was carried out with the financial support of the Russian Foundation for Basic Research (project code 19-01-00694).
References
1. Cannon J.R., Rundell W. Recovering a Time Dependent Coefficient in a Parabolic Differential Equation // J. Math. Anal. Appl. 1991. V. 160. P. 572-582.
2. Ivanchov N.I. On the Determination of the Time-Dependent Leading Coefficient in a Parabolic Equation // Siberian Mathematical Journal. 1998. V. 39(3). P. 465-475.
3. Kabanikhin, S.I., Shishlenin, M.A. Recovering a Time-Dependent Diffusion Coefficient from Nonlocal Data. 2018. Numerical Analysis and Applications, 11(1). P. 38-44.

Time synchronization over networks with random delays

Yuping Tian (Hangzhou Dianzi University)

While the world is connected by different networks, many physical devices, such as computational units. sensors and actuators. are required to work cooperatively over distances with a synchronized clock. However, delays causing by time sensing and information transmission make the accurate clock synchronization impossible. Are there any limits on time synchronization over networks with random delays? We firstly present a unified structural model of consensus-based time synchronization(CBTS) algorithms. Then, we fit different but famous time synchronization algorithms. such as DCTS. ATSWMTS etc... into the same structural model with just different algorithm parameters. By studying the asymptotic limits of the relative drift estimation error of CBTS algorithms. we discover almost sure and mean-square divergence conditions of CBTS algorithms. Using these conditions we clearly point out that the most existing time synchronization algorithms are divergent, i.e.. error-accumulated, either almost surely, or in the mean-square sense. Finally, we provide a fundamental guideline for designing future time synchronization algorithms without error accumulation. Both numerical simulation and physical experiment results are presented to verify the theory.

On the reconstruction of medium conductivity by integral equation method based on the Levi function

Jijun Liu (Southeast University, Nanjing Center for Applied Mathematics)

Magnetic resonance electrical impedance tomography (MREIT) is a new technique to recover the conductivity of biologic tissue from the induced magnetic flux density. This talk proposes an inversion scheme for recovering the conductivity from one component of the magnetic field based on the nonlinear integral equation method. To apply magnetic fields corresponding to two incoherent injected currents, an alternative iteration scheme is proposed to update the conductivity. For each magnetic field, the regularizing technique on the finite dimensional space is applied to solve an ill-posed linear system. Compared with the well-developed harmonic Bz method, the advantage of this inversion scheme is its stability, since no differential operation is required on the noisy magnetic field. Numerical implementations are given to show the convergence of the iteration and its validity for noisy input data.

Generalized asymptotical regularization for linear inverse problems

Ye Zhang (Shenzhen MSU-BIT University)

We introduce Stochastic Asymptotical Regularization (SAR) methods for the uncertainty quantification of the stable approximate solution of ill-posed linear-operator equations, which are deterministic models for numerous inverse problems in science and engineering. We demonstrate that SAR can quantify the uncertainty in error estimates for inverse problems. We prove the regularizing properties of SAR with regard to mean-square convergence. We also show that SAR is an order-optimal regularization method for linear ill-posed problems provided that the terminating time of SAR is chosen according to the smoothness of the solution. This result is proven for both a priori and a posteriori stopping rules under general range-type source conditions. Furthermore, some converse results of SAR are verified. Some numerical examples are provided.

KLR Algebras and Categorifications

Jun Hu (Beijing Institute of Technology)

Hecke algebras play important role in the study of algebraic groups, finite groups of Lie type and Lie algebras. The KLR algebras (also named as quiver Hecke algebras) can be regarded as Z-graded analogues of Hecke algebras, which were introduced by Khovanov and Lauda, and by Rouquier, about 12 years ago. There have been considerable progress on the modular representation theory of Hecke algebras since the birth of KLR algebras. In this talk I shall give a survey on these progress with a focus on the theory of the cyclotomic Hecke algebras and cyclotomic KLR algebras of type A.

Spectral geometry of Neumann-Poincare operators and applications to localized resonances

Hongyu Liu (City University of Hong Kong)

In this talk, I shall discuss our recent discoveries on the geometric patterns of plasmon resonances, which form the fundamental basis for a series of cutting-edge applications including sensor technology, invisibility cloaking and super-resolution imaging. Two salient features of this resonance phenomenon are the boundary-localization and curvature-concentration. The study relies on certain novel spectral and geometric analysis of the Neumann-Poincare operators.

The coupled complex boundary methods for inverse problems of partial differential equations

Rongfang Gong (Nanjing University of Aeronautics and Astronautics)

In this talk, a coupled complex boundary method (CCBM) is proposed for an inverse source problem. With the introduction of imaginary unit, the CCBM transfers the original real problem to a complex one. The CCBM has several merits and is further improved. Also, the applications of the CCBM to bioluminescence tomography, inverse Cauchy problem etc. are delivered.

A Mathematical Theory of Computational Resolution Limit

Hai Zhang (The Hong Kong University of Science and Technology)

Resolving a linear combination of point sources from their Fourier data in a bounded domain is a fundamental problem in imaging and signal processing. With incomplete Fourier data and inevitable noise in the measurement, there is a fundamental limit on the separation distance between the point sources that can be resolved. This is the so-called resolution limit problem. Characterization of this resolution limit is still a long-standing puzzle despite the prevalent use of the classical Rayleigh limit. It is well-known that the Rayleigh limit is heuristic and its drawbacks become prominent when dealing with data that is subjected to elaborated processing, as is what modern computational imaging methods do. Therefore, a more precise characterization of the resolution limit becomes increasingly necessary with the development of data processing methods. For this purpose, we developed a theory of 'computational resolution limit' for both the number detection problem and the support recovery problem in one dimension in (Liu and Zhang 2019 arXiv:1912.05430; Liu and Zhang 2021 IEEE Trans. Inf. Theory 67 4812–27). In this talk, we extend the theory from dimension one to multiple dimensions. More precisely, we define and quantitatively characterize the computational resolution limit for the number detection problem and the support recovery problem respectively in general multi-dimensional spaces. Our results indicate that there exists a phase transition phenomenon regarding the super-resolution factor and the signal-to-noise ratio in each of the two recovery problems. Our main results are obtained by using a projection strategy. Finally, to verify the theory, we propose deterministic projection-based algorithms for the number detection problem and the support recovery problem respectively. The numerical results in dimensions two and three confirm the phase transition phenomenons.

Deep adaptive sampling for numerical PDEs

Tao Tang (Hong Kong Baptist University, United International College)

Adaptive computation is of great importance in numerical simulations. The ideas for adaptive computations can be dated back to adaptive finite element methods in 1970s. In this talk, we shall first review some recent development for adaptive method with applications. Then, we shall propose a deep adaptive sampling method for solving PDEs where deep neural networks are utilized to approximate the solutions. In particular, we propose the failure informed PINNs (FI-PINNs), which can adaptively refine the training set with the goal of reducing the failure probability. Compared to the neural network approximation obtained with uniformly distributed collocation points, the developed algorithms can significantly improve the accuracy, especially for low regularity and high-dimensional problems.

Conductivity Imaging using Deep Neural Networks

Bangti Jin (The Chinese University of Hong Kong)

Conductivity imaging from various observational data represents one fundamental task in medical imaging. In this talk, we discuss numerical methods for identifying the conductivity parameters in elliptic PDEs. Commonly, a regularized formulation consists of a data fidelity and a regularizer is employed, and then it is discretized using finite difference method, finite element methods or deep neural networks in practical computation. One key issue is to establish a priori error estimates for the recovered conductivity distribution. In this talk, we discuss our recent findings on using deep neural networks for this class of problems, by effectively utilizing relevant stability results.

Model-driven and data-driven inverse problems with applications

Yanfei Wang (Chinese Academy of Sciences)

In the early stage of geophysical inversion, single physical property is the main feature. Due to the limitation of a single geophysical method, the inversion results are not enough in accuracy and resolution to meet the needs of actual exploration and development. In recent years, we have comprehensively used various geophysical methods to study the same geological body from different perspectives. On the basis of single geophysical field inversion, we take the correlation between multiple physical parameters as a prior information, introduce the spatial structure coupling algorithm, and study the appropriate optimization inversion algorithm to improve the accuracy of inversion interpretation. In addition, we can further introduce big data and artificial intelligence analysis to achieve the further improvement of the accuracy of geophysical inverse problem solution, so as to achieve the goal of fully approaching the reality.

Geometric Quasi-Linearization (GQL) for Bound-Preserving Schemes

KailiangWu (Southern University of Science and Technology)

Solutions to many partial differential equations satisfy certain bounds or constraints. For example, the density and pressure are positive for equations of fluid dynamics, and in the relativistic case the fluid velocity is upper bounded by the speed of light, etc. As widely realized, it is crucial to develop bound-preserving numerical methods that preserve such intrinsic constraints. Exploring provably bound-preserving schemes has attracted much attention and has been actively studied in recent years. This is however still a challenging task for many systems especially those involving nonlinear constraints. Based on some key insights from geometry, we systematically propose a novel and general framework, referred to as geometric quasilinearization (GQL), which paves a new effective way for studying bound-preserving problems with nonlinear constraints. The essential idea of GQL is to equivalently transform all nonlinear constraints into linear ones, through properly introducing some free auxiliary variables. We establish the fundamental principle and general theory of GQL via the geometric properties of convex regions and propose three simple effective methods for constructing GQL. We apply the GQL approach to a variety of partial differential equations and demonstrate its effectiveness and advantages for studying bound-preserving schemes, by diverse challenging examples and applications which cannot be easily handled by direct or traditional approaches.