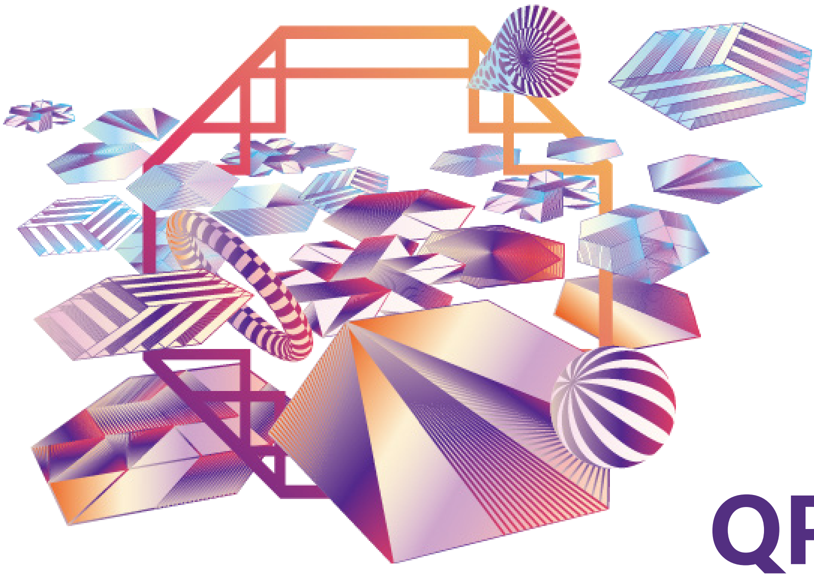
QPQIS 2022

The 4th International Symposium on Quantum Physics and Quantum Information Sciences

Theme: Advances in Fundamental Quantum Information Science Research
November 30 - December 1, 2022
Beijing, China

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



ABOUT QPQIS2022

Welcome to QPQIS-2022, the 4th edition of the International Symposium on Quantum Physics and Quantum Information Sciences, hosted by Beijing Academy of Quantum Information Sciences (BAQIS). QPQIS-2022 will be held on November 30 – December 1, 2022 (Beijing Time).

The theme of QPQIS-2022 is "Advances in Fundamental Quantum Information Science Research". Quantum information science is an intellectually exciting and rapidly developing field. QPQIS-2022 aims to provide an opportunity for international communities to exchange ideas and recent progress at its forefront. The main focus is on quantum computation implementations with superconducting circuits, semiconductor-based structures, topologically-encoded qubits, and neutral atoms. The meeting also covers new developments in quantum communication, quantum cryptography, and quantum networking.

QPQIS-2022 features 17 world-leading theoretical and experimental scientists as invited speakers to share their most recent breakthroughs.

QPQIS-2022 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:

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

MEMBER:

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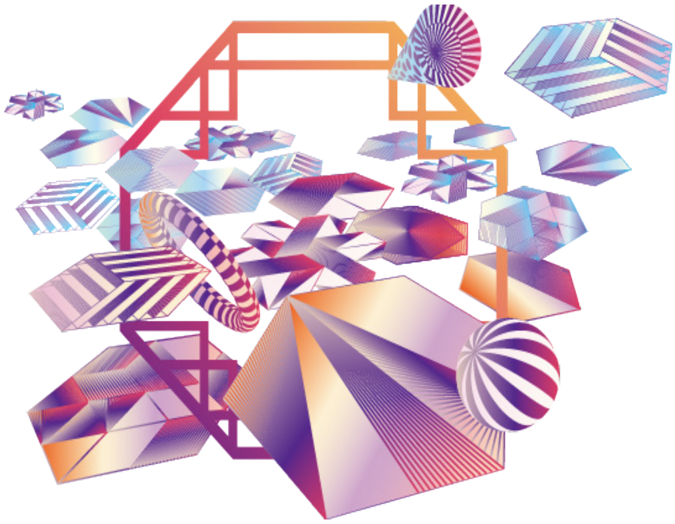
Gui-Lu LONG (Tsinghua Univ. / BAQIS)
Hong-Qi XU (Peking Univ. / BAQIS)
Li YOU (Tsinghua Univ. / BAQIS)
Huai-Bin ZHUANG (BAQIS)



BEIJING ACADEMY OF QUANTUM
INFORMATION SCIENCES

PROGRAM

Day 1 / November 30

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

09:00-09:05 **Opening Speech**
Qi-Kun XUE | President of BAQIS

09:05-09:10 **Opening Speech**
Tao XIANG | President of BAQIS

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

09:10-09:50 **Quantum Computation, Error Correction, and Simulation with Superconducting Qubits and Bosonic Modes**
Steven GIRVIN | Yale University, United States

09:50-10:30 **Advances in Quantum Machine Learning**
Seth LLOYD | Massachusetts Institute of Technology, United States

10:30-10:50 **Online Group Photo / Break**

10:50-11:30 **Quantum Computing of NP-complete Problems Using Rydberg Atoms**
Jaewook AHN | Korea Advanced Institute of Science and Technology, Korea

11:30-12:10 **Ultrafast Quantum Computer/Simulator with Attosecond Precision**
Kenji OHMORI | Institute for Molecular Science, Japan

SESSION 2 (Session Chair: *Hong-Qi XU* | Peking Univ. / BAQIS)

14:00-14:40 **Quafu Quantum Computation Cloud Platform**
Heng FAN | The Institute of Physics, Chinese Academy of Sciences / BAQIS , China

14:40-15:20 **Exploring New Semiconductor/Superconducting Hybrid Material**
Erik P.A.M. BAKKERS | Eindhoven University of Technology, Netherlands

15:20-15:40 **Break**

15:40-16:20 **Josephson Matter**
Charles MARCUS | Niels Bohr Institute, University of Copenhagen , Denmark

16:20-17:00 **Quantum State Discrimination for Sensing and Communication: Characterization and Engineering of Photon-varied Quantum States**
Andrea CONTI | University of Ferrara , Italy

17:00-17:40 **The Evolution of Quantum Key Distribution Networks: On the Road to the Qinternet in IEEE Communications Surveys and Tutorials, 2022**
Lajos HANZO | University of Southampton, United Kingdom

19:00-20:00 **Online Poster Discussion**

Day 2 / December 1

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

09:00-09:40 **Superconducting Quantum Computer and its Future Issues**
Jaw-Shen TSAI | Tokyo University of Science , Japan

09:40-10:20 **High Fidelity Quantum Control and Readout of Spins in Silicon**
Jason PETTA | The University of California, Los Angeles, United States

10:20-10:40 **Break**

10:40-11:20 **Suppressing Quantum Errors by Scaling a Surface Code Logical Qubit**
Yu CHEN | Google AI Quantum Laboratory, United States

11:20-12:00 **Long-distance Quantum Key Distribution**
Zhi-Liang YUAN | BAQIS, China

SESSION 4 (Session Chair: *Li You* | Tsinghua Univ. / BAQIS)

14:00-14:40 **Multi-Qubit Operations with Donor Spin Qubits in Silicon**
Andrea MORELLO | The University of New South Wales, Australia

14:40-15:20 **Kerr Squeezed Photon Statistics and Interferometry**
Gerd LEUCHS | Max Planck Institute for the Science of Light, Germany

15:20-15:40 **Break**

15:40-16:20 **Flying and Stationary Qubits – Challenges and Opportunities**
Klaus MØLMER | Niels Bohr Institute, University of Copenhagen, Denmark

16:20-17:00 **Quantum Nonlinear Optics with Rydberg States of Atomic and Solid-state Systems**
Thomas POHL | Aarhus University , Denmark

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

17:00-17:10 **Announcement of Best Poster Awards**
Tao XIANG | President of BAQIS

ABOUT THE SPEAKERS

Jaewook Ahn

Professor, Korea Advanced Institute of Science and Technology, Korea

Jaewook Ahn is a professor in the department of physics in Korea Advanced Institute of Science and Technology. He received his Ph. D in Physics from the University of Michigan in Ann Arbor, and BS and MS in Physics from Seoul National University in South Korea. His Ph.D thesis dealt with neutral-atom quantum computing, so called Rydberg-atom data register. During the postdoc period at Los Alamos National Laboratory, as a director-funded postdoctoral fellow, he investigated light-matter interactions of nano-scale quantum systems at THz frequency ranges. His current research at KAIST focuses on quantum applications of Rydberg atom systems including quantum computing, quantum simulations, and quantum metrology.

ABOUT THE SPEAKERS

Erik P.A.M. Bakkers

Professor, Doctor, Eindhoven University of Technology, Netherlands

After obtaining his PhD in nanoelectrochemistry at the University of Utrecht, Erik started working at Philips Research in Eindhoven in 2000. He started his own research group, and the team focused on nanowires - lines of material with a width of several tens of nanometers- an area he continues to research, looking at integration into semiconductors in particular. In 2010, his growing interest in fundamental research resulted in Erik joining the Technical University of Eindhoven as well as Delft Technical University as part-time professor in the Quantum Transport group. His current interest is in Quantum Materials, to detect and manipulate Majorana states, and in Hexagonal Silicon, to demonstrate and exploit the predicted direct band gap in this material. He has received the Technical Review award from MIT, ERC CoG, ERC AdG, Science AAAS Newcomb Cleveland Prize, and the Breakthrough of the Year 2020 by Physics World.

ABOUT THE SPEAKERS

Yu Chen

Lead Scientist, Google Quantum AI Lab, United States

Yu Chen is a research scientist at Google Quantum AI Laboratory, currently leading the Quantum Metrology team, focusing on technology developments to improve hardware performance needed to build a quantum computer. He received his PhD in physics from University of Minnesota and did his postdoc research in University of California – Santa Barbara, before joining Google in 2014. In Google, he and his team perform research over a wide range of spectrum, from new qubit architecture design to quantum operations optimization, gaining fundamental understanding and improving the system performance from the ground up.

ABOUT THE SPEAKERS

Andrea Conti

Professor, University of Ferrara, Italy

Andrea Conti is a Professor at the University of Ferrara and Research Affiliate at the MIT Wireless Information and Network Sciences Laboratory. His research interests involve theory and experimentation of wireless systems and networks including network localization and distributed sensing. He received the HTE Puskás Tivadar Medal, the IEEE Communications Society's Stephen O. Rice Prize in the field of Communications Theory, and the IEEE Communications Society's Fred W. Ellersick Prize. Dr. Conti has served as editor for IEEE journals, as well as chaired international conferences. He has been elected Chair of the IEEE Communications Society's Radio Communications Technical Committee. He is a co-founder and elected Secretary of the IEEE Quantum Communications & Information Technology Emerging Technical Subcommittee. Professor Conti is an elected Fellow of the IEEE and of the IET, and he has been selected as an IEEE Distinguished Lecturer.

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.

ABOUT THE SPEAKERS

Steven Girvin

Professor, Yale University, United States

After graduating in a high school class of 5 students in the village of Brant Lake, New York, Dr. Girvin earned a B.S. from Bates College and a Ph.D. in theoretical physics from Princeton University in 1977. Dr. Girvin joined Yale in 2001, where he is Eugene Higgins Professor of Physics and Professor of Applied Physics. From 2007 to 2017 he served as Yale's Deputy Provost for Research, overseeing science planning across Yale. From 2019 to 2021, he served as founding director of the Co-Design Center for Quantum Advantage, one of five Department of Energy national quantum information science research centers. Along with colleagues Michel Devoret and Robert Schoelkopf, Professor Girvin co-developed 'circuit QED' , the leading architecture for construction of quantum computers based on superconducting circuits. Dr. Girvin is a Foreign Member of the Royal Swedish Academy of Sciences and Member of the US National Academy of Sciences. In 2007, he and his collaborators, Allan H. MacDonald and James P. Eisenstein were awarded the Oliver E. Buckley Prize of the American Physical Society for their work on the fractional quantum Hall effect. In 2019, he and coauthor Kun Yang published the textbook "Modern Condensed Matter Physics" with Cambridge University Press.

ABOUT THE SPEAKERS

Lajos Hanzo

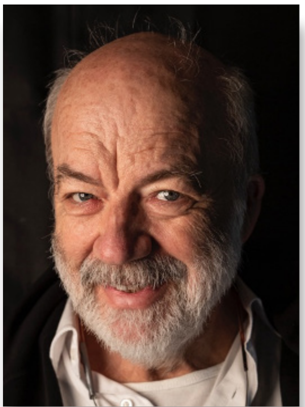
Professor, University of Southampton, United Kingdom

Lajos Hanzo FREng, FIEEE, FIET, RS Wolfson Fellow, received his 5-year Master degree in electronics from the Technical University of Budapest in 1976, his doctorate in 1983 and his Doctor of Sciences (DSc) degree in 2004. During his career in telecommunications he has held various research and academic posts in Hungary, Germany and the UK. Since 1986 he has been with the School of ECS, University of Southampton, UK, where he holds the Chair in Telecommunications. His current research interests are featured at this website (http://www-mobile.ecs.soton.ac.uk).

ABOUT THE SPEAKERS

Gerd Leuchs

Professor, Doctor, Max Planck Institute for the Science of Light, Germany



Gerd Leuchs is Director Emeritus at the Max Planck Institute for the Science of Light in Erlangen, professor emeritus at the University of Erlangen-Nuremberg and an adjunct professor with the physics department of the University of Ottawa. His scientific work includes quantum noise reduced and entangled light beams, solitons in optical fibres, quantum communication protocols, as well as studying the limits of focusing and applying this to atomic quantum gates and to nano photonics. In 2014 Gerd Leuchs won an advanced grant from the European Research Council, in 2017 a Julius-von-Haast Fellowship award from the Royal Society of New Zealand, and in 2018 a mega-grant from the Ministry of Science and Education of the Russian Federation and also. He is member of a number of advisory boards for quantum technology application and innovation in Germany and abroad. He holds honorary degrees from Danish Technical University and from St. Petersburg State University. He is a member of the German Academy of Sciences Leopoldina and a foreign member of the Russian academy of Sciences. He received the cross of merit of Germany and the Bavarian Maximilian Order. In 2022 he serves as vice-president of Optica formerly OSA.

ABOUT THE SPEAKERS

Seth Lloyd

Professor, Massachusetts Institute of Technology, United States

Seth Lloyd is professor of mechanical engineering at MIT and co-founder of Turing Quantum. Dr. Lloyd's research focuses on problems on information and complexity in the universe. He was the first person to develop a realizable model for quantum computation and is working with a variety of groups to construct and operate quantum computers and quantum communication systems. Dr. Lloyd has worked to establish fundamental physical limits to precision measurement and to develop algorithms for quantum computers for pattern recognition and machine learning. He is author of over two hundred scientific papers, and of `Programming the Universe,' (Knopf, 2004).

ABOUT THE SPEAKERS

Charles Marcus

Professor, Niels Bohr Institute, University of Copenhagen, Denmark

Charles Marcus was raised in Sonoma, California, USA, and was an undergraduate at Stanford University (1980-84). He received his Ph.D. in Physics from Harvard in 1990 and was an IBM postdoctoral fellow at Harvard from 1990-92. He then served on the Physics faculty at Stanford (1992-2000) and Harvard (2000-2011) where he also was Director of the Harvard Center for Nanoscale Systems (2006-2011). Marcus joined the Niels Bohr Institute (NBI), University of Copenhagen, in Denmark in 2012 as Villum Kann Rasmussen Professor, sponsored by the Villum Foundation, serving as Director of the Center for Quantum Devices, a Center of Excellence of the Danish National Research Foundation. From 2016-21 he was Scientific Director of Microsoft Quantum Lab–Copenhagen. He is a Fellow of the American Physical Society and the American Association for the Advancement of Science, a member of the US National Academy of Sciences and foreign member of the Danish Royal Academy of Science and Letters. In 1999 he was awarded the Industry Prize by the Danish Academy of Natural Sciences, and in 2020 was the first non-Dane to receive the H.C. Ørsted Gold Medal by the Society for the Dissemination of Natural Science.
Marcus's research interests focus on quantum coherent electronics and quantum matter, qubits, quantum chaos, complexity, and topology in condensed matter systems. A long-term research goal is to explore large-scale interconnected quantum coherent and topological systems for fundamental understanding of complex quantum materials and applications in quantum information.

ABOUT THE SPEAKERS

Klaus Mølmer

Professor, Niels Bohr Institute, University of Copenhagen, Denmark

Klaus Mølmer is a theoretical physicist, born in 1963. He obtained his PhD in 1990 and was appointed associate professor in 1991 and full professor in 2000 at Aarhus University, Denmark. Since June 2022 he has been full professor at the Niels Bohr Institute, University of Copenhagen. Klaus Mølmer has participated in numerous research centers and programs on quantum optics and quantum information. He has contributed to the understanding and application of dynamics, dissipation and measurements in quantum mechanics and quantum optics. He has developed key concepts for quantum computing gates with ions, atoms and photons. Klaus Mølmer has popularized science in more than 100 talks and in articles and book chapters, as well as in a Danish textbook on Quantum Mechanics. Klaus Mølmer has contributed to “quantum composition” of music and stage performances with composers, musicians, ballet dancers and other artists.

ABOUT THE SPEAKERS

Andrea Morello

Professor, UNSW Sydney, Australia

Andrea Morello is the Scientia Professor of Quantum Engineering at UNSW Sydney (Australia), and a Fellow of the American Physical Society. He received his PhD from the University of Leiden in 2004, followed by a postdoc at the University of British Columbia. His group at UNSW has pioneered the use of donor spins for quantum information processing, demonstrating the first electron and nuclear spin qubits in silicon. For these contributions he received numerous awards, including the 2017 Landauer and Bennett Award for Quantum Computing. His research interests further extend to quantum chaos, quantum foundations and quantum sensing. He is a passionate science communicator and a teacher: his YouTube videos gathered over 10M views, and he led the creation of the world's first bachelor's degree of Quantum Engineering at UNSW.by Physics World.

ABOUT THE SPEAKERS

Kenji Ohmori

Professor, Institute for Molecular Science, Japan

Kenji Ohmori is a Chair Professor at the Institute for Molecular Science (IMS), National Institutes of Natural Sciences, Japan. After receiving his Ph.D. from The University of Tokyo in 1992, he was a Research Associate and an Associate Professor at Tohoku University. In 2003 he was appointed a Full Professor at IMS.

Professor Ohmori is currently leading large-scale / long-term national projects on the development of ultrafast quantum simulators and quantum computers (2018-2030) generously supported with priority by the MEXT and Cabinet Office of the government of Japan, as one of the top runners in quantum technologies.

ABOUT THE SPEAKERS

Jason Petta

Professor, The University of California, Los Angeles, United States

Jason Petta is a professor of physics at UCLA. He received a PhD in physics from Cornell University in 2003. Early in his career, Petta played a leading role in a series of experiments demonstrating trapping and detection of single electrons, as well as a seminal experiment demonstrating coherent control of two-electron spin states. Recent advances in Petta's group include the fabrication of a scalable quantum dot device architecture in silicon, shuttling a single charge down an array of silicon quantum dots, and the demonstration of a high fidelity two qubit gate for spins in silicon. Petta's group has also developed hybrid quantum devices incorporating semiconducting and superconducting elements. Physics breakthroughs include the demonstration of strong coupling of a single charge to a single photon, strong coupling of a single spin to a single photon, and the long-range coupling of two spins separated by 4 mm using microwave frequency photons.

ABOUT THE SPEAKERS

Thomas Pohl

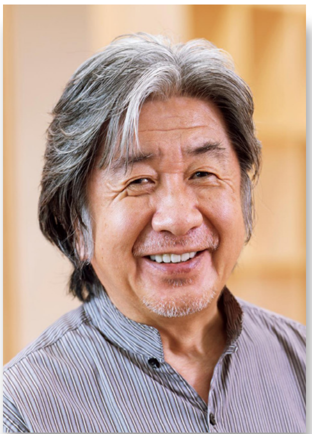
Professor, Aarhus University, Denmark

Thomas Pohl is Professor at Aarhus University, where he founded and currently leads the DNRF Center of Excellence for Complex Quantum Systems. His group conducts research in theoretical atomic physics, quantum optics and quantum many-body theory. Prior to joining Aarhus University, he has been leading a research group at the Max Planck Institute for the Physics of Complex Systems in Dresden and worked as an ITAMP Postdoctoral Fellow at the Harvard-Smithsonian Center for Astrophysics. He has been awarded a Niels Bohr Professorship by the Danish National Research Foundation, the Gustav-Hertz Award of the German Physical Society, and the Otto Hahn Medal of the Max Planck Society.

ABOUT THE SPEAKERS

Jaw-Shen Tsai

Professor, Tokyo University of Science, Japan



Jaw-Shen Tsai was born in 1952 in Taipei. He graduated from department of physics of University of California at Berkeley in 1975 and subsequently received his Ph.D. in Physics from State University of New York at Stony Brook. His research life has been devoted to the study of macroscopic quantum effect in superconductors, especially which associated with Josephson junctions. He has contributed to the area of condensed matter physics in both fundamental physics and their technological potential. He led the Josephson junction based qubit project at NEC Tsukuba laboratory for many years. He is also the Laboratory Head of Macroscopic Quantum Coherence Research laboratory in RIKEN Center for Quantum Computing. Since 2015, he is professor of physics at Tokyo University of Science. He has been working on the experiments connected quantum coherence in the Josephson systems. In this direction, his group has been pioneering the science and technology of superconducting quantum computing by demonstrating the first solid-state based qubit (1999), the first solid state CNOT gate (2003), a universal quantum gate operation (2007). Moreover, many important results relating to the quantum optics with artificial superconducting atom were demonstrated. He received Nishina Memorial Prize in 2004, Simon Memorial Prize in 2008, Leo Esaki Prize in 2014, Medal with Purple Ribbon in 2018, and Asahi Prize in 2021. He is a fellow of American Physical Society and a fellow of Japan Society of Applied Physics.

ABOUT THE SPEAKERS

Zhi-Liang Yuan

Chief Scientist, BAQIS, China

Zhiliang Yuan received his doctoral and post-doctoral training from Institute of Semiconductors, Chinese Academy of Sciences (1993 - 1997) and University of Oxford (1997-2001), respectively. He then spent 20-years at Toshiba Cambridge Research Laboratory before taking up the prestigious appointment as Chief Scientist at Beijing Academy of Quantum Information Sciences (BAQIS).

He is renowned for high-speed quantum key distribution (QKD), with notable achievements including the first 100 km (2003) and 600km (2020) fiber communication distances as well as the first 1 Mbit/s (2008) and 10 Mbit/s (2018) QKD systems. His other contributions include the first single photon LED (2001), self-differencing detectors (2006), directly phase-modulated source (2015) and twin-field QKD protocol (2017). He has published 130+ refereed journal publications, 130+ conference papers including 40+ invited/post-deadline and 50+ patents.

ABSTRACT

Day 1 Nov. 30, 2022
Session 1 09:10-09:50

Quantum computation, error correction, and simulation with superconducting qubits and bosonic modes

Steven M. Girvin
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Yale Quantum Institute, United States

This talk will present an overview of systems comprised of both superconducting qubits and microwave oscillators (bosonic modes). Such hybrid platforms offer powerful architectures with novel gates and instruction sets for quantum computation and hardware-efficient quantum error correction. Several different experiments using ‘bosonic codes’ have now reached and even exceeded the break-even point for the first time. In addition, recent experiments on quantum simulations of physical models containing bosons show that such simulations can be vastly more efficient on platforms containing bosonic modes. I will illustrate these capabilities with recent experiments on a programmable quantum simulator that uses efficient boson sampling of microwave photons to predict the Franck-Condon vibrational spectra of various small molecules.

Day 1 Nov. 30, 2022
Session 1 09:50-10:30

Advances in quantum machine learning

Seth Lloyd
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Massachusetts Institute of Technology, United States

Quantum systems can generate patterns in data that classical systems cannot generate. The field of quantum machine learning asks whether quantum information processors can find patterns in data that classical machine learning systems cannot find. The answer to this question is Yes. This talk reviews basic concepts in quantum machine learning, and shows how quantum computers can give potential speedups over classical computers for deep learning, kernel methods, regression and data analysis, financial analysis, and the topological analysis of data. We present approaches to answering the fundamental question facing quantum machine learning algorithms: How to process large amounts of classical data so that it can be loaded onto near term quantum computers?

Day 1 Nov. 30, 2022
Session 1 10:50-11:30

Quantum computing of NP-complete problems using Rydberg atoms

Jaewook Ahn
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Korea Advanced Institute of Science and Technology, Korea(South)

Currently there are growing interests in using Rydberg atom arrays for quantum computing of classically intractable problems, for example, the non-deterministic polynomial-time complete (NP-complete) problems. It has been identified some NP-complete problems are easily implementable with intrinsic Hamiltonians of interacting Rydberg atoms, of which atom arrangements define the problems in such a way that their solutions are compilable from the ground states of the Rydberg many-body Hamiltonians [1]. In the presentation, we first review our recent Rydberg-atom experiments performed for one of the NP-complete problems, the Maximum Independent Set (MIS) problem, in which we have investigated MIS solutions of planar and nonplanar graphs implemented with atoms used as data qubits and quantum wires [2,3]. Further, we discuss the experimental possibilities and also the technical requirements of Rydberg-atom implementation of other NP-complete problems such as 3-SAT, Set Packing, Graph Coloring, and Clique problems as well as Binary Integer Linear Programming.

[1] H. Pichler et al., "Quantum optimization for maximum independent set using Rydberg atom arrays," arXiv:1808.10816 (2018).
[2] M. Kim et al., "Rydberg Quantum Wires for Maximum Independent Set Problems with Nonplanar and High-Degree Graphs," Arxiv:2109.03517 (2022)
[3] A. W. Byun et al., "Quantum simulation of Ising spins on Platonic graphs," Arxiv:2203.01541 (2022).

Day 1 Nov. 30, 2022
Session 1 11:30-12:10

Ultrafast quantum computer/simulator with attosecond precision

Kenji Ohmori
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Institute for Molecular Science, National Institutes of Natural Sciences (NINS), Japan

Many-body correlations govern a variety of important quantum phenomena including the emergence of superconductivity and magnetism in condensed matter as well as chemical reactions in liquids. Understanding quantum many-body systems is thus one of the central goals of modern sciences and technologies. Here we demonstrate a new pathway towards this goal by generating a strongly correlated ultracold Rydberg gas with a broadband ultrashort laser pulse. We have applied our ultrafast coherent control with attosecond precision [1] to a strongly correlated Rydberg gas in an optical dipole trap, and have successfully observed and controlled its ultrafast many-body electron dynamics [2,3]. This new approach is now applied to an atomic BEC, Mott insulator lattice, and arbitrary array assembled with optical tweezers to develop into a pathbreaking platform for quantum simulation and computation on the ultrafast timescale [4-8].

References

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[3] C. Liu et al., Phys. Rev. Lett. 121, 173201 (2018).
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[8] UC Boulder / NIST Quantum Technology Website: CUbit Quantum Initiative
https://www.colorado.edu/initiative/cubit/newsletter/newsletter/june-2020
"A metal-like quantum gas: A pathbreaking platform for quantum simulation"

Day 1 Nov. 30, 2022
Session 2 14:00-14:40

Quafu quantum computation cloud platform

Heng Fan
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The Institute of Physics, Chinese Academy of Sciences / BAQIS , China

I will introduce our newly developed quafu quantum computation cloud platform, which is available at: http://quafu.baqis.ac.cn. This quantum cloud is available for public, users can use this quantum computation resources after registration. We provide three methods to input quantum circuits, graphic interface, open QASM and client-end of Python. There are currently three processors with respectively 45, 18 and 10 qubits to use for quantum circuits. I will also talk about our recent research results about quantum simulation.

Day 1 Nov. 30, 2022
Session 2 14:40-15:20

Exploring new semiconductor/superconducting hybrid material

Erik P.A.M. Bakkers
e.p.a.m.bakkers@tue.nl
Department of Applied Physics, Eindhoven University of Technology, the Netherlands

Signatures of Majorana Zero Modes have been collected over the last decade, but there is no definitive proof of the existence of these states. Most likely the level of disorder in these devices succeeds the energy scale of that associated with the topological gap. Disorder may be present within the semiconductor, at the surface of the semiconductor, or at the semiconductor/superconductor interface. In this work, we explore new hybrid combinations, which should lead to larger topological gaps, and a better screening of charged defects and impurities. We study the growth of PbTe, which is a trivial semiconductor but with strong spin orbit coupling, and SnTe, a material that has been predicted to be a topological crystalline insulator, and combinations of these two, ternary alloys. This system can be combined with Pb and Sn as superconductors, resulting in a new materials platform, which we envision to be promising for realizing topological superconductivity.

Day 1 Nov. 30, 2022
Session 2 15:40-16:20

Josephson Matter

Charles Marcus
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Niels Bohr Institute, University of Copenhagen, Denmark

In this talk, I will apply hybrid materials made from epitaxial semiconductor-superconductor heterostructures to the problem of Josephson arrays and networks. Semiconductor Josephson junctions have properties not found in typical tunnel junctions, including high transparency, large spin orbit coupling, gradients of g factor across the interface, and, voltage controlled Josephson coupling. These properties are being used to make topological devices, voltage controlled transmon qubits, and arrays of junctions with frustration and complex vortex dynamics. Research supported by Danish National Research Foundation and a grant from VILLUMFONDEN.

Day 1 Nov. 30, 2022
Session 2 16:20-17:00

Quantum state discrimination for sensing and communication: characterization and engineering of photon-varied quantum states

Andrea Conti
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Department of Engineering, University of Ferrara, Italy
https://wcln.unife.it/

Quantum state discrimination (QSD) is a key enabler for sensing and communication in quantum networks. This talk will (i) present preliminaries on quantum state discrimination, (ii) describe a new class of non-Gaussian states, namely photon-varied quantum states (PVQSs), and (iii) discuss how to engineer such states for improved QSD. Results will quantify how the design of quantum systems that exploit the non-Gaussian properties of PVQSs significantly improves the QSD performance.

Day 1 Nov. 30, 2022
Session 2 17:00-17:40

The evolution of quantum key distribution networks: on the road to the qinternet in IEEE communications surveys and tutorials, 2022

Cao, Zhao, Wang, Zhang, Ng and *Hanzo
*Presenter
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ECS, University of Southampton, UK

Quantum science is developing an ever faster pace and as a benefit, Quantum key distribution (QKD) solutions have become an off-the-shelf commercial reality. However, they rely on point-to-point single-user communications either via optical fiber or free space links. The quantum keys are negotiated between a pair of QKD nodes, but they can be shared amongst multiple geographically ditributed users. The challenge is that the quantum-domain information must not be amplified during its transmission, because that would destroy the quantum states, which would collapse back into the classical domain. This inevitably limits the distances that can be bridged over. The design of large-scale QKD networks requires sophisticated relaying techniques, which may evolve through the following four stages:

1. At the current state-of-the-art optical switches may be harnessed in multi-node QKD networks;
2. The next evolutionary stage relies on so-called trusted relays, which are deemed to be 'trustworthy' because they are placed in protected customer premises;
3. The family of 'trusted relays' requires substantial further scientific advances for ensuring that they remain secure with the aid of sophisticated protocol design even of the eavesdropper had physical access to them;
4. Finally, true quantum relays would have to be developed in the future relaying quantum entanglement;

We conclude with a discussion of potential future research direction and provide design guidelines for QKD networks. Please join this exciting journey valued Colleague in constructing the Quantum Internet!

Day 2 Dec. 1, 2022
Session 3 09:00-09:40

Superconducting quantum computer and its future issues

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Superconducting qubit technology is arguably the most advanced platform for the quantum computer. In recent years, commercial superconducting quantum computers and quantum annealers have already started to serve the general public. However, to further scale up the performance, there still exist many important issues for superconducting quantum system. It is crucial to improve the accuracy of the gate operations, and in this direction, further increase in the coherence time of the qubit is important. Coherence time is strongly influenced by the environments surrounding the superconducting qubit such as surface of substrate and qubit itself, and optimizations of these surface material/processing issues would be of vital importance. The further integration of the number of the qubits on a chip is required for practical quantum computers. The wiring and packaging of the integrated qubit chip is one of the challenging problems in the scaling of the quantum system. Currently, the difficulty is dealt with sophisticated 3D wring technologies. The recently proposed micro architecture that utilizes a seudo-2D wiring network might be able to help circumvent the hurdle.

Day 2 Dec. 1, 2022
Session 3 09:40-10:20

High fidelity quantum control and readout of spins in silicon

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Electron spins are excellent candidates for solid state quantum computing due to their exceptionally long quantum coherence times [1]. In the past few years, silicon spin qubits have transitioned from basic demonstrations of quantum control to high fidelity gate operations that may be sufficient to support quantum error correction. I will describe recent experiments where we achieve single spin initialization and readout with errors <1%, single qubit control with a fidelity exceeding 99.95%, and a two-qubit gate with a fidelity of 99.8% [2,3]. These results pave the way for more advanced spin qubit implementations using industrially fabricated silicon quantum devices.

[1] G. Burkard, T. D. Ladd, J. M. Nichol, A. Pan, J. R. Petta, Semiconductor Spin Qubits, Reviews of Modern Physics (in press).
[2] A. R. Mills, C. R. Guinn, M. M. Feldman, A. J. Sigillito, M. J. Gullans, M. Rakher, J. Kerckhoff, C. A. C. Jackson, J. R. Petta, High fidelity state preparation, quantum control, and readout of an isotopically enriched silicon spin qubit, Physical Review Applied (in review).
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Day 2 Dec. 1, 2022
Session 3 10:40-11:20

Suppressing quantum errors by scaling a surface code logical qubit

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Implementing practical quantum applications requires error rates that would not be possible without error correction. In this talk, we report the research progress that Google Quantum AI has been making in developing technologies towards error-corrected quantum computing. We will review the performance of logic qubits scaling across different code distances, both in forms of surface code and repetition code. We demonstrate that our superconducting quantum qubits have sufficiently low physical errors that error correction starts to improve logic qubit performance with increasing system size. We also provide detailed modeling of the experiment, from which we can extract an error budget that highlights the critical challenges to be addressed in order to achieve scalable quantum error correction.

Day 2 Dec. 1, 2022
Session 3 11:20-12:00

Long-distance quantum key distribution

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Communication at the single photon level enables quantum key distribution (QKD) to achieve

a revolutionary milestone in information security, allowing distant users to establish cryptographic keys with verifiable secrecy. Point-point fibre-optic QKD systems are already commercially available. In such systems, quantum signals experience the loss of the entire link and thus their maximally achievable rates scale linearly with the channel transmittance (η). This rate-loss scaling leads to a prohibitively low rate for long haul links, while such links often bear strategic importance for connecting metropolitan cities.

With its inception in 2018, twin-field (TF) QKD [1] has rapidly risen as a viable solution to long-distance secure fibre communication thanks to its fundamentally repeater-like rate-loss scaling. However, its implementation complexity, if not successfully addressed, could impede or even prevent its advance into real-world. Here we introduce a novel technique that can stabilise an open channel and has general applicability to phase-sensitive quantum communications. Using locally generated frequency combs to establish mutual coherence, we develop a simple and versatile TF-QKD setup that does not need service fibre and can operate over links of 100 km asymmetry. We confirm the setup's repeater-like behaviour over a fibre distance of 615.6 km.

[1] M. Lucamarini, Z. L. Yuan, J. F. Dynes and A. J. Shields, Nature 557, 400 (2018).
[2] L. Zhou, J. Lin, Y. Jing and Z. Yuan, arXiv:2208.09347v1 (2022).

Day 2 Dec. 1, 2022
Session 4 14:00-14:40

Multi-qubit operations with donor spin qubits in silicon

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Donor atoms in silicon are a versatile platform for experiments in quantum information processing, as well as quantum foundations. The electron [1] and nuclear [2] spin of a 31P donor were the first qubits demonstrated in silicon, and went on to become among of the most coherent qubits in the solid state, with coherence times exceeding 30 seconds [3], and quantum gate fidelities approaching 99.99% [4]. This talk will provide an overview of the strategies we are devising to scale up beyond singe, isolated donors. Some of these methods have been already experimentally demonstrated, while others are in progress.

Using magnetic resonance, we have demonstrated an exchange-based 2-qubit CROT gate for electron spins [5], in a device where we implanted a high dose of 31P donors. Future experiments will focus on using deterministic, counted single-ion implantation, for which we have recently demonstrated the capability to detect an individual ion with 99.85% confidence [6]. With nuclear spins, we have achieved the landmark result of universal 1- and 2-qubit logic operations with >99% fidelity, and prepared a 3-qubit GHZ entangled state with 92.5% fidelity [7]. We have also demonstrated the coherent electrical control of an electron-nuclear flip-flop qubit [8], which will greatly facilitate the integration of single-atom qubits in nanoelectronic devices.

Heavier donors possess a high nuclear spin quantum number and a nonzero electric quadrupole moment. In the process of operating a single spin-7/2 123Sb nucleus, we (re)discovered the phenomenon of nuclear electric resonance, and applied it for the first time to a single nuclear spin [9]. Encoding quantum information in the larger Hilbert space of high-spin nuclei will enable interesting options for logical qubit encoding and quantum error 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.

[1] J. Pla et al., Nature 489, 541 (2012)
[2] J. Pla et al., Nature 496, 334 (2013)
[3] J. Muhonen et al., Nature Nanotechnology 9, 986 (2014)
[4] J. Muhonen et al., J. Phys: Condens. Matter 27, 154205 (2015)
[5] M. Madzik et al., Nature Communications 12, 181 (2021)
[6] A. Jakob et al., Advanced Materials 34, 2270022 (2022)
[7] M. Madzik et al., Nature 601, 348 (2022)
[8] R. Savytskyy et al., arXiv:2022.04438 (2022)
[9] S. Asaad et al., Nature 579, 205 (2020)
[10] J. Gross, Phys. Rev. Lett. 127, 010504 (2021)

Day 2 Dec. 1, 2022
Session 4 14:40-15:20

Kerr squeezed photon statistics and interferometry

Gerd Leuchs
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In the last twenty years, considerable effort has been invested into studying squeezing coherent states of light by the optical Kerr effect [1], motivated partly by Kerr interaction squeezing being hard to avoid. It comes, so to say, for free with no phase matching condition that has to be fulfilled. On the other hand, typical Kerr nonlinearities are fairly small so that the effect is only observable, if the incoming coherent light is intense enough, the interaction is long enough and losses are small enough. Therefore, the experimental studies concentrated on optical waveguides, such as fibers of several meter length, using pulses preferentially in the soliton domain to enhance the over-all effect [2]. The Kerr effect induces a nonlinear phase shift, such that the resulting ellipse in phase space is tilted with respect to amplitude and phase quadrature. Consequently, the squeezing cannot be seen in direct intensity detection, which also complicates the potential sensitivity enhancement of an interferometer. We report on a new experimental study, and a modified set-up allowing for reliably generating 5dB of two-mode squeezing [3]. Manipulating the two-mode squeezed state using standard linear optic unitary transformations, we demonstrated the enhancement of interferometric sensitivity at IAP RAS. In addition, we are studying different glasses with higher Kerr effect [4].

[1] U.L. Andersen, T. Gehring, Ch. Marquardt, G. Leuchs; Phys. Scr. 91, 053001 (2016).
[2] R. Dong, J. Heersink, J.F. Corney, P.D. Drummond, U.L. Andersen, G. Leuchs; Opt. Lett. 33, 116 (2008)
[3] N. Kalinin, T. Dirmeier, A. Sorokin, E.A. Anashkina L.L. SÃ¡nchez-Soto, J.F. Corney, G. Leuchs, Alexey V. Andrianov, arXiv2209.14100 (2022)
[4] A.A. Sorokin, E.A. Anashkina, J.F. Corney, V. Bobrovs, G. Leuchs, A.V. Andrianov; Photonics 8, 226 (2021)

Day 2 Dec. 1, 2022
Session 4 15:40-16:20

Flying and stationary qubits – challenges and opportunities

[1]*Klaus Mølmer, [2]Fan Yang, Mads Middelhede Lund, [2]Victor Rueskov Christiansen.
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[2]Department of Physics and Astronomy, University of Aarhus, Denmark

With the scaling of quantum technologies to many separate material quantum components, we may have recourse to couple these systems by quantum radiation of light, microwaves or phonons. In future optical quantum processors, we may – conversely - need to manipulate the quantum states of radiation pulses by their interaction with non-linear stationary quantum components.

While several physical processes have been proposed and already demonstrated for these tasks, there are rather fundamental obstacles to, e.g., merely interchange flying and stationary qubits in circuits for quantum computing. These obstacles include the general multimode character of propagating fields and the duration and spatial extent of useful light and microwave pulses.

The talk will review methods to deal theoretically with these obstacles, and it will present examples of new, unforeseen, possibilities for preparation and manipulation "on the fly" of quantum states of light and matter.

References:

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arXiv:2207.01914: https://arxiv.org/abs/2207.01914

Day 2 Dec. 1 , 2022
Session 4 16:20-17:00

Quantum nonlinear optics with Rydberg states of atomic and solid-state systems

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The ability to generate and manipulate quantum states of light via effective photon-photon interactions holds exciting scientific and technological perspectives.

In this talk, I will discuss different ideas to realize optical nonlinearities that are sufficiently strong to act at the level of individual light quanta and thereby generate effective interactions between photons. In particular, I will describe how one may engineer distinct types of photon-photon interactions by exploiting interactions between collectively excited Rydberg states in cold gases of atoms, ordered atomic arrays, or excitons in semiconducting materials. Moreover, we will explore emerging many-body phenomena in the resulting dynamics of multi-photon states as well as potential applications of controllable few-body interactions between photonic qubits.

POSTER LIST

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Yuchen Guo | Department of physics, Tsinghua University

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03. High-temperature superconductivity and robustness against magnetic polarization in monolayer FeSe/$EuTiO_3$
Chong Liu | Beijing Academy of Quantum Information Sciences

04. Topological Dynamical Decoupling
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08. ScQ cloud quantum computation for generating Greenberger-Horne-Zeilinger states of up to 10 qubits
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09. Detection of highly entangled states supported by reinforcement learning
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11. Simulating quantum Hall effects on a superconducting quantum processor
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13. Classically Replaceable Operations
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14. Observing topological zero modes on a 41-qubit superconducting processor
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15. Observation of entanglement transition of pseudo-random mixed states
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16. Quantum simulation of non-Hermitian systems using linear combination of unitaries
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17. Strain effects in spiral antimonene
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19. Neural-network quantum state with proximal optimization
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20. Experimental Observation and Enhanced Sensing of Exceptional Points in Thermal Atomic Ensemble
Chao Liang | Tsinghua University

21. VEntanglement-Enhanced Quantum Metrology in Colored Noise by Quantum Zeno Effect
Wanting He | Beijing Normal University

22. Joint Estimation of Non-commuting Parameters in Spinor Condensates
Xinwei Li | Graduate School of China Academy of Engineering Physics

23. Rydberg Atom Array: Programmable Quantum Processor
Xinhui Liang | Tsinghua University

24. Complex Landau levels and related transport properties in the strained zigzag graphene nanoribbons
Junjie Qi | Beijing Academy of Quantum Information Sciences

25. Realizing Site-selective Spin-Spin Interactions via Multicolor Rydberg Dressing
Xiaoling Wu | Tsinghua University

26. QNUS: Reducing Terminal Resources in Quantum Secure Direct Communication Network Using Switches
Penghao Niu | Beijing Academy of Quantum Information Sciences

27. Variational quantum algorithm for node embedding
Hang Li | Beijing Academy of Quantum Information Sciences

28. A Probabilistic Imaginary-Time Evolution Algorithm Based on Non-unitary Quantum Circuit
Xie Hao-Nan | Tsinghua University

29. Extracting the Quantum Geometric Tensor of a Topological Raman Lattice by Bloch State Tomography
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30. Realization of quantum secure direct communication over 100 km
Haoran Zhang | Tsinghua University

31. Charge states, triple points and quadruple points in an InAs nanowire triple quantum dot revealed by an integrated charge sensor
Weijie Li | Peking University

32. Quantum enhanced sensing by echoing spin-nematic squeezing in atomic Bose-Einstein condensate
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33. Imaging system of optical array of Yb-171 atoms
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34. Quantum simulation with alkaline-earth (-like) atoms
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36. Characterizing Superradiant Phase of the Quantum Rabi Model
Yun-Tong Yang | Lanzhou University

37. Quantum calibrated magnetic force microscopy
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38. A Dilution-Refrigerator-Based Scanning Microwave Impedance Microscope
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39. Deterministic Quantum Logic for Flying Qubits in Waveguide QED Systems
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40. Variational Matrix Product State Approach for Non-Hermitian System Based on a Companion Hermitian Hamiltonian
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42. Subsystem Product Codes with Gauge Fixing and ReShape Decoder
Weilei Zeng | Zhejiang Lab

43. Growth and characterization of high quality Ge/SiGe planar heterostructure for hole spin qubit
Jieyin Zhang | Beijing Academy of Quantum Information Sciences

44. Controllable Growth of Ge Hut Wires
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45. Optimized robust entangling gates in ion-trapped quantum computation
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46. Observation of Magnetic Order in Monolayer $NiPS_3$
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47. Properties of dissipative Floquet Majorana modes using a quantum dot
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48. Quantum Computation, Simulation and Metrology with Neutral Atoms
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49. Quantum Transport Phenomena in InAs-epitaxial-Al Nanowires Hybrid Junction Devices
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50. The Application of Quantum Machine Learning in High Energy Physics
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51. Spin-orbit interaction and g factor for the holes in Ge hut wires: A k·p theory study
Yi Luo | Peking University

52. Magnetic field induced insulator to metal transition of antifferomagnet BaMn2Bi2
Takuma Ogasawara | Beijing Academy of Quantum Information Sciences

53. Anomalous universal conductance as a hallmark of non-locality in a Majorana-hosted superconducting island
Yiru Hao | Tsinghua University

54. Electrostatic effects of the MnBi2Te4-superconductor hetero-structures in chiral Majorana search

Li Chen | Tsinghua University

55. Tracing signatures of topological superconductivity in ultra-thin InAs-Al nanowire system

Huading Song | Beijing Academy of Quantum Information Sciences

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  13:00-13:45, Nov.30 (Wed) and *Dec. 1 (Thu)*
  Zoom Meeting ID - 775 921 8510
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