# QPQIS 2023

## The 5th International Symposium on Quantum Physics and Quantum Information Sciences

Theme: Advances in Fundamental Research of Quantum Information Science
October 17-19, 2023
Beijing, China

北京量子信息科学研究院
Beijing Academy of Quantum Information Sciences

# ABOUT QPQIS-2023

Welcome to QPQIS-2023, the 5th International Symposium on Quantum Physics and Quantum Information Science, hosted by Beijing Academy of Quantum Information Sciences (BAQIS). QPQIS-2023 will be held on October 17 – 19, 2023 (Beijing Time).

The theme of QPQIS-2023 will be "Advances in Fundamental Research of Quantum Information Science". The main focus will be on quantum computing based on various condensed matter and AMO platforms, including superconducting circuits, semiconductor-based structures, trapped ions and neutral atoms, etc.. The symposium will also explore the connections between quantum information science (QIS) and quantum systems, such as discussing the novel quantum states of matter, materials and devices with promising applications in QIS, and the improved understanding gained from QIS for physics, materials and beyond. Moreover, new developments in quantum communication and quantum networking will be covered.

QPQIS-2023 features 24 world-leading theoretical and experimental scientists as invited speakers to share their most recent breakthroughs.

QPQIS-2023 also consists of a poster session, which is planned to encourage participants, in particular young scholars, postdocs, and students, to present their latest results.

# BEIJING ACADEMY OF QUANTUM INFORMATION SCIENCES

Beijing Academy of Quantum Information Sciences (BAQIS) was established on December 24, 2017. It is an innovative research institution initiated by Beijing Municipal Government and co-founded with China's top universities and research institutions such as Tsinghua University, Peking University, Chinese Academy of Sciences, etc.

BAQIS endeavors to address major fundamental issues of quantum physics and quantum information science to push forward next-generation quantum science and technology advancement. BAQIS encompasses five major research fields: quantum state of matter, quantum computation, quantum communication, quantum materials and devices and quantum precision measurement.  In the meantime, it has developed two state-of-the-art experimental platforms to support the researches, i.e. the micro-nano processing platform and the synergetic testing platform.

To build a world-class research institution, BAQIS adopts an operating mechanism in line with international standards, coordinates all partners with their distinct and favorable resources, and vigorously introduces the world's top talent.  BAQIS also strives to promote international academic exchanges and collaborations through various activities, such as QPQIS (International Symposium on Quantum Physics and Quantum Information Sciences) and the "Baiwang Forum".

QR Code of BAQIS Website

QR Code of BAQIS Wechat Official Account

# ORGANIZING COMMITTEE

**CHAIR:**

Prof. Qi-Kun XUE (BAQIS/SUSTech/Tsinghua Univ.), Prof. Tao XIANG (BAQIS/IOPCAS).

**MEMBER:**

Dr. Kai Chang (BAQIS)
Prof. Heng Fan (IOPCAS/BAQIS)
Prof. Kihwan Kim (Tsinghua Univ./BAQIS)
Prof. Gui-Lu Long (Tsinghua Univ./BAQIS)
Prof. Hong-Qi Xu (Peking Univ./BAQIS)
Prof. Li You (Tsinghua Univ./BAQIS)
Dr. Huai-Bin Zhuang (BAQIS)

# PROGRAM

## Day 1 / October 17

### OPENING CEREMONY (Moderator: *Tao XIANG* | President of BAQIS )

08:50-09:00 • **Opening Speech**
*Qi-Kun XUE* | President of BAQIS

### SESSION 1 (Session Chair: *Heng FAN* | IOPCAS / BAQIS)

09:00-09:35 • **Emergent Electromagnetic Phenomena in Spin Chiral Matter**
*Yoshinori TOKURA* | RIKEN Center for Emergent Matter Science/ University of Tokyo, Japan

09:35-10:10 • **Quantum Optics with Giant Atoms: Decoherence-Free Interaction between Giant Atoms in Waveguide Quantum Electrodynamics**
*Franco NORI* | RIKEN / University of Michigan, Japan / USA

10:10-10:50 • **Group Photo & Tea Break**

10:50-11:25 • **Getting the Most Out of your Spectra: A Maximum-Entropy Success**
*David ASPNES* | North Carolina State University, USA

11:25-12:00 • **Quantum Convolutional Neural Networks**
*Michael J. HARTMANN* | Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

12:00-14:00 • **Lunch / Poster Session**

### SESSION 2 (Session Chair: *Kai Chang* | BAQIS)

14:00-14:35 • **The Josephson Diode Effect**
*Stuart PARKIN* | Max Planck Institute for Microstructure Physics, Halle (Saale), Germany

14:35-15:10 • **Superconducting Quantum Computing**
*Xiao-Bo ZHU* | University of science and technology of China, China

15:10-15:35 • **Tea Break**

15:35-16:10 • **Noise-resilient Circuit Design and Noise Benchmarking Strategy Based on Periodic Unitary Circuit**
*Dong LIU* | Tsinghua University / BAQIS, China

16:10-16:45 • **The Thermodynamical Cost of Accurate Information Processing**
*Giulio CHIRIBELLA* | The University of Hong Kong, China

16:45-17:20 • **The Ginzburg-Landau Theory of Flat Band Superconductors with Quantum Metric**
*Kam Tuen LAW* | The Hong Kong University of Science and Technology, China

## Day 2 / October 18

### SESSION 3 (Session Chair: *Gui-Lu LONG* | Tsinghua University / BAQIS)

09:00-09:35 **How to Distribute Entangled States Among Two or More Nodes of a Network?**
*Anirban PATHAK* | Jaypee Institute of information technology, India

09:35-10:10 **Cloud Quantum Computation Platform and Quantum Simulation**
*Heng FAN* | Institute of Physics, CAS/ BAQIS, China

10:10-10:35 **Tea Break**

10:35-11:10 **Multiqubit Superconducting Devices for Simulating Quantum Many-body Physics**
*Hao-Hua WANG* | Zhejiang University, China

11:10-11:45 **Coherent Control of a Symmetry-engineered Multi-qubit Dark State in Waveguide Quantum Electrodynamics**
*Gerhard KIRCHMAIR* | University of Innsbruck, Austria

11:45-14:00 **Lunch / Poster Session**

### SESSION 4 (Session Chair: *Kihwan KIM* | Tsinghua University / BAQIS)

14:00-14:35 **Towards Scalable Quantum Information Processing with Superconducting Qubits: from Architecture to Algorithm Compilation**
*Fei YAN* | BAQIS, China

14:35-15:10 **Noisy Circuits and Pairwise-parallel Gates on a Trapped-ion Machine**
*Norbert Matthias LINKE* | Duke University, USA

15:10-15:45 **Dimensional Reduction in a Quantum World**
*Mile GU* | Nanyang Technological University , Singapore

15:45-15:55 **Tea Break**

15:55-17:30 **Poster Session**

## Day 3 / October 19

### SESSION 5 (Session Chair: *Li YOU* | Tsinghua University / BAQIS)

09:00-09:35 **Exploring Collective Physics in Atom-Cavity Systems for Quantum Sensing and Quantum Simulation**
*James K. THOMPSON* | JILA, University of Colorado, USA

09:35-10:10 **Fast and Converged Classical Simulation of a Quantum Circuit Experiment for Quantum Dynamics**
*Garnet K. CHAN* | California Institute of Technology, USA

10:10-10:35 **Tea Break**

10:35-11:10 **Quantum Science with Rydberg Atoms**
*Wen-Chao XU* | ETH Zürich, Switzerland

11:10-11:45 **Silicon-photonic Quantum Computing and Networking**
*Jian-Wei WANG* | Peking University, China

11:45-14:00 **Lunch / Poster Session**

### SESSION 6 (Session Chair: *Hong-Qi XU* | Peking University / BAQIS)

14:00-14:35 **Quantum Enhanced Sensing with Spinor Atomic Condensates in Linear and Nonlinear Interferometries**
*Li You* | Tsinghua University / BAQIS, China

14:35-15:10 **Spin Qubits in Semiconductors for Scalable Quantum Computers**
*Daniel LOSS* | University of Basel, Switzerland

15:10-15:35 **Tea Break**

15:35-16:10 **Semiconductor Hole Qubits**
*Silvano DE FRANCESCHI* | CEA Grenoble, France

16:10-16:45 **2D semiconducting SnTe-PbTe lateral heterostructures and superlattices**
Kai Chang | BAQIS, China

### CLOSING CEREMONY (Moderator: *Huai-Bin ZHUANG* | BAQIS)

16:45-17:00 **Announcement of Best Poster Awards**
*Tao XIANG* | President of BAQIS

# ABOUT THE SPEAKERS

## David ASPNES

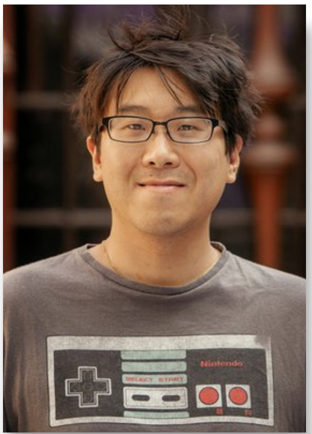
Professor, North Carolina State University, USA

David Aspnes is Distinguished University Professor of Physics at North Carolina State University. He received his Ph.D. from the University of Illinois Urbana/Champaign in 1965. Following a year as a postdoctoral research associate at UIUC and another at Brown University, he joined Bell Laboratories, Murray Hill, NJ, as a Member of the Technical Staff. In 1984 he became Head of the Interface Physics Department of the newly created Bellcore. He joined NC State University 1992. He is best known for his experimental and theoretical work on the development and application of optical techniques for the analysis of materials, thin films, interfaces, and structures. These include the theory and practice of spectroscopic ellipsometry, modulation spectroscopy, reflectance difference spectroscopy, and nonlinear optics. His most recent work involves eliminating noise and extracting information from spectra, optical and otherwise, by.linear and nonlinear methods. His work has been recognized with various awards. He was elected to the US National Academy of Sciences in 1998, and was named a Fellow of the National Academy of Inventors in 2013. He has 23 patents and over 500 publications in scientific journals.

# ABOUT THE SPEAKERS

## Garnet K. CHAN

Professor, California Institute of Technology, USA



Garnet Chan is the Bren Professor of Chemistry at the California Institute of Technology and a Simons Investigator in Physics. He previously held appointments at Princeton and Cornell University.

# ABOUT THE SPEAKERS

## Kai Chang

Principle Invastigator, BAQIS, China

Dr. Chang received his B.S. degree from School of Physics, Shandong University in 2009, and Ph.D. degree from Department of Physics, Tsinghua University in 2015. He worked in Max Planck Institute of Microstructure Physics as a postdoctoral research staff until the end of 2019, and then joined BAQIS as the Principal Investigator of the Low-dimensional Quantum Materials team in Division of Quantum State of Matter. Dr. Kai Chang dedicated to the molecular beam epitaxial (MBE) growth and in situ scanning tunneling microscopy (STM) characterization of low-dimensional quantum materials, including 2D ferroelectric/ferromagnetic materials, topological materials, unconventional superconductors, etc. In BAQIS, he is building a laboratory combining MBE, ultra-low/variable temperature STM and ultra-fast optical thin film characterization approaches. His current work focuses on the electronic structure tuning effect of 2D ferroic materials in their heterostructures with topological materials.

# ABOUT THE SPEAKERS

## Giulio CHIRIBELLA

Professor, The University of Hong Kong , China

Professor Giulio Chiribella is the director of QICI Quantum Information and Computation Initiative at the Department of Computer Science of The University of Hong Kong. He has done pioneering research on quantum causal networks, on the information-theoretic foundations of quantum theory, and on the ultimate precision limits of quantum measurements, for which he was awarded the Hermann Weyl Prize 2010. In 2020 and 2018 he received Senior Research Fellowships from the Hong Kong Research Grant Council (RGC) and from the Croucher Foundation, respectively. He currently serves as an elected member of the Hong Kong Young Academy of Sciences, as a visiting professor at the University of Oxford, and as an editorial board member of the journal Communications in Mathematical Physics. Before joining the University of Hong Kong, he held faculty positions at Oxford University and Tsinghua University, Beijing.

# ABOUT THE SPEAKERS

## Silvano DE FRANCESCHI

Research Director, CEA Grenoble, France

Silvano De Franceschi is an expert in quantum nanoelectronics and experimental mesoscopic physics. He received his PhD in 1999 at the Scuola Normale Superiore of Pisa and, he currently works as research director at the Interdisciplinary Research Institute of Grenoble (IRIG). In 2005 he was awarded the Nicholas Kurti European Prize for his achievements in the field of quantum transport and, in particular, his works on the Kondo effect in quantum dots and on hybrid normal/superconductor nanostructures. He is CEA Senior Fellow for the field of quantum technologies and his current research activity focuses primarily on the development of silicon-based devices for quantum information processing.

# ABOUT THE SPEAKERS

## Heng FAN

Professor, The Institute of Physics, Chinese Academy of Sciences / BAQIS, China

Heng Fan is a Professor in Institute of Physics, Chinese Academy of Science and also Beijing Academy of Quantum Information Sciences. His research interests focus on quantum computation, quantum information and quantum simulation. Recently, he and his colleagues devote to superconducting quantum computation both theoretically and experimentally. He has published more than 300 peer review papers including Science, Nature Physics, Science Advances, Physical Review Letters etc. He has received Zhou Peiyuan prize for his contributions to superconducting quantum computation.

# ABOUT THE SPEAKERS

## Mile GU

Associate Professor, Nanyang Technological University , Singapore

Gu obtained his Ph.D. at the University of Queensland in 2009. In 2012, he joined the Institute for Interdisciplinary Information science where he was named a China young 1000 Talent. In 2016, Gu was named a National Research Foundation Fellow by the Government of Singapore, and is presented as Associate Professor at Nanyang Technological University. There, he directs the quantum and complexity science initiative – focusing on topics bridging quantum, complexity and information science. Gu is also a CQT Fellow at the National University of Singapore and a principal investigator in the Singapore-France joint institute, Majulab.

# ABOUT THE SPEAKERS

## Michael J. HARTMANN

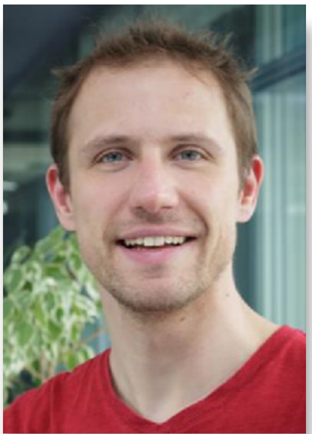
Professor, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Prof. Hartmann studied physics at the Ludwig Maximilians University in Munich and received his PhD from University of Stuttgart in 2005. After working three years as a Feodor-Lynen Fellow of the Alexander von Humboldt Foundation at Imperial College London he was awarded an Emmy Noether fellowship of the German Research Foundation to build up his own research group at Technical University Munich in 2008. He worked at Heriot-Watt University Edinburgh as an associate professor from 2013-2019 before working as a visiting faculty with the Google Quantum AI team in 2019. Since 2020 he is a full professor at Friedrich-Alexander University (FAU) Erlangen and an associate PI to the Max Planck Institute for the Science of Light in Erlangen. His research group works on quantum algorithms for near term devices as well as on modelling and designing new components for superconducting circuit quantum processors.

# ABOUT THE SPEAKERS

## Gerhard KIRCHMAIR

Professor, University of Innsbruck, Austria



Gerhard Kirchmair was born in 1981 in Austria. He studied physics at the University of Innsbruck and did his PhD work, in the group of Prof. Blatt, working on realizing quantum information protocols and quantum simulation experiments with calcium ions in a linear Paul trap. He received his PhD in 2010, with Presidential Honors, on the subject "Quantum non-demolition measurements and quantum simulation". From 2010 on, he joined the group of Prof. Robert Schoelkopf as a post-doctoral associate at Yale University working on superconducting circuits. He contributed to developing the 3D circuit QED architecture which increased coherence times of superconducting qubits by a factor of 100. He used this architecture to create setups for QIP and quantum optics experiments. These experiments led to the observation of the single photon Kerr effect and the generation of microwave cat states consisting of more than 100 photons. Since 2013 Gerhard is professor for experimental physics at the University of Innsbruck and Group leader at the Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences. His research group works on superconducting circuits for quantum optics and quantum simulation experiments and on interfacing microwave circuits with micromechanical systems.

# ABOUT THE SPEAKERS

## Kam Tuen LAW

Professor, The Hong Kong University of Science and Technology , China

After graduating from HKUST in 2003, I moved to Brown University for graduate study and received my PhD degree in 2008. After spending one year as a joint postdoc fellow of HKUST-IAS and MIT, I moved to MIT in 2009 as a Croucher Postdoc Fellow. I joined the HKUST physics department in 2011. In general, I am interested in theoretical condensed matter physics with emphasis on topological materials, moiré materials and unconventional superconductors. Currently, our group is studying 1. The Berry curvature multiple (such as quadruple) induced higher order anomalous Hall effects; 2. The electron interaction-induced correlated states in twisted bilayer graphene and moiré transition metal dichalcogenides; 3. Quantum metric effects in flat band superconductors and magnets; 4. The realization of topological and other superconducting qubits using Majorana zero modes and unconventional Josephson junctions. 5. Heesch Weyl fermions (a new type of Weyl fermions we discovered) in anti-ferromagnets.

# ABOUT THE SPEAKERS

## Norbert Matthias LINKE

Assistant Professor, Duke University , USA

Norbert M. Linke is an Assistant Professor of Physics at the Duke Quantum Center (DQC), Duke University, North Carolina, USA, working on quantum applications of trapped ions, including quantum computing. Born in Munich, Germany, he graduated from the University of Ulm, and received his doctorate at the University of Oxford, UK, working on micro-fabricated ion-traps and microwave-addressing of ions. He spent four years as a post-doc and research scientist in the group of Chris Monroe at the University of Maryland's Joint Quantum Institute where he led a project that turned a physics experiment into a programmable quantum computer. He became an assistant professor at UMD in 2019 and transferred to the DQC in 2022.

# ABOUT THE SPEAKERS

## Dong LIU

Associate Professor, Tsinghua University / BAQIS, China

Prof. Dong E. Liu completed his undergraduate degree at Peking University and obtained his PhD from Duke University in 2012. He held postdoc positions at Michigan State University and Microsoft Station Q from 2012 to 2017. In 2018, he joined the faculty at Tsinghua University and became an adjunct scientist at BAQIS in 2020, where he leads a quantum computer operating system research group. His research focus on the theoretical study of validation schemes for quantum devices, noise-resistant methods and system architectures for quantum computers, and non-equilibrium quantum many-body physics.

# ABOUT THE SPEAKERS

## Daniel LOSS

Professor, University of Basel, Switzerland

Daniel Loss received his Diploma (1983) and Ph.D. (1985) in theoretical physics at the University of Zürich. From 1989 to 1991 he worked as a postdoc with Nobel Laureate A. J. Leggett in Urbana, and from 1991 to 1993 at the IBM T.J. Watson Research Center, NY. In 1993 he joined the faculty of SFU in Vancouver, and then returned to Switzerland in 1996 to become Professor of Theoretical Physics (Ordinarius) at the University of Basel where he founded the Basel Center for Quantum Computing and Quantum Coherence (QC2) in 2005. His research interests include spin physics, quantum coherence, and topological effects in semiconducting and magnetic nanostructures, and quantum computing. Loss has an extensive publication record with over 59’000 citations and an h-index of 109. In 2000 he became an APS Fellow, in 2013 Member of the European Academy of Sciences, in 2014 Member of the German National Academy of Sciences Leopoldina, and in 2021 External Scientific Member of the Max Planck Society at MPI Halle. In 2005 he received the Humboldt Research Prize, in 2010 the Marcel Benoist Prize by the Swiss government, in 2014 the Blaise Pascal Medal in Physics from the European Academy of Sciences, and in 2017 the King Faisal International Prize in Science. Since 2012 he holds an honorary position at RIKEN near Tokyo. He is currently co-director of the Swiss national center on spin-based quantum computing in semiconductors, a field he pioneered in a series of publications starting in 1998 with his work on spin qubits in quantum dots (with D. DiVincenzo). Their visionary paper led to a new field and is one of the highest cited research papers in quantum computing.

# ABOUT THE SPEAKERS

## Franco NORI

Professor, RIKEN, Japan / University of Michigan, USA

Nori's research group has done pioneering interdisciplinary studies at the interface between nanoscience, dissipative quantum open systems, quantum information processing, superconducting quantum circuitry for quantum computing, photonics, quantum optics, atomic physics, nano-mechanics, mesoscopics, computational physics, and condensed matter physics.

During the past decade, his research group has produced numerous highly cited papers (i.e., top 1% most cited publications among all papers in all areas of Physics) according to the Web of Science. Also, more than 132 publications in Physical Review Letters, over 70 in Science and Nature journals, and also numerous ones in other top journals. According to the Web of Science: >61K citations and h-index > 114 (Google Scholar: > 86K citations and h-index >131).

He has been listed by the Web of Science as a "Highly Cited Researcher" in Physics (covering all areas of Physics) for the past six consecutive years: from 2017 to 2022 (Less than 0.1% of physicists are selected).

He is an Elected Fellow of the: American Physics Society (APS), Institute of Physics (IoP), American Association for the Advancement of Science (AAAS), and Optical Society of America (OSA) [this last one "for fundamental contributions to quantum information science and optics, including circuit quantum electrodynamics, and the interface between quantum optics and quantum circuits"]. He received the 2014 Prize for Research in Physics, from the Matsuo Foundation, Japan; and the 2013 Prize for Science, by the Minister of Education, Culture, Sports, Science and Technology, Japan. Also, an "Excellence in Research Award" and an "Excellence in Education Award" from the University of Michigan. He is an Elected Member of the Academia Europaea, the Latin American Academy of Sciences, and a Foreign Member of the Swedish Royal Society of Arts and Sciences, in Gothenburg, Sweden. He won the 2023 W.E. Lamb Medal, for research on Quantum Optics, Quantum Electronics and Quantum Information.

# ABOUT THE SPEAKERS

## Stuart PARKIN

Director, Max Planck Institute for Microstructure Physics, Halle (Saale), Germany

Stuart Parkin is Director of the Max Planck Institute for Microstructure Physics, Halle, Germany, and an Alexander von Humboldt Professor, Martin Luther University, Halle-Wittenberg. His research interests include spintronic materials and devices for advanced sensor, memory, and logic applications, oxide thin-film heterostructures, topological metals, exotic superconductors, and cognitive devices. Parkin's discoveries in spintronics enabled a more than 10,000-fold increase in the storage capacity of magnetic disk drives. For his work that thereby enabled the "big data" world of today, Parkin was awarded the Millennium Technology Award from the Technology Academy Finland in 2014 and, most recently the King Faisal Prize for Science 2021 for his research into three distinct classes of spintronic memories. Parkin is an elected Fellow/ Member: Royal Society (London), Royal Academy of Engineering, National Academy of Sciences, National Academy of Engineering, German National Academy of Science - Leopoldina, Royal Society of Edinburgh, Indian Academy of Sciences, and TWAS - academy of sciences for the developing world. Parkin has received numerous awards including the American Physical Society International Prize for New Materials (1994); Europhysics Prize for Outstanding Achievement in Solid State Physics (1997); 2009 IUPAP Magnetism Prize and Neel Medal; 2012 von Hippel Award - Materials Research Society; 2013 Swan Medal - Institute of Physics (London); Alexander von Humboldt Professorship − International Award for Research (2014); Millennium Technology Award (2014); ERC Advanced Grant - SORBET (2015); King Faisal Prize for Science 2021; ERC Advanced Grant – SUPERMINT (2022). Parkin has received 4 honorary doctorates. Parkin has published >670 papers, has >123 issued patents, and has given >800 invited talks around the world. Parkin was named a "Highly Cited Researcher" by Clarivate for the years 2018-2022 and has an h-index of 128.

# ABOUT THE SPEAKERS

## Anirban PATHAK

Professor, Jaypee Institute of information technology, India

Prof. Anirban Pathak (FNASc) is a theoretical physicist with strong interest in experiment. He did his Ph.D. from Visva Bharati, Santiniketan, India. Subsequently, he was a post-doctoral fellow in the Freie University, Berlin. He joined Jaypee Institute of Information Technology (JIIT), Noida, India in 2002. At present he heads the Physics and Materials Science & Engineering Department of JIIT and is actively involved in teaching and research related to several aspects of quantum optics and quantum information with a focus on quantum cryptography. He is a fellow of The National Academy of Sciences, India (NASI), Institute of Electronics and Telecommunication Engineering (IETE). He is also a member of Editorial Board of Quantum Information Processing, Springer-Nature. He guided several PhD students and Post-Doctoral Fellows. At present he leads a research group focused on quantum optics and quantum information. He has also completed several DST, India and DRDO, India funded projects and at present he has a few ongoing projects funded by these agencies. He has played an important role in the development of the field of quantum information in India. He is a recipient of 2017 Shri O. P. Bhasin Award in the field of Electronics and Information Technology.

# ABOUT THE SPEAKERS

## James K. THOMPSON

Professor, JILA, University of Colorado , USA

James K. Thompson earned his undergraduate degree in Physics from Florida State University and his Ph.D. in Physics from the Massachusetts Institute of Technology. His doctoral work with David E. Pritchard focused on comparing the masses of two trapped ions with precision better than ten parts in a trillion for testing Einstein's mass-energy relationship $E=mc^2$. As part of this work, James and his colleague Simon Rainville also discovered a novel method for making non-demolition measurements of the quantum state of single molecules. James was awarded the APS DAMOP thesis prize for this work. James moved to the MIT laboratory of Vladan Vuletic at the MIT/Harvard Center for Ultracold Atoms for his postdoctoral work, where he developed atomic quantum memories and entangled photon sources using laser-cooled atoms. Since moving to JILA and the Department of Physics at the University of Colorado, James's work has focused on studying how to exploit collective and quantum effects to advance precision measurement and explore many-body physics. His work includes the demonstration of highly entangled spin-squeezed states, the realization of superradiant lasers based on mHz linewidth transitions, development of novel spectroscopy and laser cooling techniques, and exploration of dynamical phase transitions.

# ABOUT THE SPEAKERS

## Yoshinori TOKURA

Professor, RIKEN/University of Tokyo, Japan

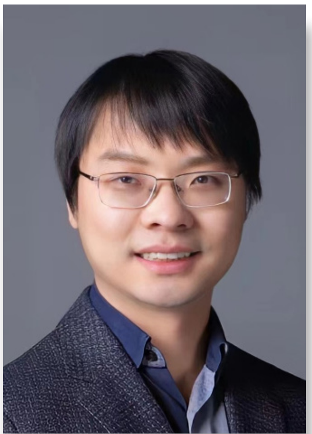
Yoshinori Tokura received his BSc in applied physics from University of Tokyo in 1976, and Ph.D in applied physics from University of Tokyo 1981. From 1986 to 1993, he was an associate professor, and from 1994 to 1995 a full professor, at Dept. of Physics, University of Tokyo. From 1995 to 2019, he was a professor at Dept. of Applied Physics, University of Tokyo, and he is from 2017 to present, Distinguished Professor, and from 2019 to present the Special University Professor Emeritus, University of Tokyo. He is now Director of RIKEN Center for Emergent Matter Science (2013 – Present).

His research interests include strongly correlated electrons including transition metal oxides, electronic processes in organic materials, topological aspects of condensed matters, spintronics, and optical properties of solids.

# ABOUT THE SPEAKERS

## Jian-Wei WANG

Assistant Professor, Peking University, China

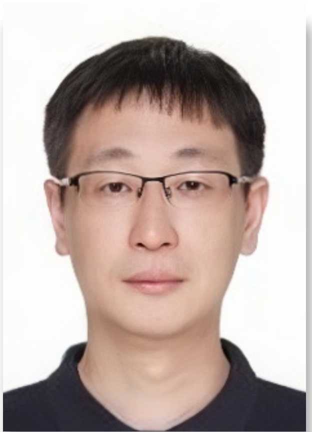


Dr. Jianwei Wang is an Assistant Professor in the Physics of Peking University. He obtained his PHD in the University of Bristol in 2016. His group focuses on quantum information science and technologies with integrated optics. The group is developing large-scale integrated quantum photonic devices for applications in the fields of quantum computations, quantum simulations and quantum communications, as well as for the understanding of fundamental respects of quantum physics. He is also interested in developing hybrid quantum technologies of integrated optics, trapped ions, cold atoms, and superconducting systems. He has published more than 30 peer-reviewed papers in Science, Nature Physics, Nature Photonics, Nature Review Physics, Nature Communications, Science Advances, PRL and Optica.

# ABOUT THE SPEAKERS

## Hao-Hua WANG

Professor , Zhejiang University, China



Haohua Wang, received his PhD degree at Penn State University, and conducted postdoctoral research in the superconducting phase qubit group at UC Santa Barbara sponsored by Prof. John Martinis. He joined Department of Physics of Zhejiang University in 2010, and since then he has established a research team capable of designing, fabricating and characterizing complex superconducting quantum devices based on Josephson junctions. His research interests primarily focus on scaling up multiqubit devices and developing peripheral microwave technologies, shooting for a balanced performance covering a few key factors including qubit connectivity, coherence, gate fidelity and number of integrated elements. With the improvement of system performance, he is also interested in experimentally demonstrating quantum advantage in certain well-designed computation/simulation tasks.

# ABOUT THE SPEAKERS

## Wen-Chao XU

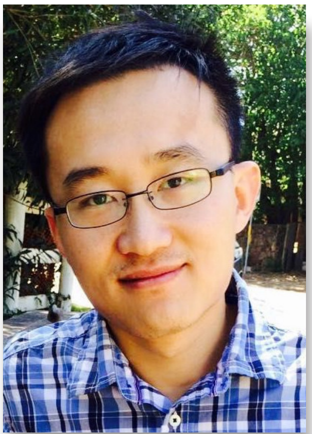
Assistant Professor, ETH Zürich, Switzerland

Wenchao Xu is a tenure track assistant professor in the Physics Department since August 2022.She currently is also a group leader at Paul Scherrer Institute. Prior to join ETH Zurich, she worked as a postdoctoral associate at the Massachusetts Institute of Technology between 2018 and 2022. She received her Ph.D. in physics from the University of Illinois at Urbana-Champaign in 2018. Her research interests are centered on quantum simulation, quantum computation, and quantum nonlinear optics with experimental platforms based on neutral atoms.

# ABOUT THE SPEAKERS

## Fei YAN

Research Scientist, BAQIS, China



Dr. Fei Yan is a research scientist in the superconducting quantum computing group at Beijing Academy of Quantum Information Sciences. He graduated from Nanjing University majoring in Physics, after which he did his Ph.D. and postdoctoral research at MIT. His current research focuses on developing enabling technologies for scalable quantum information processing with superconducting qubits, including quantum control, noise and decoherence, architectural design, algorithm compilation. His work on tunable coupling design has helped achieving high-fidelity quantum gate operations in research labs around the world, and led to many experimental breakthroughs including Google's quantum supremacy experiments.

# ABOUT THE SPEAKERS

## Li YOU

Professor, Tsinghua University / BAQIS, China

Li You, APS Fellow (2007), obtained his BS from Nanjing University in 1987, and his Ph.D. from JILA, University of Colorado in 1993. From 1993-1996, he was an NSF postdoctoral fellow at Institute for Theoretical Atomic and Molecular Physics (ITAMP) of Harvard-Smithsonian Center for Astrophysics. He joined Georgia Tech in 1996 and became Professor of Physics in 2004. He moved to Tsinghua University in 2009. His research interests include atomic physics, quantum optics, and quantum information science.

# ABOUT THE SPEAKERS

## Xiao-Bo ZHU

Professor, University of Science and Technology of China, China

Xiaobo Zhu, Professor, University of Science and Technology of China. In 2003, he received his PhD from the Institute of Physics, Chinese Academy of Sciences, and continued to work in the Institute; In 2008, he joined NTT Basic Research Laboratories; In 2013, he returned to China and joined the Institute of Physics, Chinese Academy of Sciences; In 2016, he joined the University of Science and Technology of China. His research focus is quantum computation and simulation with superconducting Josephson junctions. He has made a series of important works on the quantum hybrid system of flux qubit and NV color centers in diamonds. He also set several records for the maximum number of entangled superconducting qubits, developed the prototype of superconducting quantum computer "Zuchongzhi" and achieved "quantum superiority".

# ABSTRACT

Day1 Oct-17 2023
Session 1 09:00 - 09:35

## Emergent Electromagnetic Phenomena in Spin Chiral Matter

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Intriguing electromagnetic phenomena can show up in a solid when the electrons spins take a helical form. To name a few, the cycloidal order of spin moments can produce the electric polarization and realize the multiferroics where ferroelectric and magnetic orders coexist and enable the cross control of magnetism with electric field. When spin helices hybridize to form with plural propagation directions, there emerge the topological spin textures, such as magnetic skyrmions and emergent magnetic (anti) monopoles, hosting the large emergent magnetic field or Berry curvature acting on the conduction electrons and causing the gigantic topological Hall effect. Furthermore, the dynamics of these helical-spin or skyrmion forms, as excited by electric current flow, can generate the emergent electric field acting on the electrons and hence cause a sort of electromagnetic induction. Such emergent electromagnetic induction based on the spin chiral matter is applied to the design of nanometric inductor element.

Here, those spin chiral textures and real-space topological spin textures are overviewed with perspectives of exploration for new quantum materials and functions.

Day1 Oct-17 2023
Session 1 09:35 - 10:10

# Quantum Optics with Giant Atoms: Decoherence-Free Interaction between Giant Atoms in Waveguide Quantum Electrodynamics

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In quantum optics, atoms are usually approximated as point-like compared to the wavelength of the light they interact with. However, recent advances in experiments with artificial atoms built from superconducting circuits have shown that this assumption can be violated. Instead, these artificial atoms can couple to an electromagnetic field in a waveguide at multiple points, which are spaced wavelength distances apart. Such systems are called giant atoms. They have attracted increasing interest in the past few years (e.g., see the review in [1]), in particular because it turns out that the interference effects due to the multiple coupling points allow giant atoms to interact with each other through the waveguide without losing energy into the waveguide (theory in [2] and experiments in [3]).

This talk will review some of these developments [1-4]. Finally, we will also show how a giant atom coupled to a waveguide with varying impedance can give rise to chiral bound states [5].

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Day1 Oct-17 2023
Session 1 10:50 - 11:25

# Getting the Most Out of your Spectra: A Maximum-Entropy Success*

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Working with an entropy-rate cost function, Burg developed an approach for extracting weak harmonic signals from stationary time series. We recently showed that Burg's approach could be modified to yield a maximum-entropy (most-probable) method of forward-projecting trends established in low-order Fourier coefficients of a spectral segment into the white-noise region in a model-independent way. By eliminating noise as well as apodization and its associated errors, this approach has changed how spectra are analyzed, for example allowing essentially noise-free differentiation of data. Moreover, the procedure yields a polynomial whose roots provide information about the location of singularities (critical points) in the spectra, useful for discovering features that may be too weak to observe directly. Combining this approach with standard model-lineshape analysis allows critical-point parameters to be determined with confidence levels considerably better than classical estimates. Capabilities are illustrated by examples, including recent applications to X-ray diffraction.

*Coworkers: L.V. Long, Vietnam Academy of Science and Technology, Hanoi, Viet Nam; Y. D. Kim, Kyung Hee University, Seoul, Korea.

Day 1 Oct. 17, 2023
Session 1 11:25-12:00

# Quantum Convolutional Neural Networks

[1,2]*Michael J. Hartmann.
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Quantum computing has made significant progress in recent years so that substantial gate sequences can now be run, and the output states of cutting-edge devices become too complex to be fully analyzed by classical techniques. Here, Quantum Convolutional Neural Networks, gate sequences that condense the relevant quantum information of the output state onto just a few qubits, can become a highly valuable tool. In this talk I will discuss how Quantum Convolutional Neural Networks can be used for recognizing topological and symmetry protected topological phases with non-local order parameters by reading out just a few qubits.

On near term quantum hardware, such as superconducting quantum processors, the input quantum states of Quantum Convolutional Neural Networks will contain imperfections and there will be a limited budget of quantum gates to implement the network. A particular focus of my discussion will thus be on strategies to reduce the networks to constant, very shallow depth and to make them tolerant against error on the input.

Day 1 Oct. 17, 2023
Session 2 14:00-14:35

# The Josephson Diode Effect

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Recently we have discovered a non-reciprocal Josephson diode effect in several Josephson junctions, both lateral and vertical, formed from conventional superconducting electrodes (Nb, NbSe2) separated by several non-superconducting metals including the 2D van der Waals metals, NiTe2 [1] and WTe2 [2], as well as sputtered layers of platinum that are magnetically proximitized via a magnetic insulator (YIG) [3]. Each of these materials becoming superconducting by proximity to the conventional superconducting electrodes. The superconductivity can be sustained over long distances of, in some cases, up to ~1 micron. The critical supercurrent densities for current flowing in opposite directions within the junction are distinct and can vary by up to 40% or more. For the van der Waals metals the non-reciprocity is only observed in the presence of a small magnetic field oriented perpendicular to the supercurrent, whereas for the Pt based junctions the diode effect is observed in zero field. For vertical Josephson junctions formed from WTe2 we show that the non-reciprocity depends on the orientation of the magnetic field with respect to the crystal structure of the WTe2, proving thereby the intrinsic origin of the Josephson diode effect. Such an effect could have important applications as a novel magnetic field detector at cryogenic temperatures, for example, to “read” magnetic domain walls in a cryogenic racetrack memory*. Cryogenic digital memories that are energy efficient and have large capacities are urgently needed to provide essential support circuits for quantum computing systems based, for example, on spin or superconducting qubits.
* Funded through an European Research Council Advanced Grant “SUPERMINT” (2022-2027).

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Day 1 Oct.17, 2023
Session 2 14:35-15:10

# Superconducting Quantum Computing

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In this talk, I will show our recent progress with our collaborators on superconducting multi-qubits system. We designed and fabricated several versions of quantum processor, on which integrated up to 66 quibts. The fidelity of single-bit gate and two-bit gate are calibrated by randomized benchmarking or parallel cross-entropy benchmarking. For the single-qubit gate, the average error is ~0.14% and that of the two-qubit gate is ~0.59%. I will also show some of the multi-qubits experiment results, e.g., genuine multiparticle entanglement for 51 superconducting qubits[1], quantum walks on a programmable two-dimensional 62-qubit superconducting processor[2], and strong quantum advantage[3].

[1] Nature (2023). https://doi.org/10.1038/s41586-023-06195-1
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Day 1 Oct 17, 2023
Session 2 15:35-16:10

# Noise-resilient Circuit Design and Noise Benchmarking Strategy Based on Periodic Unitary Circuit

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We introduce an innovative noise-resilient circuit design strategy for control-free phase estimation (periodic unitary circuit) and a novel method, channel spectrum benchmarking (CSB), to advance robust quantum processors development. Our approach effectively identifies and mitigates benign noise types, reducing phase estimation error significantly. Coupled with a randomized compiling protocol, we transform generic noise into stochastic Pauli noise, facilitating quantum phase estimation in pre-fault-tolerant quantum computing. Furthermore, we propose CSB to circumvent existing benchmarking limitations. CSB infers noise properties from the noisy channel's eigenvalues of a target gate, offering valuable insights into process fidelity and unitary parameters. Our method allows for benchmarking of universal gates and scales to multi-qubit systems, providing critical noise information. Collectively, our findings contribute to the development of efficient, robust quantum computation.

Day 1 Oct. 17, 2023
Session 2 16:10-16:45

# The Thermodynamical Cost of Accurate Information Processing

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Accurate information processing is crucial both in technology and in nature. To achieve it, any information processing system needs an initial supply of resources away from thermal equilibrium. In this talk, I will discuss the in-principle limits on the accuracy achievable with a given amount of nonequilibrium resources. Specifically, I will present a limit based on an entropic quantity, named the reverse entropy, associated to a time reversal of the information processing task under consideration. The limit is achievable for all deterministic classical computations and for all their quantum extensions. As an application, I will show the optimal tradeoffs between nonequilibrium and accuracy for thel tasks of storing, transmitting, cloning, and erasing information. These results set a target for the design of new devices approaching the ultimate efficiency limit, and provide a framework for demonstrating thermodynamical advantages of genuine quantum information processing.

Reference for this paper: G. Chiribella, F. Meng, R. Renner, and M.-H. Yung, Nature Communications 13, 7155 (2022)

Day 1 Oct. 17, 2023
Session 2 16:45-17:20

# The Ginzburg-Landau Theory of Flat Band Superconductors with Quantum Metric

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Recent experimental study unveiled highly unconventional phenomena in the superconducting twisted bilayer graphene (TBG) with ultra-flat bands, which cannot be described by the conventional BCS theory. For example, given the small Fermi velocity of the flat bands, the predicted superconducting coherence length accordingly to BCS theory is more than 20 times shorter than the measured values. A new theory is needed to understand many of the unconventional properties of flat band superconductors. In this talk, based on a recent theoretical work [1], we establish a Ginzburg-Landau (GL) theory from a microscopic flat band Hamiltonian. The GL theory shows how the properties of the physical quantities such as the critical temperature, the superconducting coherence length, the upper critical field and the superfluid density are governed by the quantum metric of the Bloch states. One key conclusion is that the superconducting coherence length is not determined by the Fermi velocity but by the size of the optimally localized Wannier functions which is limited by quantum metric. Applying the theory to TBG, we calculated the superconducting coherence length and the upper critical fields. The results match the experimental ones well without fine tuning of parameters. The established GL theory provides a new and general theoretical framework for understanding flat band superconductors with quantum metric.

[1] Shuai A. Chen and K. T. Law arXiv:2303.15504.

Day 2 Oct. 18, 2023
Session 3 09:00-09:35

# How to Distribute Entangled States Among Two or More Nodes of a Network?

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This work primarily aims to answer: How to distribute entangled states among ≥2 nodes of a network in an efficient manner? How to find the most optimal path to perform the X protocol for entanglement routing? Is it always the shortest path? Which types of network (line/grid/ring) lead to bottlenecks in establishing simultaneous Bell pairs in nearest-neighbor architectures? These questions are systematically addressed by presenting a protocol for extracting maximally entangled n-partite GHZ states for any number of parties in a quantum network and showing that the concept of majorization can be utilized to establish a hierarchy among different paths in a network that can be used for entanglement routing [1]. Further, it is established through examples that the most optimal path to perform entanglement routing using the X protocol is not essentially along the shortest path [2], and the advantage of considering general paths (as opposed to just considering the shortest path) increases with the size of the grid graph. Finally, local equivalency relations from graph theory are used to establish that the bottleneck issues exist in line, ring and grid networks [2].

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Day 2 Oct. 18, 2023
Session 3 09:35-10:10

# Cloud Quantum Computation Platform and Quantum Simulation

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Cloud quantum computation platform can be accessed through internet. It will provide quantum computational power to users world-wide. Here, the Quafu, in terms of quantum future, cloud quantum computation platform will be introduced, including information of superconducting processors such as coherence time, fidelities of logic gates and the methods to submit quantum circuits. Also, the approach of runtime will be presented, which is a hybrid quantum-classical computational method and can promote greatly the efficiency of cloud quantum computation. Finally, a series of quantum simulation of Hawking radiation in curved space time, Hofstadter buttery and Chern insulators will be presented.

Day 2 Oct. 18, 2023
Session 3 10:35-11:10

# Multiqubit Superconducting Devices for Simulating Quantum Many-body Physics

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Superconducting qubits provide a promising platform for simulating intriguing phenomena in quantum many-body systems. The simulation efficiency depends on various intertwining factors including the underlying circuit architecture, the number of highly coherent qubits that can be precisely controlled and measured, and the upper-level simulation protocol. In this talk, I will introduce the multiqubit superconducting devices that are being developed at Zhejiang University. These devices are fabricated using the flip-chip recipe, with frequency-tunable transmon qubits and couplers located on the sapphire substrate and the control/readout wirings on the silicon substrate. The coupler is of transmon type, which is used to adjust the effective coupling strength between two neighboring qubits. For our devices, the median lifetime of the frequency-tunable qubits on a single chip is above 100 microseconds; the median single- and two-qubit gate fidelities are around 99.96% and 99.5%, respectively. The decent device performance enables us to execute complex digital quantum circuits to simulate quantum many-body dynamics and other intriguing phenomena. In particular, we implement a quantum simulation protocol to realize a distinct type of non-equilibrium state of matter, a Floquet symmetry-protected topological phase, which breaks the time translational symmetry only at the boundaries and has trivial dynamics in the bulk.

Day 2 Oct. 18, 2023
Session 3 11:10-11:45

# Coherent Control of a Symmetry-engineered Multi-qubit Dark State in Waveguide Quantum Electrodynamics

Maximilian Zanner [1,2], Tuure Orell [3], Christian M. F. Schneider [1,2], Romain Albert [1,2], Stefan Oleschko [1,2], Mathieu L. Juan [4], Matti Silveri [3] and Gerhard Kirchmair [1,2,*]

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In this talk I will introduce, how we use a circuit quantum electrodynamics architecture to realize a platform for building small interacting quantum many body systems. Our basic building blocks are transmon qubits, where we use the naturally occurring dipolar interactions to realize interacting spin systems. Additionally, these qubits can be coupled strongly to a microwave waveguide, which allows us to study open system dynamics with interacting spin systems. Using these building blocks, we have engineered a four-qubit system [1] combining a direct dipole-dipole with waveguide-mediated interactions to form collective sub-radiant (dark) and super-radiant (bright) states. The dark state's protection against decoherence results in a decay time that exceed those of the waveguide limited single qubits by more than two orders of magnitude. The bright state can be used to read out the encoded qubit. We show experimentally that this four-qubit dark-state can be coherently controlled by utilizing a driving scheme relying on the symmetries of the quantum states. Furthermore, this coherent control allows us to perform phase sensitive spectroscopy on the higher excitation manifold revealing bosonic many-body statistics in the transmon array [2]. In the future such a platform can be used to mediate entanglement between remote parts of a superconducting qubit quantum processor and implement quantum information protocols with collective states.

[1] Coherent control of a multi-qubit dark state in waveguide quantum electrodynamics
M. Zanner, T. Orell, C. Schneider, R. Albert, S. Oleschko, M. L. Juan, M. Silveri, G. Kirchmair Nat. Phys. 18, 538 (2022)
[2] Collective bosonic effects in an array of transmon devices
Tuure Orell, Maximilian Zanner, Mathieu L. Juan, Aleksei Sharafiev, Romain Albert, Stefan Oleschko, G. Kirchmair, Matti Silveri
Phys. Rev. A 105, 063701 (2022)

Day 2 Oct. 18, 2023
Session 4 14:00-14:35

# Towards Scalable Quantum Information Processing with Superconducting Qubits: From Architecture to Algorithm Compilation

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Superconducting qubits hold great promise for realizing large-scale quantum computing applications. In this talk, we present advancements in several aspects of superconducting quantum processors, including architectural design, control techniques, and algorithm compilation methods, which all contribute to the improvement of their scalability. These developments highlight the potential for scalable and widely applicable approaches in quantum information processing, which help bring meaningful quantum applications on noisy devices closer to realization.

Day 2 Oct. 18, 2023
Session 4 14:35-15:10

# Noisy Circuits and Pairwise-parallel Gates on a Trapped-ion Machine

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In this talk I will review several proposals and two experiments in which spectral engineering was used in order to generate two-dimensional spin-coupling maps in trapped ion systems. In the first experiment I will describe, the simultaneous coherent excitation of multiple modes of motion was used to couple 4 ions on a 2D lattice with nearest-neighbor interactions and periodic boundary conditions. In a different experiment, we used an energy gradient across a trapped-ion crystal to generate geometries that contain effective gauge fields that pierce through the 2D spin lattice. Such synthetic gauge fields led to dynamics which breaks timereversal symmetry. Both observations demonstrate that coherent-control techniques are an important in the scaling of quantum simulators to large scales.

1. Programmable quantum simulations on a trapped-ions quantum computer with a global drive; Yotam Shapira, Jovan Markov, Nitzan Akerman, Ady Stern, Roee Ozeri arxiv:230816036 (2023)

2. Quantum Simulations of Interacting Systems with Broken Time-Reversal Symmetry; Yotam Shapira, Tom Manovitz, Nitzan Akerman, Ady Stern, and Roee Ozeri Phys. Rev. X 13, 021021 (2023)
protection [10]. This "scaling up inwards" strategy, combined with "scaling up outwards" via exchange interaction and electric dipole coupling, provides great flexibility in the design of a blueprint large-scale donor-based quantum computer in silicon.

Day 2 Oct. 18, 2023
Session 4 15:10-15:45

# Dimensional Reduction in a Quantum World

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Dimensionality reduction captures the spirit of Occam's razor – asking the fundamental question: What features of current data are the essential indicators of future behavior? By isolating such features and discarding the rest, we gain a better understanding of underlying causal behavior. Such dimensionally reduced models also have many practical benefits, from reduced memory and energy resource requirements to enhanced generalization capability. Could quantum computers offer fundamental advantages in this arena?

In this talk, I outline our ongoing research along these directions in the context of stochastic modelling and adaptive agents. I illustrate quantum information processing offers means to dimensionally reduce beyond what provably classical limits, and experiments realizing this in optical systems. Time permitting, I will discuss the resulting thermodynamic consequences – enabling quantum machines to execute certain complex decision-making behavior using less energy than fundamental classical limits.

Day 3 Oct. 19 , 2023
Session 5 09:00-09:35

# Exploring Collective Physics in Atom-Cavity Systems for Quantum Sensing and Quantum Simulation

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Laser-cooled atoms in a high-finesse optical cavity are a powerful platform for quantum simulation and quantum sensing. The optical-cavity enhances the light-matter interaction, enabling both effective atom-atom interactions and the probing of quantum states below the mean-field level. In this talk, I will provide an overview of my group's work in this area including: quantum nondemolition measurements that surpass the Standard Quantum Limit on phase resolution by a factor of 60 [1,2], the first matter-wave interferometer operated with phase resolution below the Standard Quantum Limit [3], a novel Mössbauer-like collective recoil mechanism for suppressing Doppler dephasing [4], squeezed-state enhancement of a differential strontium optical lattice clock comparisons [5], simulation of predicted dynamical phases [5,6] of BCS superconductors [7], and superradiant lasing on a mHz linewidth optical transition [9-10].

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Day 3 Oct. 19 , 2023
Session 5 09:35-10:10

# Fast and Converged Classical Cimulation of a Cuantum Circuit Cxperiment for Quantum Dynamics

[1]Tomislav Begusic, [1]Johnnie Gray, [1]*Garnet Kin-Lic Chan
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estimation in quantum circuit experiments.

I will describe recent work on approximate classical algorithms for quantum dynamics and their application to quantum mean-value estimation in quantum circuit experiments.

Day 3 Oct. 19 , 2023
Session 5 10:35-11:10

# Quantum Science with Rydberg Atoms

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Quantum science promises great potential to revolutionize our current technologies. Arrays of individual atoms trapped in optical tweezers have emerged as an attractive architecture for quantum computation and simulation. This architecture has demonstrated great advantages in scalability, and programmability over the array configurations. Controllable inter-atomic interactions are achieved via the Rydberg states of atoms, which facilitate two-qubit gate operations and to simulate quantum many-body systems.

However, a long-standing challenge is the readout of Rydberg atoms, which is often a destructive process, precluding qubit reuse and the application of many quantum error-correcting protocols. To address these challenges, we take an alternative approach based on arrays of atomic ensembles. By harnessing the collective optical response of the atomic ensemble, we demonstrate a rapid preparation, manipulation, and non-demolish readout of a single Rydberg qubit embedded in an atomic ensemble. Scaling up the system towards large arrays of atomic ensembles has been achieved with apparatus upgrade, and preliminary results have demonstrated fast, parallel qubit readout.

At the end of this talk, I will outline my proposed research at ETH, which aims for building a novel architecture for quantum computation/simulation with dual type dual-element atom arrays. I expect this architecture can mitigate some long-standing challenges, including individual addressability and non-demolish selective detection.

Day 3 Oct. 19 , 2023
Session 5 11:10-11:45

# Silicon-photonic Quantum Computing and Networking

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On-chip generating, controlling, storing and detecting quantum states of light with integrated photonic circuits provides the way to realizing complex quantum technologies for applications in the fields of quantum computation, simulation and communication. In this talk we present recent progress in large-scale integrated photonic circuit for quantum information processing. We will discuss several silicon-photonic quantum devices that is able to generate, manipulate and analyze various entanglement structures, e.g., multidimensional entanglement, multiphoton entanglement, and topologically protected entanglement. Several state-of-the-art large-scale programmable quantum photonic chips will be introduced, for the study of quantum coherence, generation of entanglement, and quantum computing. We will then show the demonstrations of several quantum computing models and algorithms, including Gaussian quantum Boson sampling, quantum simulation of physical and chemical systems, linear combinations of unitarian for quantum information processing, and cluster-state quantum computing. These results show silicon-integrated quantum photonics as a route towards large-scale quantum information processing, pointing the way to applications in fundamental science and quantum technologies.

Day 3 Oct. 19 , 2023
Session 6 14:00-14:35

# Quantum Enhanced Sensing with Spinor Atomic Condensates in Linear and Nonlinear Interferometries

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Statistical inference of a parameter based on measurements from an ensemble of uncorrelated particles is lower bounded by the classical precision limit or the standard quantum limit (SQL). Quantum entangled ensembles can beat the SQL. Several paradigms for such enhanced interferometry will be discussed, and demonstrative experiments with spinor atomic Bose-Einstein condensates reported. Many-atom squeezed states, entangled states with reduced quantum noise, are deterministically generated and applied in linear interferometry [1,2,3], effective time-reversed evolutions of entanglement generating interactions are implemented for nonlinear interferometry to amplify signal preferentially over noise [4,5,6], both demonstrating quantum enhanced precisions.

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Day 3 Oct. 19 , 2023
Session 6 14:35-15:10

# Spin Qubits in Semiconductors for Scalable Quantum Computers

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Semiconductor spin qubits offer a unique opportunity for scalable quantum computation by leveraging classical transistor technology. This has triggered a worldwide effort to develop spin qubits, in particular, in Si and Ge based quantum dots, both for electrons and for holes [1-4]. Due to strong spin orbit interaction, hole spin qubits benefit from ultrafast all-electrical qubit control and sweet spots to counteract charge and nuclear spin noise . In this talk I will present an overview of the state-of-the art in the field and focus, in particular, on recent developments on hole spin physics in Ge and Si nanowires, Si FinFETs, and Ge heterostructures [5-10].

References:

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Day 3 Oct. 19 , 2023
Session 6 15:35-16:10

# Semiconductor Hole Qubits

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Hole spins in semiconductor quantum dots are emerging as a promising candidate for the realization of scalable spin-qubit architectures. Following an introduction to the field, I shall present recent advances in the development of hole-spin qubits based on foundry-compatible Si-MOS devices: the discovery of operational sweet spots maximizing hole-spin coherence1 and the first demonstration of a strong-coupling between a hole-spin and a microwave photon in a superconducting resonator[1]. I shall conclude with an outlook on hole devices made from Ge/SiGe heterostructures, an emerging platform offering a unique combination of attractive properties[2,3].

References:

1. Piot et al., Nat. Nanotechnol. 17, 1072–1077 (2022). https://doi.org/10.1038/s41565-022-01196-z
2. Yu et al., Nat. Nanotechnol. (2023). https://doi.org/10.1038/s41565-023-01332-3
3. Scappucci et al., Nat Rev Mater 6, 926 (2021). https://doi.org/10.1038/s41578-020-00262-z

Day 3 Oct. 19 , 2023
Session 6 16:10-16:45

# 2D semiconducting SnTe-PbTe lateral heterostructures and superlattices

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Lateral heterostructures and superlattices between 2D materials are promising for the future quantum devices like topological qubits, superconducting qubits and quantum dots. Hindered by the difficulty in creating atomically sharp in-plane interfaces, lateral superlattices (LSL) between 2D materials can rarely reach a period in the order of 10 nm. Here we report the molecular beam epitaxially (MBE) grown SnTe-PbTe ferroelectric-paraelectric LSLs that reaches a minimum period of 5 nm, the narrowest 2D LSL to the best of our knowledge, and characterized them by scanning tunneling microscopy (STM). 1D metallic nanowires and in-plane ferroelectric tunneling junctions have been created based on the LSLs. Tunneling through the PbTe barrier only happens when the neighboring SnTe layers have the same polarization direction. This can be interpreted from the spontaneously broken symmetry of SnTe's electronic structure in the ferroelectric state. The 1D metallic states and lateral tunneling junctions can be potentially used in creating Majorana bound states and lateral Josephson junctions used for topological and superconducting quantum computing.

# POSTER LIST

**01. Quantum Computing on Magnetic Racetracks with Flying Domain Wall Qubits**
*Ji Zou* | University of Basel

**02. Scalable Quantum State Tomography with Locally Purified Density Operators and Local Measurements**
*Yuchen Guo* |Tsinghua University

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**03. Noise effects on purity and quantum entanglement in terms of physical implementability**
*Yuchen Guo* | Tsinghua University

**04. Non-Hermitian Parent Hamiltonian and Composite Quantum Phases**
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**05. Lattice gauge theory and topological quantum error correction with quantum deviations in the state preparation and error detection**
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**06. Classification of universal quantum computing models**
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**07. Quantum Dueling: An Efficient Algorithm for Combinatorial Optimization**
*Zhengyang Li* | Tongji University

**08. Benchmarking universal quantum gates via channel spectrum**
*Yanwu Gu* | Beijing Academy of Quantum Information Sciences

**09. Spin-Orbit Interaction Enabled High-Fidelity Two-Qubit Gates**
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**10. A stochastic pseudomode model to simulate open quantum system**
*Si Luo* | Graduate school of CAEP

**11. Study on single frequency instantaneous bandwidth of Rydberg atomic microwave electric field sensor**
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**12. Efficient numerical approach to phase-modulated gates in long chains of trapped ions**
*Shengchen Liu* | Peking University

**13. Quantum-enhanced sensing by echoing spin-nematic squeezing in atomic BEC**
*Wenxin Xu* | Tsinghua University

**14. Tunable Coupling Architectures with Capacitively Connecting Pads for Large-Scale Superconducting Multi-Qubit Processors**
*Guihan Liang* | Institute of Physics, CAS

**15. Thermal Transport Phenomena of Antiferromagnetic Semiconductor BaMn2Bi2**
*Takuma Ogasawar* | Beijing Academy of Quantum Information Sciences

**16. Weyl phonons in chiral crystals**
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**17. Ultra-flat superconductor/semiconductor interface in a Al/Ge epitaxial film**
*Ding-Ming Huang* | Beijing Academy of Quantum Information Sciences

**18. Ultra-narrow 2D ferroelectric-paraelectric lateral superlattices**
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**19. Strain-induced Ordered Ge Hut Wires**
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**20. A Topological Phase Out of Equilibrium Without Localisation**
*Tom Lane* | Beijing Academy of Quantum Information Sciences

**21. Tunneling spectroscopic signatures of charge doping and Mott transition in α-RuCl3 in proximity to graphite**
*Xiaohu Zheng* | Beijing Academy of Quantum Information Sciences

**22. Error Mitigation Strategies for Eigenvalue Problems in Analog Quantum Simulation**
*Rui-Cheng Guo* | Tsinghua University

**23. Revealing multi-time quantum statistics without measurement back-action**
*Chunyang Luan* | Tsinghua University

**24. Observing synthetic spin exchange from Rydberg dressing in programmable atom array**
*Xinhui Liang* | Tsinghua University

**25. Enhanced localization in the prethermal regime of continuously measured many-body localized systems**
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**26. A Proposal for Quantum Computation verifying Quantum Simulation**
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**27. Topological Single-Photon Emission from Quantum Emitter Chains**
*Yubin Wang* | Tsinghua University

**28. High-quality parallel entangling gates in long mixed-species ion chains**
*Lin Cheng* | Peking University

**29. A method to measure the laser linewidth using time-resolved Hong-Ou-Mandel interference**
*YanFeng Li* |Beijing Academy of Quantum Information Sciences

**30. Spin squeezing with arbitrary quadratic collective-spin interaction**
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**31. Giant electrically tunable magnon transport anisotropy in a van der Waals antiferromagnetic insulator**
*Di Chen* | Beijing Academy of Quantum Information Science

**32. Classical interference origin of two-photon interference**
*Manman Wang* | Beijing Academy of Quantum Information Sciences

**33. Meissner effect induced Majorana zero modes at small magnetic field**
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**34. Variational ansatz inspired by quantum imaginary time evolution**
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**35. Single-Flux-Quantum-Activated Controlled-Z Gate for Transmon Qubits**
*Yifan Wang* | Shanghai Institute of Microsystem and Information Technology

**36. Codespace Entanglement of Orthogonal AQEC codes**
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**37. Equivalence between operator spreading and information propagation**
*Cheng Shang* | The University of Tokyo and RIKEN

**38. Tsallis relative α entropy of coherence dynamics in Grover′s search algorithm**
*Zhaoqi Wu* | Nanchang University

**39. Optimization Strategies for Collective Neutrino Oscillation Algorithms on Quantum Processors**
*Xiangjun Tan* | University of New South Wales

**40. Quantum computation based on dual-species of atomic-ions**
Pengfei Wang | Beijing Academy of Quantum Information Sciences

**41. An explicit evolution from Néel to striped antiferromagnetic states in the spin-1/2 J1-J2 Heisenberg model on the square lattice**
*Yun-Tong Yang* | Lanzhou University

**42. Simulating Many-Body Physics Via  Floquet Engineering**
*Zhao SK* | Beijing Academy of Quantum Information Sciences

**43. Design and Implementation of a Miniaturized Bell-Bloom Type Atomic Magnetometer**

*Weipeng Li* | Beijing Academy of Quantum Information Sciences

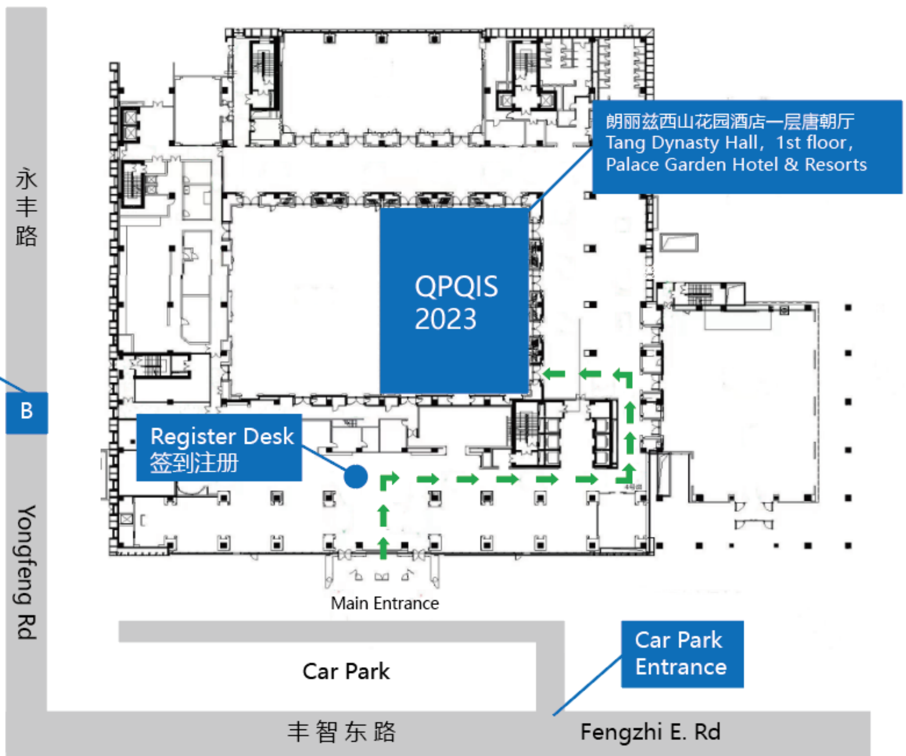
**44. Learning Mean-Field Dynamics of Spin Models with Neural ODE**
*Yaofeng Chen*| Tsinghua University

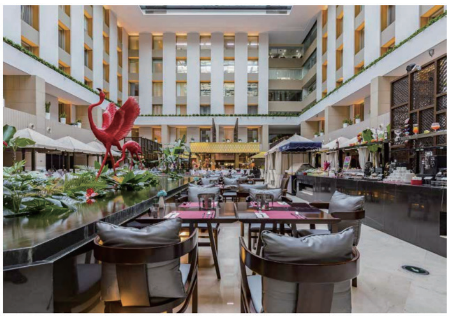
**45. Quantum Hamiltonian Algorithms for Maximum Independent Sets**
*Peiyun Ge* | Tsinghua University

All posters will be exhibited both onsite and online.

- **Onsite Poster Exhibition:** Tang Dynasty Hall (BC) (1st floor)
- **Online Poster Exhibition:** http://qpqis.baqis.ac.cn/2023/poster/poster-list
- **Poster Sessions:** 12:00 - 14:00 October 17 (Lunch/Poster Session)
  11:45 - 14:00 October 18 (Lunch/Poster Session)
  15:55 - 17:30 October 18 (Poster Session)
  11:45 - 14:00 October 19 (Lunch/Poster Session)
- **Announcement of Best Poster Awards:** 16:45 - 17:00 October 19

# LOCATION & MAPS



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