جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Agenda

KAUST Research Conference on Mathematical and Data Sciences

January 26-28, 2026

Speakers

Zhiming Chen
Cinese Academy of Sciences

James Demmel
University of California, Berkley

Jack Dongarra
University of Tennessee

Xingao Gong
Fudan University

Martin Grötschel
Technische Universität Berlin

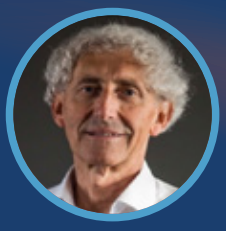
William Gropp
University of Illinois in Urbana-Champaign

Zhi-Quan (Tom) Luo
The Chinese University of Hong Kong, Shenzhen

Zhi-Ming Ma
Chinese Academy of Sciencess

Nader Masmoudi
New York University

Paul Milewski
The Pennsylvania State University



Alfio Quarteroni
Politecnico di Milano and EPFL

Jürgen Schmidhuber
King Abdullah University of Science and Technology

James Sethian
University of California, Berkley

Gang Tian
Peking University

Shuhong Wu
Research Institute of Petroleum Exploration and Development

Nanhua Xi
Chinese Academy of Sciences

Ya-xiang Yuan
Chinese Academy of Sciences

Xiaohua Zhou
Peking University

Overview

The conference brings together researchers from Saudi Arabia and around the world to share recent advances, foster collaboration, and promote scientific exchange and networking activities.

A central theme of the conference is the theory and applications of data science, emphasizing its strong connections to mathematics, scientific computing, computer science, and a wide range of interdisciplinary fields.

Organizing committee

Prof. Danielle Boffi
King Abdullah University of Science and Technology

Prof. Diogo Gomes
King Abdullah University of Science and Technology

Prof. Hussein Hoteit
King Abdullah University of Science and Technology

Prof. David E. Keyes (Co-chair)
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Prof. Rolf Krause
King Abdullah University of Science and Technology

Prof. Ying Wu
King Abdullah University of Science and Technology

Prof. Jinchao Xu (Co-chair)
King Abdullah University of Science and Technology

Prof. Ya-xiang Yuan
Chinese Academy of Sciences

Speakers
Bios and Talks

Zhiming Chen
Chinese Academy of Sciences

Zhiming Chen is a Professor of Mathematics in Academy of Mathematics and Systems Science of Chinese Academy of Sciences. His research focuses on developing numerical methods for solving partial differential equations with particular applications in computational electromagnetism and seismic imaging. He is an invited speaker of ICM in 2006 and an elected member of Chinese Academy of Sciences.

Talk:
Recent progress of high order finite element methods on arbitrarily shaped domains

We consider high-order unfitted finite element methods on Cartesian meshes with hanging nodes for elliptic interface problems, which release the work of body-fitted mesh generation and allow us to design adaptive finite element methods for solving curved geometric singularities. We will review the results for two-dimensional problems and introduce a new high order unfitted finite element method in threedimension that improves the numerical stability of high-order unfitted finite element methods on arbitrarily shaped smooth domains. This talk is based on joint works with Ke Li, Yong Liu, Maohui Liu and Xueshuang Xiang.

James Demmel
University of California, Berkeley

James Demmel is the Dr. Richard Carl Dehmel Distinguished Professor Emeritus of Computer Science and Mathematics at the University of California at Berkeley. Demmel's research is in high performance computing, numerical linear algebra, and communication avoiding algorithms. He is a member of the National Academy of Sciences, National Academy of Engineering, and American Academy of Arts and Sciences; a Fellow of the AAAS, ACM, AMS, IEEE and SIAM; and winner of the Charles Babbage Award, Sidney Fernbach Award, Paris Kanellakis Award, J. H. Wilkinson Prize in Numerical Analysis and Scientific Computing, and numerous best paper prizes.

Talk:
Communication avoiding algorithms, but not at the cost of accuracy!

Algorithms have two costs: arithmetic and communication, i.e. moving data between levels of a memory hierarchy or processors over a network. Communication costs (measured in time or energy per operation) greatly exceed arithmetic costs, so our goal is to design algorithms that minimize communication. We survey some known algorithms that communicate asymptotically less than their classical counterparts, for a variety of linear algebra and machine learning problems, often attaining lower bounds. We also discuss recent work on automating the design and implementation of these algorithms, and open problems. Finally, we discuss the impact of using low-precision GEMM accelerators to "emulate" conventional higher accuracy, and how to "grade" the accuracy of the resulting BLAS implementations.

Jack Dongarra
University of Tennessee

Jack Dongarra received a Bachelor of Science in Mathematics from Chicago State University in 1972 and a Master of Science in Computer Science from the Illinois Institute of Technology in 1973. He received his Ph.D. in Applied Mathematics from the University of New Mexico in 1980. He worked at the Argonne National Laboratory until 1989, becoming a senior scientist. He holds appointments at the University of Manchester (Turing Fellow), Oak Ridge National Laboratory, and the University of Tennessee (Distinguished Professor of Computer Science), where he founded the preeminent Innovative Computing Laboratory. In 2019 he received the ACM/SIAM Computational Science and Engineering Prize. In 2020 he received the IEEE-CS Computer Pioneer Award and, most recently, he received the 2021 ACM A.M. Turing Award for his pioneering contributions to numerical algorithms and software that have driven decades of extraordinary progress in computing

Talk:
HPC in transition

High-performance computing is entering a decisive transition driven by forces that are largely external to traditional scientific HPC. The economics of AI and hyperscale cloud now shape leading-edge silicon, system architectures, and software ecosystems, while energy and data movement have become the dominant constraints on performance, facility design, and long-term sustainability. This talk examines how these dynamics shift HPC's center of gravity from a primarily FP64, node-centric worldview toward accelerator-heavy, rack-scale, and workflow-defined systems.
We argue that the next era of scientific capability will be measured less by peak floating-point rates and more by time–energy–fidelity trade-offs across end-to-end pipelines. The most plausible path to "effective zettascale" is not brute-force FP64, but certified mixed-precision algorithms, communication-avoiding methods, AI-augmented reduced-order models, and hybrid AI+simulation workflows with rigorous error control and uncertainty quantification. We also outline an emerging reference architecture for platforms comprising integrated simulation, AI, and data/workflow partitions, linked and coordinated across multiple separate resources with secure cloud resources and instruments.

Xingao Gong
Fudan University

Dr. Xingao Gong is Chair Professor of Physics at Fudan University, Director of its Academic Committee, Fellow of the American Physical Society, and Academician of the Chinese Academy of Sciences. His research focuses on computational and AI-driven physics, spanning theoretical method development, low-dimensional structure modeling, and the computational design of novel materials.

Talk:
AI physics and materials design

Artificial intelligence has profoundly altered the development of the economy and society and revolutionized the paradigms of scientific research. In this talk, I will explore the impact of artificial intelligence on contemporary physics by discussing the main bottlenecks of computational physics. Based on our own research, I will introduce the latest progress in molecular dynamics methods and first-principles electronic structure calculations, especially the successfully constructed universal Kohn-Sham Hamitonian, and demonstrate how AI is changing the landscape of computational physics. Several examples will be presented to illustrate the efficiency and effectiveness of AI-based algorithms, especially in the field of material design.

Martin Grötschel
Technische Universität Berlin

Martin Grötschel's main areas of research are discrete mathematics, optimization, and operations research. He has made significant contributions to polyhedral combinatorics, the development of methods for proving the polynomial time solvability of optimization problems, and the design of practically efficient algorithms for hard combinatorial optimization problems appearing in practice. Cutting plane algorithms for integer programming are among his favorites. The application areas include telecommunications, chip design, energy, production planning and control, logistics, and public transport. He is currently involved in investigating mathematical aspects of the humanities, i.e., in fostering digital humanities.
Grötschel's scientific achievements were honored with several distinctions including the Fulkerson, the Dantzig, the Leibniz, the Beckurts, the John von Neumann Theory Prize, and the Cantor Medal. He holds four honorary degrees and is a member of seven scientific academies.
Martin Grötschel studied mathematics at U Bochum, he received his PhD in economics (1977) and habilitation in operations research (1981) at U Bonn. He was professor of applied mathematics at U Augsburg (1982-1991), professor of information technology at TU Berlin and vice president/president of the Zuse Institute for Information Technology Berlin (1991-2015). Grötschel chaired the German Mathematical Society (1993-1994), the DFG Research Center MATHEON "Mathematics for Key Technologies" (2002-2008),and the Einstein Foundation (2011-2015). He was Secretary General of the International Mathematical Union (2007-2014) and President of the Berlin Brandenburg Academy of Sciences and Humanities (2015-2020).

Talk:
On the mutual fertilization of theory, applications, and experiments in mathematics: My experiences!

Academic research seeks to deepen our understanding of the world and to improve everyday life. But who defines the goals, how is research initiated, and how does mathematical research actually evolve? After more than fifty years in academia, I have arrived at a personal conclusion: meaningful research and the formulation of its goals arise from a subtle interplay of curiosity, abstract reasoning, practical applications, and carefully designed experiments. When these elements interact productively, they become a powerful source of inspiration, often leading to profound insights and tangible successes in practice. Chance, too, plays its part.
In this lecture, I will share experiences—surprising, rewarding, and at times disappointing—from interdisciplinary and collaborative projects in which I have been involved. These span a wide range, from theoretical work in geometry, convexity, combinatorics, numerical analysis, and optimization, to the design, complexity analysis, and implementation of algorithms, and further to applications in telecommunications, gas pipeline networks and VLSI design, public transportation, logistics, healthcare, physics, and manufacturing. I will outline these applications, reflect on their contributions to theoretical development, and illustrate how theory, in turn, impacts and shapes real-world practice.

William Gropp
University of Illinois in Urbana-Champaign

William Gropp is a professor in the Siebel School of Computing and Data Science and holds a Grainger Distinguished Chair in Engineering at the University of Illinois in Urbana-Champaign. He received his Ph.D. in Computer Science from Stanford University in 1982 and worked at Yale University and Argonne National Laboratory. His research interests are in parallel computing, software for scientific computing, and numerical methods for partial differential equations. He was Director of the National Center for Supercomputing Applications from 2016-2025. He chairs the Computing Community Consortium for the Computing Research Association. He is a Fellow of AAAS, ACM, IEEE, and SIAM and a member of the National Academy of Engineering and has received numerous awards for his work in HPC.

Talk:
Using performance engineering to navigate the revolution in computing

The end of Dennard or frequency scaling in computer processors nearly twenty years ago has caused a transformation in computing. Innovations in computer architecture have enabled continued improvements in performance, but at the cost of increasing software and algorithmic complexity. Software has also undergone major transformations, making it both easier and harder to exploit the changes in hardware. This talk will provide some background on the transformations in computing over the last two decades, how the National Center for Supercomputing Applications has adapted to these changes, and how performance engineering can help guide the developments of algorithms and applications in this rapidly changing environment.

Zhi-Quan (Tom) Luo
The Chinese University of Hong Kong, Shenzhen

Zhi-Quan (Tom) Luo (Fellow, IEEE and SIAM) received the B.S. degree in Applied Mathematics from Peking University and the Ph.D. degree in Operations Research from the Massachusetts Institute of Technology (MIT) in 1989. From 1989 to 2003, he was on the faculty of the Department of Electrical and Computer Engineering at McMaster University, Canada, where he held a Tier-1 Canada Research Chair in Information Processing (2001–2003). He subsequently joined the University of Minnesota as a Full Professor and the endowed ADC Chair in Digital Technology. Currently, He is Vice President (Academic) at The Chinese University of Hong Kong, Shenzhen, and serves as the Director of the Shenzhen Research Institute of Big Data (SRIBD) and Executive Dean of the Shenzhen Loop Area Institute (SLAI). Professor Luo was elected a Fellow of the Royal Society of Canada in 2014 and a Foreign Member of the Chinese Academy of Engineering in 2021. His honors include four IEEE Signal Processing Society Best Paper Awards, a EUSIPCO Best Paper Award, the 2020 ICCM Best Paper Award, the Farkas Prize from INFORMS, the Paul Y. Tseng Memorial Lectureship Prize, the inaugural CSIAM Wang Xuan Applied Mathematics Prize (2022), the Shenzhen Science and Technology Progress Award (First Class, 2023), and the Hua Prize (2025). He served as Editor-in-Chief of the IEEE Transactions on Signal Processing (2012–2014) and as an Associate Editor for several leading journals.
In 2020, Professor Luo pioneered a data-driven approach to network optimization that integrates statistical network models with artificial intelligence. This methodology has been deployed in more than 30 countries to optimize 1.8 million base stations, improving wireless network performance for roughly one quarter of the global population while substantially reducing operators' costs and carbon emissions, thereby delivering significant economic and societal impact worldwide.

Talk:
Algorithm design automation

This talk addresses the challenge of designing and optimizing algorithms under strict computational and memory constraints, with applications spanning massive MIMO systems, wireless communication, and large-scale AI training. Beginning with a finite-horizon optimization perspective, we review classical gradient descent, its limitations with constant step sizes, and optimal finite-step schemes derived from Chebyshev minimax polynomials. We then present recent advances in matrix multiplication, including AI-discovered state-of-the-art algorithms for structured products such as XX^T, achieving notable speedups and energy savings over recursive Strassen methods in both CPU and GPU settings. The discussion extends to assessing large language models' (LLMs) capabilities in mathematical reasoning and novel problem solving, highlighting cases where LLM-assisted approaches led to breakthroughs. Finally, we introduce AlphaEvolve, a code-space search framework for automated algorithm discovery, demonstrating its success in improving long-standing algorithmic bounds and generating efficient CUDA kernels. The talk concludes with potential future directions, including new algorithms for causal attention, constrained SVD, and advanced GPU kernels.

Zhi-Ming Ma
Chinese Academy of Sciences

Zhi-Ming Ma is a Professor of the Academy of Math and Systems Science of CAS, Founding Dean of the School of Mathematical Sciences at the University of Science and Technology of China, and Founding Dean of the School of Statistics and Data Science at Nankai University.
His major research area is Probability and Statistics. He has made important contributions in the theory of Markov processes and Dirichlet forms. He joint with his co-authors found a new framework of quasi-regular Dirichlet forms which corresponds to right processes in one-to-one manner. This result completes a twenty years old problem in the area. The framework of quasi-regular Dirichlet forms has been used e.g. in the study of infinite dimensional analysis, quantum field theory, the theory of Markov processes, and others. Their book 'An Introduction to the Theory of (Non-symmetric) Dirichlet Forms' has been a major reference book in the area. In Malliavin calculus Zhi-Ming Ma with his co-authors proved that the capacities of Wiener spaces are invariant under the change of Gross measurable norms. This result settled the problem concerned respectively by Prof. P. Malliavin (founder of Malliavin calculus, Academician of French Academy) and Prof. K. Ito (founder of Ito integral, Wolf Prize winner) and is of basic for the invariance of Malliavin Calculus. He has obtained also other important results concerning the Schroediner equations, Feynman-Kac semi-groups, Charatheodory-Finsler manifolds, Nowhere Radon smooth measures, Super processes of stochastic flows, reflected Symmetric Stable Processes, boundary problems for fractional Laplacians, and others. One of Prof. Ma's earlier important contributions was his proof of the probabilistic representation of mixed boundary problems of Schroedinger operators. In this work he solved an open problem posed by the prominent probabilist Kailai Chung.
Being recognized for his contributions, Prof. Ma delivered an invited talk at the International Congress of Mathematicians (ICM) in 1994. He was awarded Max-Planck Research Award, the First Class Prize for Natural Sciences of CAS, the Chinese National Natural Sciences Prize, the Shing-Shen Chern Mathematics Prize, the Hua Loo-Keng Mathematics Prize, and other academic prizes.
Professor Ma was elected an Academician of the Chinese Academy of Sciences in 1995, a Fellow of the World Academy of Sciences (TWAS) in 1998, and a Fellow of the Institute of Mathematical Statistics (IMS) in 2007.
He has also held some academic leadership positions, including Chairman of the Organizing Committee of the 24th International Congress of Mathematicians, Vice President of the Executive Committee of the International Mathematical Union (IMU), and two terms as President of the Chinese Mathematical Society.

Talk:
Polar codes and AI for SPDE

In this talk I shall introduce some of our recent research outputs, including research on 5G polar codes and research on AI-enabled solutions to stochastic partial differential equations.

Nader Masmoudi
New York University

Nader Masmoudi received his BS in Mathematics from the École Normale Supérieure Paris in 1996, his PHD from Paris Dauphine University in 1999 and his HDR in 2000. He was a CNRS researcher from 1998 till 2000. Since 2000, he is a Professor at the Courant Institute of Mathematical Sciences at New York University. He is currently spending few years at NYUAD in Abu Dhabi as an affiliated faculty where he is the director of the center Stability, Instability and weak turbulence. His research lies in the iterface between fluid mechanics, partial differential equations and dynamical system. His honors include a gold medal at the International Mathematic Olympiads in 1992, a Sloan Fellowship from 2001 to 2003, a Senior Clay Math Scholar in 2014, a chair of excellence from the Foundation Sciences Mathématiques de Paris from 2016 to 2018, a chair position from the Institut des hautes études scientifiques in Paris from 2018 to 2020. He was the recipient of the Fermat prize in 2017, of the Kuwait prize in 2019 of the King Faisal Prize in Sciences in 2022. He was elected to the the American Academy of Arts and sciences in 2021.

Talk:
Nonlinear inviscid damping

Inviscid damping refers to the long-time decay of velocity perturbations in an ideal fluid, even though there's no viscosity to dissipate the energy. This phenomenon is similar to the Landau damping in plasma physics. We review some old results and give some more recent advances about nonlinear inviscid damping. In particular, we will discuss the extension of the original result to more general shear flows. We will also discuss the optimality of the regularity spaces involved in some results by showing instability constructions. Joint results with J. Bedrossian, Yu Deng, Weiren Zhao.

Paul Milewski
The Pennsylvania State University

Dr. Paul Milewski is a Professor and Department Head in the Department of Mathematics at Penn State University. He received his B.Sc. and M.Sc. in Aerospace Engineering at Boston University and his Ph.D. (1993) from Mathematics at M.I.T. Prior to joining Mathematics at Penn State in 2023, he had positions in the Departments of Mathematical Sciences at the University of Bath (UK, 2011-2023), and in Mathematics at Wisconsin-Madison (1995-2011) and at Stanford. He has held visiting positions, among others, at IMPA (Brazil) and ENS (France). He was recipient of a Royal Society Wolfson Fellowship and a Sloan Fellowship. His research is in applied and computational mathematics, mainly in nonlinear waves in fluids, but also with interests across mathematical modeling of physical and biological systems, and data science.

Talk:
Unexpected resonance behavior for nonlinear waves in fluids

We discuss 2 problems where resonances yield unexpected results in fluids. One problem concerns whether certain solitary waves exist in stratified flows (such as the ocean). Based on physical intuition, this type of solitary wave is not expected to exist because of the dissipative effects of energy radiation. However, we show that such waves do exist at particular (discrete) amplitudes. A second problem concerns surface gravity waves in a cylindrical container. This is a classic problem, and conventional wisdom is that resonances between 3 waves (triad resonances) are impossible, perhaps because they do not exist in unbounded problems and in rectangular domains. We give a complete characterization of the generic character of such resonances in arbitrary cross-sectional cylinders, given the spectrum of the Laplacian on its cross-section. This demonstrates how boundaries can alter fundamental nonlinear wave resonance properties and how non-sinusoidal eigenfunctions play a critical role.

Alfio Quarteroni
Politecnico di Milano and EPFL

Alfio Quarteroni is an Emeritus Professor at Politecnico di Milano and at EPFL, Lausanne. He is the founder of MOX at Politecnico di Milano. Quarteroni is a member of several prestigious academies, including the Accademia Nazionale dei Lincei, the European Academy of Sciences, the Academy of Europe, the Lisbon Academy of Sciences, and the Italian Academy of Engineering and Technology. He has authored 25 books and more than 450 research papers. Quarteroni has been honored with numerous awards, including the NASA – Group Achievement Awards (1992), the Galilean Chair from Scuola Normale Superiore in 2011, the International Galileo Galilei Prize for Sciences in 2015, the ECCOMAS Euler Medal in 2022, the ICIAM Lagrange Prize in 2023, the Blaise Pascal Prize for Mathematics in 2024, the ECCOMAS Ritz-Galerkin medal in 2024, the SIAM Ralph Kleinman Prize in 2025. His research spans applications in medicine, earthquake geophysics, environmental science, aeronautics, and the oil industry. He led the mathematical modeling for the design of Alinghi, the Swiss yacht that won the America's Cup in 2003 and 2007, and developed the first comprehensive mathematical model of the human heart.

Talk:
Scientific machine learning for the iHeart simulator

Recent advances in artificial intelligence have led to remarkable achievements across a broad spectrum of applications. Despite these successes, persistent concerns remain regarding the accuracy, robustness, and interpretability of AI models, which are often criticized as opaque “black boxes.” Scientific Machine Learning (SciML) has emerged as a powerful alternative paradigm, combining data-driven techniques with models informed by physical laws, thereby creating a principled bridge between artificial intelligence and traditional scientific modeling. In this presentation, I will briefly discuss some of the theoretical properties as well as the intrinsic limitations of machine learning. I will then focus on Scientific Machine Learning, illustrating how incorporating prior physical knowledge of the underlying processes can significantly enhance the reliability, interpretability, and performance of numerical solvers. This paradigm plays a key role in the development of Digital Twins—high-fidelity numerical replicas of real-world systems—across a wide range of scientific and engineering applications. As a central case study, I will present recent advances in the numerical simulation of human cardiac function.

Jürgen Schmidhuber
King Abdullah University of Science and Technology

The New York Times headlined: "When A.I. Matures, It May Call Jürgen Schmidhuber 'Dad'." In 1990-91, he laid foundations of Generative AI, by introducing the principles of Generative Adversarial Networks (now used for deepfakes), unnormalised linear Transformers (see the T in ChatGPT), self-supervised Pre-Training for deep learning (see the P in ChatGPT), and neural network distillation (essential for the famous DeepSeek). His lab also produced LSTM, the most cited AI of the 20th century, and the Highway Net (a variant of which is the most cited AI of the 21st century). He also pioneered meta-learning machines that learn to learn (1987-), and neural AIs that set themselves their own goals (1990-). His formal theory of creativity & curiosity & fun (2006-2010) explains art, science, music, and humor. He also generalized algorithmic information theory and the many-worlds theory of physics (1997-2000). Elon Musk tweeted: "Schmidhuber invented everything." His AI is on billions of smartphones, and used many billions of times per day.

Talk:
Falling Walls, WWW, modern AI, and the future of the universe

Around 1990, the Cold War ended, the WWW was born at CERN, the first smartphones were created, self-driving cars appeared in traffic, and modern AI based on very deep artificial neural networks emerged, including the principles behind the G, P, and T in ChatGPT. I place these events in the history of the universe since the Big Bang, and discuss what's next: not just AI behind the screen in the virtual world, but real AI for real robots in the real world. Intelligent (but not necessarily super-intelligent) robots that can learn to operate the tools and machines operated by humans can also build (and repair when needed) more of their own kind. This will culminate in life-like, self-replicating and self-improving machine civilisations, which represent the ultimate form of upscaling, and will shape the long-term future of the entire cosmos. The wonderful short-term side effect is that our AI will continue to make people's lives longer, healthier and easier.

James Sethian
University of California, Berkley

James Sethian is Professor of Mathematics and James Simons Chair at the University of California Berkeley, the Directory of The Center for Advanced Mathematics for Energy Research Applications (CAMERA), and the Head of the Mathematics Department at the Lawrence Berkeley National Laboratory. He has made contributions to mathematics and algorithms for complex interface dynamics for multiscale multiphase physics, including level set methods, narrow band level set methods, fast marching methods, escape arrival methods, and Voronoi Implicit Interface Methods. Applications of his work span process modeling for the semiconductor industry, industrial inkjet plotters for the microfluidics industry, rotary bell dynamics for the automotive industry, seismic migration for secondary oil recovery, and mixing dynamics for combustion simulations, as well as across materials science. He is a member of the US National Academy of Sciences and the US National Academy of Engineering.

Talk:

Advances in advancing interfaces: The mathematics of manufacturing of industrial foams, fluidic devices, and automobile painting

Complex dynamics underlying industrial manufacturing depend in part on multiphase multiphysics, in which fluids and materials interact across orders of magnitude variations in time and space. In this talk, we will discuss the development and application of a host of numerical methods for these problems, including Level Set Methods, Voronoi Implicit Interface Methods, implicit adaptive representations, and multiphase discontinuous Galerkin Methods. Applications for industrial problems will include modeling how foams evolve, how electro-fluid jetting devices work, and the physics and dynamics of rotary bell spray painting across the automotive industry.

Gang Tian
Peking University

Dr. Gang Tian has made fundamental contributions to geometric analysis, complex geometry and symplectic geometry. He did his undergraduate study at Nanjing University in China, received his MS at Peking University and PhD at Harvard University. He was a professor at Courant Institute of NYU, a Simons professor at MIT and a Higgins professor at Princeton University. He is now a Chair Professor of Peking University. And he has been the director of Beijing International Center for Mathematical Research (BICMR) since 2005. He served as a Member of the IMU Executive Committee from 2019 to 2022, and as President of the Chinese Mathematical Society from 2020 to 2023.

Dr. Gang Tian solved completely the existence of Kahler-Einstein metrics on compact complex surfaces with positive first Chern class. He proved that the deformation of Calabi-Yau manifolds is unobstructed, now known as the Bogomolov–Tian–Todorov theorem. Together with Ruan, he established a mathematical theory for quantum cohomology and Gromov-Witten invariants on semi- positive symplectic manifolds which include any symplectic manifolds of dimension 3 and Calabi-Yau spaces. He was also one of pioneers in constructing virtual cycles and consequently constructed the Gromov-Witten invariants for any closed symplectic manifolds. He developed a compactness theory for high dimensional Yang-Mills fields and found a deep connection between high dimensional gauge fields and calibrated geometry. He introduced the K-stability which has been further developed and become a central topic in the theory of geometric stability. He initiated the Analytical Minimal Model program through Kahler-Ricci flow, known as Tian-Song MMP theory in complex geometry. Together with J. Morgan, amongst others, Dr. Gang Tian played a very important role in the solution of Poincaré Conjecture and Thurston's Geometrization Conjecture. He gave a complete solution for the Yau-Tian-Donaldson's conjecture, a central conjecture in Kahler geometry. His solution follows the approach he proposed before. Together with J. Streets, he introduced new geometric flows and found their connection to the duality in the superstring theory.

Dr. Gang Tian won Alan T. Waterman Award in 1994 and Veblen Prize in 1996. He spoke twice at the International Congress of Mathematics in 1990 and 2002. He was elected to the National Academy of China in 2001 and the American Academy of Arts and Science in 2004.

Talk:

Counting algebraic curves in complex plane

In this talk, I will discuss a classical problem in enumerative geometry and its connections to current research in mathematics. This problem concerns counting curves in complex plane and quantum cohomology of symplectic spaces. In the end, I will give a brief introduction on our program on AI4M at BICMR.

Shuhong Wu
Research Institute of Petroleum Exploration and Development

Wu Shuhong, PhD, Professor reservoir engineer, Deputy Director of AI Research Center of PetroChina；Committee Member of CSiam Big Data and AI Technologies and Society of Computational mathematics (Beijing), Experienced in oil & gas field development plan design Contributed in developing reservoir simulator HiSim and HiSimPro of PetroChina with extensive experiences in complex reservoir fluid modelling and advanced computational simulation technologies. Experienced in big data and AI technologies in oil & gas industrial, especially in reservoir characterization, production forecast and FDP optimization, and also, couple physical laws with AI, especially in reservoir numerical simulation. Published more than 100 scientific papers, conference articles and technical reports in the areas of reservoir simulation, CO2 EOR application, and AI for science in general.

Talk:

AI-assisted reservoir simulation: Drive oil & gas production more efficient and more intelligent

In petroleum industry, reservoir simulation is a key tool to modeling complex fluid flow in the oil & gas reservoir, widely applied in reservoir characterization, production forecast and field development plan (FDP) optimization. This topic will detail the core simulation technologies including complex fluid modelling (both conventional and compositional modelling), cloud-based parallel computing, and other advanced computational simulation methods. It will also focus on AI innovations in reservoir simulation, such as intelligent history matching, and PINN-based intelligent proxy models.

Nanhua Xi
Chinese Academy of Sciences

Nanhua Xi is a Professor at the Academy of Mathematics and Systems Science, Chinese Academy of Sciences (Beijing, China). His research focuses on the representation theory of algebraic groups and quantum groups. He received his PhD in 1988 from East China Normal University (Shanghai) and has been with AMSS, CAS since 1988, where he has served as a postdoctoral fellow, assistant and associate professor, and has been a full professor since 1994; he also served as President from July 2017 to November 2022. He has held visiting positions at the Institute for Advanced Study (Princeton), the Max Planck Institute for Mathematics (Bonn), IHES (Bures-sur-Yvette), and RIMS (Kyoto University). He was elected a Member of the Chinese Academy of Sciences in 2009.

Talk:

Some computational problems in representation theory of algebraic groups over fields of positive characteristics

A challenging problem in representation theory of algebraic groups over fields of positive characteristics is to understanding rational irreducible modules of simple algebraic groups over an algebraically closed field of positive characteristic. For characters of these irreducible modules, when the characteristic of the filed is large enough, Lusztig's conjeture has been proved to be true. When the characteristic of the filed is samll, the characters of these irreducible modules are much less understood. Moreover, in any case, it is difficult to get information on bases of these irreducible modules, even for type A2. In this talk, we will present an approach to compute the bases of these irreducible modules, especially for low rank cases.

Ya-xiang Yuan
Chinese Academy of Sciences

Ya-xiang Yuan is a professor at the Academy of Mathematics and Systems Science, Chinese Academy of Sciences. He graduated from Xiangtan University in 1982, and obtained his Ph.D. from Cambridge University in 1986.
He mainly works on numerical methods for nonlinear optimization, he has made outstanding contributions to trust region algorithms, quasi-Newton methods, nonlinear conjugate gradient methods and subspace methods. He gave a plenary lecture at ICIAM 1999, and an invited lecture at ICM-2014. He won numerous awards, including Fox Prize (London, 1985), National Natural Science Award(2nd grade, Beijing 2006), Shiing S. Chern Award of CMS(Beijing, 2011), TWAS Prize of Mathemtaics (2014), Su Buqing Prize of CSIAM(Beijing, 2016), Ho Leung Ho Lee Prize (Beijing, 2016) and SIAM Prize for Distinguished Service to the Profession(Pittsburg, 2017).

Talk:
Optimization on product manifolds under a preconditioned metric

Since optimization on Riemannian manifolds relies on the chosen metric, it is appealing to know how the performance of a Riemannian optimization method varies with different metrics and how to exquisitely construct a metric such that a method can be accelerated. To this end, we propose a general framework for optimization problems on product manifolds endowed with a pre-conditioned metric, and we develop Riemannian methods under this metric. Generally, the metric is constructed by an operator that aims to approximate the diagonal blocks of the Riemannian Hessian of the cost function. We propose three specific approaches to design the operator: exact block diagonal preconditioning, left and right preconditioning, and Gauss--Newton type preconditioning. Specifically, we tailor new preconditioned metrics and adapt the proposed Riemannian methods to the canonical correlation analysis and the truncated singular value decomposition problems, which provably accelerate the Riemannian methods. Additionally, we adopt the Gauss-Newton type pre-conditioning to solve the tensor ring completion problem. Numerical results among these applications verify that a delicate metric does accelerate the Riemannian optimization methods. Joint work with B. GAO and R.F. Peng.

Xiaohua Zhou
Peking University

Xiaohua Zhou is a Distinguished Professor in the Overseas High-Level Talent Recruitment Programs of China and the Chair of the Department of Biostatistics at Peking University. He also holds the PKU Endowed Chair Professor in the Beijing International Center for Mathematical Research and is Vice Dean of Peking University Chongqing Research Institute for Big Data. He is currently Presendent of the International Biometric Society China and President of the Medical Mathematics Professional Committee of the Chinese Mathematical Society.
Professor Zhou is an elected Fellow of the American Association for the Advancement of Science (AAAS), the American Statistical Association (ASA), and the Institute of Mathematical Statistics (IMS). He serves as Editor-in-Chief of Biostatistics & Epidemiology, the official journal of IBS-China, and has authored or co-authored more than 300 SCI papers in leading international statistical and biostatistical journals. His research focuses on statistical methods in diagnostic medicine, clinical trial design, causal inference, and AI in medicine.
He has received numerous awards including the Mitchell Prize from the International Society for Bayesian Analysis and the American Statistical Association, the Distinguished Overseas Young Scientist Award from the National Natural Science Foundation of China, and the Research Career Scientist Award from the U.S. Department of Veterans Affairs. Professor Zhou also served on the Medical Devices and Radiological Health Advisory Committee of the U.S. Food and Drug Administration (FDA). He currently serves on the Advisor Committee of the National Medical Products Administration (NMPA) Center for Medical Device Evaluation.

Talk:

Causal statistical/machine learning in complex scenarios

In this talk, I introduce some new mathematical and statistical methods for causal statistical learning in complex scenarios. Specifically, I first discuss the causal learning methods for recommendation systems, then discuss the methods for making causal learning when the outcome has a network structure. Next, I discuss the methods for dealing with interference in causal learning, as well as how to make causal inferenvce with intercurrent events. Finally, I introduce some causal learning methods in large language models (LLM).

Panel-Enabled Discussion:

Genesis, AI+, and HUMAIN: Prospects for International Collaboration in Scientific Machine Learning?

2025 saw ambitious AI goals expressed in new national agendas: the Genesis Mission, with the goal to double scientific productivity in 10 years using AI, was launched in the USA; China embarked on the AI+ initiative, aimed at industrial transformation and a fully AI-powered economy by 2035; and Saudi Arabia announced HUMAIN to help power its ambition to be the world's third-ranked AI provider.

These and related initiatives around the globe promise scientific discovery, technological advance, and societal transformation. In delivering on these promises, their researchers in academia are accustomed to open exchange and low barriers. At the same time, these initiatives reflect differing national approaches to large-scale investment in AI-enabled science and technology.

Our panel-enabled group discussion, with researchers from around the globe in conversation, is to understand the evolving structure, foci, and magnitudes of these and other national initiatives for AI in science and technology, to compare them, and to examine opportunities for mutually beneficial research given current policy, institutional, and resource environments. We also want to subject these initiatives to strategic critiques concerning their emphasis on the scale of computational facilities, compared with investment in new algorithmic approaches.

Moderator:
David Keyes, KAUST

Panelists:
William Gropp, University of Illinois at Urbana-Champaign
Zhi-Quan (Tom) Luo, The Chinese University of Hong Kong at Shenzhen
Jürgen Schmidhuber, KAUST

Program

Venue: Talks and panel discussions will be held in the Auditorium (between Building 2 & 3).
Breakfast: Served daily from 08:00–08:30 (Jan 26–28) at the same venue as above.

25.01 Sunday

12:00-18:00	Registration (Location: Al Khozama Hotel)
	A light lunch (12:00) will be provided in the hotel lobby.
18:00-20:00	Reception (Location: Al Khozama Hotel lobby)

26.01 Monday

08:30-08:50	Opening: President **Sir Edward Byrne AC**, Vice President **Omar Knio**	Chair: **Jinchao Xu**
08:50-09:35	**Martin Grötschel**: On the mutual fertilization of theory, applications, and experiments in mathematics: My experiences!	
09:35-10:00	Group Photo	
10:00-10:30	Coffee break	
10:30-11:15	**Ya-xiang Yuan**: Optimization on product manifolds under a preconditioned metric	
11:15-12:00	**Nanhua Xi**: Some computational problems in representation theory of algebraic groups over fields of positive characteristics	
12:00-13:30	Lunch (Location: Campus Dining Hall)	
13:30-14:15	**Jack Dongarra**: HPC in transition	Chair: **David Keyes**
14:15-15:00	**William Gropp**: Using performance engineering to navigate the revolution in computing	
15:00-15:45	**Zhiming Chen**: Recent progress of high-order finite element methods on arbitrarily shaped domains	
15:45-16:15	Coffee break	
16:15-17:30	**Panel Discussions**: Genesis, AI+, and HUMAIN: Prospects for international collaboration in scientific machine learning? Moderator: **David Keyes** Panelists: **William Gropp**, **Zhi-Quan (Tom) Luo**, **Jürgen Schmidhuber**	
18:00-20:00	Gala Dinner (Location: Al Marsa, by invitation)	

27.01 Tuesday

08:30-09:15	**James Demmel**: Communication avoiding algorithms, but not at the cost of accuracy!	Chair: **Daniele Boffi**
09:15-10:00	**James Sethian**: Advances in advancing interfaces: The mathematics of manufacturing of industrial foams, fluidic devices, and automobile painting	
10:00-10:30	Coffee break	
10:30-11:15	**Paul Milewski**: Unexpected resonance behavior for nonlinear waves in fluids	Chair: **Ying Wu**
11:15-12:00	**Xiaohua Zhou**: Causal statistical/machine learning in complex scenarios	
12:00-13:30	Lunch (Location: Campus Dining Hall)	
13:30-14:15	**Xingao Gong**: AI physics and materials design	Chair: **Rolf Krause**
14:15-15:00	**Jürgen Schmidhuber**: Falling Walls, WWW, modern AI, and the future of the universe	
15:00-16:30	Coffee break & Poster Session (Location: Library)	
16:30-17:30	Musical Soirée (Location: Library)	
18:00-20:00	Dinner (Location: Library, by invitation)	

28.01 Wednesday

08:30-09:15	**Gang Tian**: Counting algebraic curves in complex plane	Chair: **Diogo Gomes**
09:15-10:00	**Nader Masmoudi**: Nonlinear inviscid damping	
10:00-10:30	Coffee break	
10:30-11:15	**Alfio Quarteroni**: Scientific machine learning for the iHeart simulator	Chair: **Hussein Hoteit**
11:15-12:00	**Shuhong Wu**: AI-assisted reservoir simulation: Drive oil & gas production more efficient and more intelligent	
12:00-13:30	Lunch (Location: Campus Dining Hall)	
13:30-14:15	**Zhi-Ming Ma**: Polar codes and AI for SPDE	Chair: **Ya-xiang Yuan**
14:15-15:00	**Zhi-Quan (Tom) Luo**: Algorithm design automation	
15:00-16:00	Campus tour. Badr Mesha	
16:00-18:00	Ocean Activity & Cruise Dinner (Location: Yacht club, by invitation)	
18:00-20:00	Dessert Party (Location: I-552M, by invitation)	

Poster session

Sameh Abdulah (KAUST, Senior Research Scientist)
Title: Federation beyond ML: rethinking spatial modeling for distributed data science

Mofdi El Amrani El Anjoumi (Abdelmalek Essaâdi University, Professor)
Title: A NURBS-based isogeometric Lagrange–Galerkin method for convection–diffusion problems

Lisa Gaedke-Merzäuser (KAUST, Postdoctoral Researcher)
Title: DALIA — A high-performance computing approach to Bayesian modeling

Yeva Gevorgyan (KAUST, Postdoctoral Researcher)
Title: Price formation in mean field games: a monotonicity-based numerical approach

Boou Jiang (KAUST, Postdoctoral Researcher)
Title: Dualization: from subspace correction to operator splitting and alternating direction methods of multipliers

Rolf Krause (KAUST, Professor)
Title: Parallel preconditioned strategies for the training of neural networks

David Keyes (KAUST, Professor)
Title: For what should the Bell toll?

Tong Mao (KAUST, Postdoctoral Researcher)
Title: On the approximation and spectral properties of shallow ReLU networks

Nabil El Mocayd (Mohammed VI Polytechnic University, Professor)
Title: Revealing nonlinear climate–ecosystem dependencies in marine systems using copula-based modeling

Jongho Park (KAUST, Research Scientist)
Title: A polynomial dimension-dependence analysis of Bramble–Pasciak–Xu preconditioners

Mufutau Ajani Rufai (Free University of Bozen-Bolzano, Postdoctoral Researcher)
Title: An adaptive collocation method as a faster solver for some model PDEs in applied science and engineering

Widodo Samyono (Jarvis Christian University, Professor)
Title: Neural operator learning for modeling cancer cell growth: bridging mechanistic ODEs and experimental in vitro data

Mohammed Seaid (University of Durham, Professor)
Title: A surrogate model for efficient quantification of uncertainties in tidal flows

Jianwei Shi (KAUST, Postdoctoral Researcher)
Title: Scalable asynchronous federated modeling for spatial data

Cong Sun (Beijing University of Posts and Telecommunications, Professor)
Title: Cyclic stochastic gradient method

Lorenzo Tedesco (University of Bergamo, Professor)
Title: Nonparametric estimation of conditional probability distributions using a generative approach based on conditional push-forward neural networks

Melih Ucer (KAUST, Postdoctoral Researcher)
Title: Existence of solutions to mean field games via monotone operators

Jindong Wang (KAUST, Postdoctoral Researcher)
Title: Stabilization methods for general convection-diffusion equations

Jinchao Xu (KAUST, Professor)
Title: Approximation of high-dimensional functions by ReLU networks: curse or no curse

Halima Yusuf (African University of Science and Technology (AUST), Ph. D. Student)
Talk title: A single-forward-step projective splitting without cocoercivity for monotone inclusion problems

Stefano Zampini (KAUST, Senior Research Scientist)
Title: On second-order solvers for training models in scientific machine learning

Jianqing Zhu (KAUST, Postdoctoral Research)
Title: Second language (Arabic) acquisition of LLMs via progressive vocabulary expansion

Transportation schedule

Al Khozama Hotel - residence and reception venue

University Library - poster and soirée venue

Spine Auditorium B2/3 - plenary lecture venue

Diner - lunch venue

Al Marsa - banquet venue and cruise departure

Date	Route (One-way)	Operating Time	Frequency
Jan 25	Visitor Center → Al Khozama	12:00–20:00	Every 30 minutes
Jan 26	Al Khozama → B16	08:00–09:30 13:30–16:00	Every 10 minutes
	B16 → Al Khozama	12:00–13:30	Every 10 minutes
	B16 → Al Marsa	17:30–18:30	Every 10 minutes
	Al Marsa → Al Khozama	19:30–21:00	Every 10 minutes
	Visitor Center → B16	08:00–10:00 15:00–17:00	Every 10 minutes
Jan 27	Al Khozama → B16	08:00–09:30 13:30–16:00	Every 10 minutes
	B16 → Al Khozama	12:00–13:30 18:30–21:00	Every 10 minutes
	Visitor Center → B16	08:00–10:00 15:00–17:00	Every 10 minutes
Jan 28	Al Khozama → B16	08:00–09:30 13:30–15:00	Every 10 minutes
	B16 → Al Khozama	12:00–13:30	Every 10 minutes
	B16 → Yacht Club	15:30–16:00	Every 10 minutes
	Yacht Club → I-552M	18:00–19:00	Every 10 minutes
	I-552M → Al Khozama	19:30–21:30	Every 10 minutes
	Visitor Center → B16	08:00–10:00 15:00–17:00	Every 10 minutes