3rd International Conference On
Emerging Quantum Technology

ICEQT 2025

3rd

September 18-22
Huifeng Wanyun Hotel,
Hefei, China

International Conference on Emerging Quantum Technology

第三届新兴量子技术国际会议

HANDBOOK

Intro to ICEQT2025

2025 is a special year that is proclaimed by the United Nations as the International Year of Quantum Science and Technology (IYQ) as it recognizes 100 years since the initial development of quantum mechanics. Serving as one of the important events in China in celebration of IYQ, the 3rd International Conference on Emerging Quantum Technology (ICEQT2025) will take place from September 18-22, 2025, in Hefei, China. As a biennial international conference series, ICEQT is committed to providing an appropriate and timely platform for the community to celebrate the latest achievements and exchange new ideas. During the conference, On September 20, the ceremony for Micius Quantum Prize, which was established by the Micius Prize Foundation, will also be held to award the laureates of 2023 and 2025.

History of ICEQT

Building on the strong foundation established by ICEQT2019, ICEQT2023 further expanded the conference's impact by bringing together over 650 scientists and scholars from 17 countries in Hefei, China. A highlight of ICEQT2023 was the 2020 and 2021 Micius Quantum Prize Ceremony, where laureates were honored for their groundbreaking contributions and delivered exceptional award talks.

The origins of ICEQT trace back to its predecessor, the International Conference on Quantum Foundation and Technology (ICQFT), which was held four times over thirteen years, including ICQFT2006 in Hangzhou, ICQFT2009 in Shanghai, ICQFT2012 in Dunhuang, and ICQFT2016 in Shanghai. This long-standing history of quantum research gatherings laid the groundwork for ICEQT to evolve into a premier biennial conference in the field.

Scope of ICEQT2025

- Quantum Communication
- Quantum Computing and Simulations
- Quantum Measurement and Metrology
- Quantum Foundations
- Quantum for AI

Committee (2025)

Advisory Committee Members

Rainer Blatt	University of Innsbruck (2018 Micius Quantum Prize winner)
Immanuel Bloch	Max Planck Institute of Quantum Optics / LMU Munich (2025 Micius Quantum Prize winner)
Ignacio Cirac	Max Planck Institute of Quantum Optics (2018 Micius Quantum Prize winner)
Artur Ekert	University of Oxford / CQT / NUS Singapore / OIST (2019 Micius Quantum Prize winner)
Hidetoshi Katori	The University of Tokyo
Hoi-Kwong Lo	National University of Singapore
Yasunobu Nakamura	RIKEN / The University of Tokyo (2021 Micius Quantum Prize winner)
Jörg Schmiedmayer	TU Wien
Jaw-Shen Tsai	Tokyo University of Science / RIKEN
Jörg Wrachtrup	University of Stuttgart
Anton Zeilinger	Austrian Academy of Sciences (2022 Nobel Prize in Physics winner, 2019 Micius Quantum Prize winner)
Peter Zoller	University of Innsbruck (2018 Micius Quantum Prize winner)

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- *Chair: Jian-Wei Pan, University of Science and Technology of China*
- *Co-chair: Luming Duan, Tsinghua University*
- *Co-chair: Yi Luo, University of Science and Technology of China*

Yu-Ao Chen	University of Science and Technology of China
Youjin Deng	University of Science and Technology of China
Zhonghuai Hou	University of Science and Technology of China
Chao-Yang Lu	University of Science and Technology of China
Feihu Xu	University of Science and Technology of China
Qiang Zhang	University of Science and Technology of China

*Alphabetical Order

Plenary Talks

Yu-Ao Chen	University of Science and Technology of China
Artur Ekert (online)	University of Oxford / CQT / NUS Singapore / OIST
Hoi-Kwong Lo	National University of Singapore
Yasunobu Nakamura	RIKEN / The University of Tokyo
Jörg Schmiedmayer	TU Wien
Jaw-Shen Tsai	Tokyo University of Science / RIKEN
Xiaobo Zhu	University of Science and Technology of China

Micius Prize Talks

Immanuel Bloch	Max Planck Institute of Quantum Optics / LMU Munich
Tilman Esslinger	ETH Zurich
Nicolas Gisin	University of Geneva / Constructor University
Markus Greiner (online)	Harvard University
John Rarity	University of Bristol

Invited Talks

Xiao-Hui Bao	University of Science and Technology of China
Hannes Bernien	University of Innsbruck / IQOQI / University of Chicago
Antoine Browaeys	Institut d' Optique / CNRS
Michel Brune	Laboratoire Kastler Brossel / CNRS / Collège de France
Gerald Buller	Heriot-Watt University
Wenlan Chen	Tsinghua University
Marcos Curty	University of Vigo
Eleni Diamanti	CNRS / Sorbonne University
Peter D. Drummond	Swinburne University of Technology
Toshimori Honjo	NTT Basic Research Laboratories
Jinfeng Jia	Shanghai Jiao Tong University / Southern University of Science and Technology

Zeyang Li	Stanford University
W. Vincent Liu	University of Pittsburgh
Jevon Longdell	University of Otago
Fernando Luis	INMA / CSIC-Universidad de Zaragoza
Vadim Makarov	Russian Quantum Center / University of Vigo / National University of Science and Technology MISiS
Robert Mann	University of Waterloo
Nir Navon	Yale University
Francesco Petruccione	NITheCS / Stellenbosch University
Ernst Maria Rasel	Leibniz University Hannover
Arno Rauschenbeutel	Humboldt University of Berlin
Giacomo Roati	CNR-INO / LENS / University of Florence
Nicolas Sangouard	CEA Paris-Saclay
Piet O. Schmidt	Physikalisch-Technische Bundesanstalt / Leibniz University Hannover
Augusto Smerzi	CNR-INO / LENS
Yoshiro Takahashi	Kyoto University
James K. Thompson (online)	JILA / University of Colorado, Boulder
Masahito Ueda	The University of Tokyo / RIKEN CEMS
Da-Wei Wang	Zhejiang University
Martin Weitz	University of Bonn
Sen Yang	The Hong Kong University of Science and Technology
Xing-Can Yao	University of Science and Technology of China
Juan Yin	University of Science and Technology of China
Pan Zhang	Institute of Theoretical Physics, CAS
Zong-Quan Zhou	University of Science and Technology of China
Martin Zwierlein (online)	Massachusetts Institute of Technology

Supported by

- The Micius Quantum Foundation

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Conference Program

9-18 (Thursday)	9-19 (Friday)	9-20 (Saturday)	9-21 (Sunday)	9-22 (Monday)
Opening Ceremony (8:30-8:40)				
Chair: Luming Duan	*Chair: Feihu Xu*	*Chair: Xinhua Peng*	*Chair: Xiongfeng Ma*	*Chair: Xiao-Song Ma*
Prize Talk (8:40-9:30)			*Plenary Talk (8:40-9:30)*	
Nicolas Gisin	John Rarity	Tilman Esslinger	Yasunobu Nakamura	Xiaobo Zhu
Invited Talk (9:30-10:20)				
Juan Yin	Masahito Ueda	Xing-Can Yao	Arno Rauschenbeutel	Ernst Maria Rasel
Gerald Buller	Nicolas Sangouard	Augusto Smerzi	James K. Thompson (online)	Giacomo Roati
Coffee Break (10:20-10:50)				
Chair: Xiang-Bin Wang	*Chair: Zhen-Sheng Yuan*	*Chair: Zheng-Wei Zhou*	*Chair: Chang-Ling Zou*	*Chair: Zheng-Tian Lu*
Plenary Talk (10:50-11:40)	*Prize Talk (10:50-11:40)*		*Invited Talk (10:50-12:05)*	
Jörg Schmiedmayer	Immanuel Bloch	Markus Greiner (online)	Martin Zwierlein (online)	Fernando Luis
Invited Talk (11:40-12:05)			Zeyang Li	Yoshiro Takahashi
Toshimori Honjo	Robert Mann	Piet O. Schmidt	Antoine Browaeys	Jinfeng Jia
Lunch Break (12:05-14:15)				
Chair: Qiang Zhang	*Chair: Youjin Deng*	*Chair: Dapeng Yu*	*Chair: Xing Rong*	
Plenary Talk (14:15-15:05)				
Hoi-Kwong Lo	Artur Ekert (online)	Yu-Ao Chen	Jaw-Shen Tsai	
Invited Talk (15:05-15:55)				
Eleni Diamanti	Hannes Bernien	Wenlan Chen	Marcos Curty	
W. Vincent Liu	Nir Navon	Peter D. Drummond	Da-Wei Wang	
Coffee Break (15:55-16:25)				
Chair: Chuan-Feng Li	*Chair: Yiheng Lin*	**Poster Session (16:25-17:40)**	*Chair: Chang-Ling Zou*	
Invited Talk (16:25-17:40)			*Invited Talk (16:25-17:40)*	
Xiao-Hui Bao	Pan Zhang		Michel Brune	
Martin Weitz	Vadim Makarov		Francesco Petruccione	
Sen Yang	Jevon Longdell		Zong-Quan Zhou	
Buffet Dinner (18:30-)	Banquet (19:00-)	Buffet Dinner (18:30-)	Buffet Dinner (18:30-)	
		Micius Prize Ceremony (20:00-21:30)		

Prize Talk: 50 mins (40-min talk+10-min Q&A)

Plenary Talk: 50 mins (40-min talk+10-min Q&A)

Invited Talk: 25 mins (20-min talk+5-min Q&A)

Thursday, September 18

8:40-9:30
Micius Prize Talk

Nicolas Gisin
University of Geneva / Constructor University

Title: From "impossible" measurements in quantum field theory to the classification of all joint quantum measurements

Abstract: Naive attempts to put together relativity and quantum measurements lead to signaling between space-like separated regions. In QFT, these are known as impossible measurements. We show that the same problem arises in non-relativistic quantum physics, where joint nonlocal measurements (i.e., between systems kept spatially separated) in general lead to signaling. We recall how to measure non-local variables without signaling by exploiting entanglement as a resource, recovering thus the Born rule, but not the projection postulate. We use these findings to classify all joint quantum measurements from the simplest to the more complex ones, based on the required amount of entanglement necessary to measure them. In particular, we generalize the Elegant Joint Measurements from 2 qubits to an arbitrary number of parties.

With Flavio Del Santo, Jef Pauwels and Alejandro Pozas-Kerstjens

9:30-9:55
Invited Talk

Juan Yin
University of Science and Technology of China

Title: Progress in Testing Quantum Effects in Curved Spacetime

Abstract: The emergence of quantum mechanics and general relativity has radically transformed our understanding of nature, yet their integration poses immense challenges and their interplay remains untested. Recent theoretical work indicates that single-photon interference across large distances provides a promising pathway for testing quantum effects in curved spacetime. To explore this possibility, we carried out a series of ground-based verification experiments using unbalanced interferometers to emulate long-baseline single-photon interference under realistic atmospheric conditions. These efforts have successfully demonstrated high-precision phase stability over multi-kilometer free-space channels and validated critical technologies, including high-brightness single-photon sources and ultra-stable interferometric control. In this talk, I will first introduce the background and motivation for this new direction in experimental research. I will then present our recent progress in developing a satellite payload specifically designed for single-photon interference experiments in space. The ultimate objective of this work is to test gravitationally induced phase shifts in curved spacetime. Hopefully, these advances mark a significant step toward experimentally exploring quantum phenomena in gravitational fields.

9:55-10:20
Invited Talk

Gerald Buller
Heriot-Watt University

Title: Single-photon lidar for challenging imaging scenarios

Abstract: Picosecond resolution single-photon imaging approaches offer great potential for high-resolution three-dimensional profiling of remote objects in a number of application areas. Whilst slow data acquisition has traditionally been a major challenge, innovative routes to real-time 3D imaging of moving objects are being developed. This presentation reports progress in several aspects of time-resolved single photon imaging, including: imaging through clutter; imaging through high levels of atmospheric obscurants; potential for facial recognition at long range; and human activity recognition using neural networks trained on simulated data.

10:50-11:40
Plenary Talk

Jörg Schmiedmayer
Vienna Center for Quantum Science and Technology / Atominstitut / TU Wien

Title: Quantum Many-Body Systems and their Information Content

Abstract: Quantum Many Body Systems are at the basis of many Quantum Simulations. It is therefore of upmost interest to understand their information content and structure and how it can be manipulated and extracted or measured. One avenue, based on our understanding of quantum field theories, is based on correlation functions, which reveal the accessible structure [1] and their effective descriptions either directly [2] or through learning algorithms [3]. A different approach is through many-body tomography [4] which then allows to extract of von Neuman entropies. This allowed us to verify the area law for mutual information [5] in quantum many body systems. The tomography approach is limited to Gaussian effective models. Currently we are developing a new model agnostic approach, which allows to study also strongly correlated and topological systems. Finally, I will ask the question what it takes to erase information in a many-body system and present our experiments probing Landauer's principle in the quantum many-body regime [6].

Work performed in collaboration with the groups of P. Zoller (Innsbruck), Th. Gasenzer und J. Berges (Heidelberg), Jens Eisert (FU Berlin), E. Demler (Harvard/ETH) and Silke Weinfurtner (Nottingham). Supported by the DFG-FWF SFB ISOQUANT, and the ERC-AdG Emergence in Quantum Physcs (EmQ)

References:

[1] T. Schweigler et al., Nature 545, 323 (2017), arXiv:1505.03126.
[2] T. Zache et al., Phys. Rev. X 10, 011020 (2020).
[3] R. Ott et al., Phys. Rev. Res. 6, 043284 (2024).
[4] M. Gluza et al., Communication Physics 3, 12 (2020).
[5] M. Tajik et al., Nature Physics 19, 1022 (2023).
[6] S. Aminet et al., Nature Physics 21, 1326 (2025).

11:40-12:05
Invited Talk

Toshimori Honjo
NTT Basic Research Laboratories

Title: Quantum communication experiments using telecom-band entangled photon pairs

Abstract: We have been conducting quantum communication experiments using telecom-band entangled

photon pairs [1][2]. However, the coincidence rate and key generation rate have remained relatively low. Improving the distribution and detection rates of entangled photon pairs is crucial for enabling entanglement-based quantum communication and realizing a quantum internet. Although several experimental demonstrations have been reported, the achievable coincidence rates have thus far been limited. One of the primary bottlenecks is the dead time of single-photon detectors, which restricts coincidence detection at high photon-pair generation rates. To address this issue, we employ 16-pixel superconducting nanowire single-photon detectors (SNSPDs) to mitigate the effects of detector dead time [3][4]. Using 5-GHz clocked sequential time-bin entangled photon pairs, we performed two-photon interference and CHSH experiments. As a result, we achieved a coincidence rate exceeding 3 million counts per second (Mcps). To the best of our knowledge, this is the first demonstration of time-bin entangled photon-pair distribution and detection at multi-Mcps rates. We believe that this achievement represents a significant step toward the realization of a quantum internet and the advancement of photonic quantum information processing. Finally, we will briefly introduce standardization activities in JTC3 related to quantum technologies.

References:

[1] T. Honjo et al. Opt. Express, 15, 13957 (2007).

[2] T. Honjo et al. Opt. Express, 16, 19118 (2008).

[3] S. Miki et al. Opt. Lett. 46, 6015 (2021).

[4] T. Honjo et al. QCrypt 2024, poster, 171 (2024).

14:15-15:05 | **Hoi-Kwong Lo**
Plenary Talk | National University of Singapore

Title: Towards Secure Quantum Key Distribution

Abstract: I survey some recent progress towards secure quantum key distribution. Modulator side channels threaten the security of quantum key distribution systems. Here, I first review a newly discovered modulator side-channel, which applies to any practical bandwidth-limited modulators. Such a side channel violates the dimensional assumption, which is fundamental to the security of QKD and leads to unambiguous state discrimination (USD) attacks. After that, I present an overview of the recent development of the general theory and experiment on fully passive quantum key distribution, which removes modulator side channels completely by eliminating any modulators that carry secret information. Such a general theory can be applied to various use cases: continuous variable, BB84, twin-field (TF), and measurement-device-independent (MDI)-QKD. Proof-of-principle experimental demonstrations are also discussed. I will end with the scalability problem of the authentication in a multi-user QKD network and explain how the Distributed Symmetric Key Establishment (DSKE) protocol could solve this problem.

15:05-15:30 | **Eleni Diamanti**
Invited Talk | CNRS / Sorbonne University

Title: Advanced quantum networking: resources and applications

Abstract: Quantum networks at local and global scale are presently under deployment, with both optical fiber and satellite links, everywhere in the world. We discuss examples of applications of such networks spanning from ultra secure communication to advanced cryptographic and communication protocols in distributed architectures. The experimental demonstration of the obtained quantum advantage in each case relies on high performance photonic systems encoding quantum information on discrete or continuous properties of light. These advances enrich the resources and applications of quantum networks, which underpin quantum-safe communications and open the way to a new era of quantum connectivity in emerging quantum processor data centers.

15:30-15:55 | **W. Vincent Liu**
Invited Talk | University of Pittsburgh

Title: Fermionic atoms and electrons in orbital synthetic lattices

Abstract: Orbital degrees of freedom are central to the physics of a wide range of quantum matter, influencing phenomena such as superconducting pairing, magnetism, and density-wave ordering. Recent advances in the spatiotemporal control of cold atoms in optical lattices and electrons in quantum dots have opened new frontiers for exploring orbital physics beyond conventional quantum regimes, offering a complementary perspective to studies of synthetic quantum materials. In this talk, I will present a family of models with fermionic particles occupying the p-orbital bands of optical lattices. Such systems not only reproduce long-sought-after phases and effective models but also reveal unique, previously unexplored phases and quantum phase transitions. Examples include: (i) the low-energy physics of spinless fermions on a hexagonal lattice, described by a quantum 120-degree model closely related to the well-known Kitaev spin model, where degenerate orbital states serve as pseudospins; (ii) a ferro-orbital phase of spin-1/2 fermions in which the two-dimensional system spontaneously reduces into arrays of one-dimensional spin Luttinger liquids; and (iii) a purely repulsive interaction-driven quantum phase transition between ferromagnetic and antiferromagnetic order. Remarkably, this first-order FM–AFM transition appears to be absent in prior studies.

16:25-16:50 | **Xiao-Hui Bao**
Invited Talk | University of Science and Technology of China

Title: Long-distance entanglement between remote atomic quantum memories

Abstract: Quantum internet will enable a number of revolutionary applications, such as distributed quantum computing, distributed quantum sensing, and long-distance quantum communication via quantum repeater. Laser cooled atoms are a very promising approach for quantum internet, featuring long coherence time and collectively enhanced interaction with single photons. The current central theme in this direction is to improve the performance of fundamental building blocks and to construct small-scale networks which go beyond state of the art. In this talk, I will present our recent experimental progress, including the improvement of single-node performance, the extension of memory-memory entangling distance, and the construction of a metropolitan-scale quantum network etc.

16:50-17:15 | **Martin Weitz**
Invited Talk | University of Bonn

Title: Dissipative phases of a Bose-Einstein condensate of photons

Abstract: Photons in optical microcavities radiatively coupled to a room temperature bath, such as dye molecules or more recently also semiconductor materials, can operate as collective quantum systems of light at near thermal equilibrium conditions, enabling e.g. the observation of photon Bose-Einstein condensates [1-3]. I here report experiments observing a non-Hermitian phase transition in a photon Bose-Einstein condensate realized in the dye-microcavity platform. The dissipative phase transition occurs due to an exceptional point in the condensate that is associated with its radiative coupling to a bath of dye molecules and the (small) system losses. While usually Bose-Einstein condensation is separated by a smooth crossover to lasing, the presence of the here observed phase transition reveals a state of the light field characterized by a bi-exponential second order coherence that is separated by a phase transition from lasing [4]. In more recent work, we have studied periodic driving of the condensate of light [5]. We find that the exceptional point also closely relates to the elementary excitation spectrum of the photon condensate coupled to the reservoir of photo-excitable dye molecules.

References:

[1] J. Klaers, J. Schmitt, F. Vewinger, and M. Weitz, Nature 468, 545 (2010).

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[3] M. Pieczarka, M. Gebski, A. Piasecka, J. Lott, A. Peslter, M. Wasiak, and T. Czyszanowski, Nature Photon. 18, 1090 (2024).

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17:15-17:40 | **Sen Yang**
Invited Talk | The Hong Kong University of Science and Technology

Title: Progresses on quantum sensing based on Nitrogen-Vacancy Color Centers in diamond

Abstract: In recent years, color centers in wide-bandgap semiconductors have emerged as promising physical systems for quantum sensing. In this talk, we will review progress in this field and report on our work using nitrogen-vacancy color centers for quantum sensing in solid state physics. We will discuss how to use interface engineering technique from materials science field to improve the quantum coherence of those quantum sensors.

Friday, September 19

8:40-9:30 | **John Rarity**
Micius Prize Talk | University of Bristol

Title: From Path Interference to Quantum Technologies

Abstract: In the early 1980's we focused on experiments trying to prove the counter intuitive correlations predicted by quantum mechanics are correct and had discovered new ways to create entanglement through path interference. However, when Arthur Ekert showed us, we could use quantum interference to generate secure truly random bit strings (keys) at remote locations our focus moved towards applications. This led to our early experiments showing single photon interference and entanglement over many kilometers proving that quantum secure key exchange is possible (leading to this Micius prize). Beyond the exchange of single Qubits, the concept of entangling arrays of Qubits through quantum gates led Schor to discover exponential speed up is possible, in a future Quantum computer. Since then, astounding experimental progress has led to intermediate scale quantum computing demonstrators showing quantum supremacy in hero experiments. The ability to scale without incurring debilitating errors and loss beyond 100 physical Qubits is now the remaining challenge and no doubt latest results will be presented here at this conference. Here I will review some of our latest experiments in integrated quantum photonics addressing these challenges and also highlight experiments applying quantum photonic technologies in imaging, gas sensing and range finding.

9:30-9:55 | **Masahito Ueda**
Invited Talk | The University of Tokyo / RIKEN CEMS

Title: Topology of Discrete Feedback Control

Abstract: Topological phases of matter have been actively studied in physics for decades. Since the discovery of the quantum Hall effect, it has been recognized that topological structures in quantum and classical systems lead to robust physical phenomena. The general concept of topology can be utilized to classify not only static phases but also nonequilibrium dynamical phases. In fact, several important classes of nonequilibrium topological phases have been found in periodically driven systems [1] and non-Hermitian systems [2]. While dynamical control of topological phases has many practical applications such as photo-induced topological phase transitions [3] and topological lasers [4], out-of-equilibrium systems can exhibit genuinely dynamical topological phases that have no static analogues [1, 2, 5]. Thus, finding a new class of nonequilibrium topological phases not only provides a novel way of control of topological phases, but also expands the scope of topological phases of matter. In this talk, we develop a general framework to classify topology of quantum channels for discrete quantum feedback control, construct prototypical models of topological feedback control using Maxwell's demon, and report discovery of a new class of genuinely dynamical topological phases [6].

References:

[1] T. Kitagawa et al., Phys. Rev. B 82, 235114 (2010).

[2] Z. Gong et al., Phys. Rev. X 8, 031079 (2018).

[3] T. Oka and H. Aoki, Phys. Rev. B 79, 081406 (2009).

[4] M. A. Banders et al., Science 359, 6381 (2018).

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9:55-10:20 | **Nicolas Sangouard**
Invited Talk | CEA Paris-Saclay

Title: Quantum Threats and Opportunities for Secure Communication

Abstract: Algorithms that exploit quantum principles can efficiently solve mathematical problems that form the foundation of classical cryptographic systems. At the same time, these principles enable the development of cryptographic protocols with provable security guarantees. During this talk, I will present on-going efforts to precisely quantify the resources required to break widely used classical crypto-systems. I will also highlight recent results demonstrating that cryptographic keys can be distributed between remote locations with provable security guarantees—even in the extreme scenario where the quantum devices involved in the distribution are untrusted.

10:50-11:40 | **Immanuel Bloch**
Micius Prize Talk | Max Planck Institute of Quantum Optics / LMU Munich

Title: Quantum Simulations with Atoms and Molecules in Optical Lattices

Abstract: 40 years ago, Richard Feynman outlined his vision of a quantum computer for quantum simulations of complex calculations of physical problems. Today, his dream of analog and digital quantum simulations has become a reality and a highly active field of research across different platforms ranging from ultracold atoms and ions, to superconducting qubits and photons. In my talk, I will outline how ultracold atoms in optical lattices started this vibrant and interdisciplinary research field 20 years ago and now allow probing quantum many-body phases in- and out-of-equilibrium with fundamentally new tools and single particle resolution and control. Novel (hidden) order parameters, entanglement properties, full counting statistics or topological features can now be measured routinely in and out of equilibrium and provide deep new insight into the world of correlated quantum matter.

11:40-12:05 | **Robert Mann**
Invited Talk | University of Waterloo

Title: Sensing Superposed Spacetime

Abstract: One of the most basic expectations of quantum gravity is that gravitational fields can be placed in a state of superposition, analogous to what can be done for electromagnetic fields. However, in a relativistic context a gravitational field is equivalent to a particular spacetime, and so a superposed gravitational field is a superposed spacetime. Rather than consider how such a state might emerge from a quantum theory of gravity, I will discuss instead how such states might be probed by model 2-level detectors. Examples will include flat spacetimes, expanding spacetimes, black holes, and cosmic strings. Quantum interference between the superposed spacetimes leads to qualitatively new features in the detector response. I will discuss these and close with some comments as to how these ideas can be further explored.

14:15-15:05 | **Artur Ekert**
Plenary Talk (online) | University of Oxford / CQT / NUS Singapore / OIST

Title: Privacy for the paranoid ones—a device independent perspective

Abstract: Among those who make a living from the science of secrecy, worry and paranoia are simply signs of professionalism. Can we protect our secrets against adversaries who wield superior technological powers? Can we trust those who provide us with the very tools for protection? Recent developments in quantum cryptography suggest that privacy is possible under surprisingly weak assumptions. I will give an overview of how Bell inequalities, after shaping the foundations of quantum theory, have become a new tool for those who seek the ultimate limits of secrecy in the forthcoming quantum age.

15:05-15:30 | **Hannes Bernien**
Invited Talk | University of Innsbruck / IQOQI / University of Chicago

Title: Dual-Species Atom Array Quantum Processors

Abstract: Reconfigurable arrays of neutral atoms have emerged as a leading platform for quantum science. Their excellent coherence properties combined with programmable Rydberg interactions have led to intriguing observations such as quantum phase transitions, the discovery of quantum many-body scars, and novel quantum computing architectures.

Here, I am introducing a dual-species Rydberg array that naturally lends itself for measurement-based protocols [1] such as quantum error correction, long-range entangled state preparation, and measurement-altered many-body dynamics. Furthermore, Rydberg interactions between the two species then lead to novel regimes, including greatly enhanced resonant dipole interactions, that we use to demonstrate a two-qubit gate and quantum non-demolition readout [2].

I will present our current experiments on implementing a quantum cellular automata in a dual-species array. Cellular automata are famous for producing complex behavior as well as universal computation based on simple initial states and update rules. Here we investigate this paradigm by implementing an update rule based on dual species Rydberg blockade and periodic driving.

References:

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[2] Anand, Bradley, White, Ramesh, Singh, Bernien, Nature Physics 20, 1744 (2024).

15:30-15:55 | **Nir Navon**
Invited Talk | Yale University

Title: Quantum many-body physics with fermions in an optical box

Abstract: Recent advances in optical control of complex quantum systems have enabled revisiting long-standing questions, realizing thought experiments once inaccessible, and exploring new regimes [1]. I will present a series of studies on fermions confined in "boxes of light", a deceptively simple setting that reveals remarkably rich physics. Highlights include: few-body recombination in multicomponent fermions [2,3]; the first observation of the quantum Joule–Thomson effect for fermions [4]; strong-drive spectroscopy of Fermi-polaron quasiparticles [5]; the first direct measurement of the Lindhard response

[6]; and the observation of the emergence and breakdown of Fermi's Golden Rule in a strongly interacting quantum system [7]. Together, these results span thermodynamics, few-body physics, quantum impurity problems, and hydrodynamics, bringing long-predicted effects into view while uncovering unexpected phenomena.

References:

[1] Navon et al., Nature Phys. 17, 1334 (2021).
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16:25-16:50 | **Pan Zhang**
Invited Talk

Institute of Theoretical Physics, Chinese Academy of Sciences

Title: Decoding of quantum error-correcting codes: from exact spin glass solution to neural network decoder, then to quantum-circuit decoder

Abstract: In this talk, the speaker will first show how to map optimal maximum-likelihood decoding for certain quantum error-correcting codes—such as the surface code with independent qubit noise and the repetition code under circuit-level noise—into the exact computation of the partition function of planar spin glasses, yielding an exact decoder that runs in polynomial time. Next, the speaker will present a more general decoding framework based on generative neural networks and introduce its faster variational quantum-circuit counterpart, which can be deployed directly on quantum hardware and operates without syndrome measurements.

16:50-17:15 | **Vadim Makarov**
Invited Talk

Russian Quantum Center / University of Vigo /
National University of Science and Technology MISiS

Title: Certification of quantum cryptography against implementation loopholes

Abstract: Quantum cryptography is unbreakable in principle, but its real implementations have vulnerabilities arising from equipment imperfections. Certification standards and accredited labs are being established that can test commercial products for these flaws. I explain how we have analysed a commercial quantum key distribution system for loopholes, patched them, and designed tests for the certification lab [1]. I show some of the testbenches in this lab, such as an ultrawide spectral characterization testbench [2,3], laser damage testbench that verifies the quality of a power limiter [4], and results of an intersymbol-correlation measurement [5].

References:

[1] V. Makarov et al., Phys. Rev. Appl. 22, 044076 (2024).
[2] H. Tan et al., arXiv:2508.15136.
[3] M. Fadeev et al., arXiv:2503.11239.
[4] A. Ponosova et al., arXiv:2506.19091.
[5] D. Trefilov et al., arXiv:2411.00709, Opt. Quantum (in press).

17:15-17:40 | **Jevon Longdell**
Invited Talk

University of Otago

Title: Long optical coherence times and coherent rare earth-magnon coupling in a rare earth doped anti-ferromagnet

Abstract: We report on the coherence properties and coherent coupling between rare-earth ions and magnons in an erbium-doped gadolinium vanadate (Er: GdVO_4) crystal. Rare-earth ions, known for their narrow linewidths and long coherence times, are typically limited by magnetic fluctuations from the host crystal's electronic and nuclear spins. Our research demonstrates that by using a magnetic host with fully concentrated electron spins, such as antiferromagnetically ordered GdVO_4, we can achieve a quiet magnetic environment conducive to long optical coherence times. We report the observation of avoided crossings in the optical spectra, indicative of strong coupling between erbium ions and gadolinium magnons. This coupling, with a fitted exchange strength of -11.3 GHz, opens up exciting possibilities for microwave-to-optical quantum transduction mediated by magnons.

Saturday, September 20

8:40-9:30
Micius Prize Talk
Tilman Esslinger
ETH Zurich

Title: Synthetic Quantum Many-Body Systems

Abstract: Cooling and manipulating atomic gases have opened up new avenues for exploring fundamental concepts of quantum many-body physics. Synthetically created potentials and the control of atom-atom interactions have made it possible to tailor the properties of experimental systems at the microscopic level. This has led to the concept of quantum simulation—a system capable of reproducing the physics of many-body Hamiltonians, such as the Fermi-Hubbard model. One of the goals of this approach is to provide answers to open questions related to phenomena observed in condensed matter physics. An equally important frontier is the construction of novel systems that may have no counterparts in solid-state or other systems. This path leads to new questions and surprises. In this talk, I will discuss examples of analogue quantum simulations with optical lattices, systems with cavity-mediated interactions, and transport settings. I will also report on our latest results on the use of topological pumps to create high-fidelity quantum gates.

9:30-9:55
Invited Talk
Xing-Can Yao
University of Science and Technology of China

Title: Quantum simulation of the fermionic Hubbard model: from short-range correlations to antiferromagnetic order

Abstract: The fermionic Hubbard model (FHM), which describes interacting fermions on a lattice, is a paradigmatic framework for exploring strongly correlated quantum matter and is closely connected to the physics of high-temperature superconductivity. Yet, resolving its low-temperature phase diagram has remained a longstanding challenge. Ultracold fermions in optical lattices offer a clean and highly controllable platform to simulate the FHM and investigate its correlation-driven phases. In this talk, I will present our recent progress in quantum simulation of the FHM using a large, homogeneous Hubbard system. By analyzing interference patterns of fermions, we have extracted short-range first-order correlations and revealed nonzero coherence even in the Mott insulating regime, indicating strong underlying antiferromagnetic correlations [1]. Building on this, we directly probed spin correlations using spin-sensitive Bragg scattering and observed a critical enhancement of the spin structure factor consistent with a power-law divergence, providing compelling evidence for the realization of the antiferromagnetic phase transition [2].

References:

[1] Interference and short-range correlation in fermionic Hubbard gases. Zhu et. al., arXiv: 2507.14868 (2025).

[2] Antiferromagnetic phase transition in a 3D fermionic Hubbard model. Shao et. al., Nature 632, 267 (2024).

9:55-10:20
Invited Talk
Augusto Smerzi
CNR-INO / LENS

Title: Advances in Multiparameter Quantum Sensing and Metrology

Abstract: Multiparameter quantum sensing and metrology open new opportunities for quantum information and foundations science and for practical applications in navigation, field mapping and medical diagnostics. We present recent theoretical progress on distributed quantum sensing with squeezed states, focusing on the fundamental sensitivity limits dictated by quantum mechanics. A central result of our analysis is a direct comparison between an ensemble of entangled and separable sensors. We show that entangled distributed protocols can reach the same sensitivity as an ensemble of independent sensors while consuming quite fewer quantum resources. Moreover, properly engineered entangled states can provide collective enhancements with respect to an ensemble of separable sensors, with sensitivity that improves as the number of sensors increases. Beyond Gaussian approximations, we examine strategies approaching the Heisenberg limit, including multimode squeezed states and NOON-like configurations. These results outline a unified framework for distributed quantum metrology, linking ultimate precision bounds to near-term implementations with photonic and atomic platforms.

10:50-11:40
Micius Prize Talk (online)
Markus Greiner
Harvard University

Title: Quantum Simulation of the unknown: Emergent Fermi-Hubbard Physics at Ultralow Temperatures

Abstract: What happens when quantum simulations get cold enough to surprise us? Quantum simulations have served as impressive proof-of-principle demonstrations-creating a wide range of many-body quantum phases. Temperatures so far, however, were too high to truly get into uncharted territory, where we can address open questions on quantum materials such as cuprate superconductors. I will present a recent breakthrough in which we show a several-fold temperature reduction in an atomic Hubbard system, bringing quantum simulations into a regime of emergent low-temperature phenomena where the physics is not well understood theoretically. We achieve this by adiabatically transforming a low-entropy product state of ~300 atoms into a correlated final state. Using a quantum gas microscope, we report the first signs of novel physics appearing in this system upon cooling, including a line of thermodynamic anomalies separating the low-doping from high-doping regimes, the pseudo gap state, and a region of enhanced rotational symmetry breaking that may indicate a state of fluctuating stripes. This work signals the emergence of novel physics at low temperatures in the Hubbard model, and directly demonstrates the utility of quantum simulation in addressing open problems in correlated electron physics.

11:40-12:05
Invited Talk
Piet O. Schmidt
Physikalisch-Technische Bundesanstalt / Leibniz University Hannover

Title: Quantum engineering optical clocks based on trapped ions

Abstract: Optical atomic clocks with eighteen significant digits are the most accurate measurement devices available to us with applications ranging from tests of fundamental physics to height difference measurements in relativistic geodesy. The uncertainty in trapped-ion clocks is limited by systematic

frequency shifts and quantum projection noise. In my presentation, I will show how quantum engineering techniques can overcome these limitations. Quantum algorithms provide access to new clock species such as highly charged ions with reduced systematic shifts and high sensitivity to searches for new physics, including hypothetical fifth forces, variation of fundamental constants and dark matter candidates. Dynamical decoupling and entangled state spectroscopy in a multi-ion frequency reference offer suppression of systematic shifts, while improving the signal-to-noise ratio of the clock and thus the required averaging time to reach a certain resolution. These developments will pave the way towards a next generation of quantum-enhanced clocks that enter the 10^{-19} relative frequency uncertainty regime.

14:15-15:05 ***Plenary Talk***

Yu-Ao Chen
CAS Center for Excellence in Quantum Information and Quantum Physics / University of Science and Technology of China

Title: Quantum experiments in space

Abstract: The Micius satellite has created extensive opportunities for advanced research in quantum information and quantum physics using space-based platforms. With this satellite, several critical experiments have been successfully performed, such as satellite-to-ground quantum key distribution, bidirectional quantum entanglement distribution between satellite and ground, and ground-to-satellite quantum teleportation. After achieving these predefined scientific goals, we extended our efforts to experimentally examine a class of theoretical models that predict gravitationally induced quantum entanglement decoherence—representing an initial step toward experimentally probing the unification of quantum mechanics and general relativity. This presentation will first summarize the series of quantum experiments conducted with the Micius satellite, then offer an outlook on the future of space-based quantum science. It will also highlight recent advances in medium- and high-orbit quantum satellites as well as micro-nano quantum satellites, covering key areas such as all-day quantum communication, high-precision wide-area time-frequency transfer and optical atomic clocks, experimental tests of quantum effects in gravitational fields, and novel approaches for measuring gravitational redshift.

15:05-15:30 ***Invited Talk***

Wenlan Chen
Tsinghua University

Title: Dynamical probe of quantum criticality in 1D Rydberg arrays

Abstract: The Kibble-Zurek scaling reveals the universal dynamics when a system is linearly ramped across a critical point of symmetry-breaking phase transition. In reality, inevitable finite-size effects or symmetry-breaking perturbations can often smear out the critical point and render the phase transition into a smooth crossover. We show that the key ingredient to achieving the precise Kibble-Zurek scaling in the near-critical crossover regime is that the system size and the symmetry-breaking field must be appropriately scaled following the variation of ramping speeds. The experiment is performed in a reconfigurable Rydberg atom array platform, and strengthen the Kibble-Zurek scaling as an increasingly valuable tool for investigating phase transition in quantum simulation platforms.

Reference:

[1] Tao Zhang, Hanteng Wang, Wenjun Zhang, Yuqing Wang, Angrui Du, Ziqi Li, Yujia Wu, Chengshu Li, Jiazhong Hu, Hui Zhai, Wenlan Chen. "Observation of Near-Critical Kibble-Zurek Scaling in Rydberg Atom Arrays". Phys. Rev. Lett. 135, 093403 (2025).

15:30-15:55 ***Invited Talk***

Peter D. Drummond
Swinburne University of Technology

Title: Matrix coherent states for quantum information and GBS validation

Abstract: We introduce a novel quantum phase-space: a matrix coherent state distribution. This extends and improves any quantum phase-space to include symmetry groups. The purpose of this is to distinguish global symmetries from local fluctuations, greatly improving efficiency and precision. The general method is applicable to any nearly symmetric state or Hamiltonian, and has very many potential uses. This unifies the positive-P method with the Carusotto et al Bloch state method.

As an example, we treat quantum advantage experiments on Gaussian boson sampling (GBS), where computing exact random photon counts would be exponentially hard. The positive-P (+P) method is used to validate current, lossy GBS experiments. However, in future ultra-low loss experiments, this will no longer be enough. The cause is subtle: with nearly conserved parity symmetry, the +P method develops extended phase-space probability tails, increasing sampling errors.

This sampling problem can be efficiently solved with matrix coherent states, which include such group symmetries in the coherent basis set. In the case of low-loss GBS of >1000 modes, as potential future quantum advantage experiments, the sampling variance using matrix coherent states is reduced by millions of times compared to previous competing methods. This gives speed-up factors of billions for validation checks. We give present and future numerical examples.

Sunday, September 21

8:40-9:30 | **Yasunobu Nakamura**
Plenary Talk | RIKEN / The University of Tokyo

Title: Superconducting quantum computing technology at the International Year of Quantum Science and Technology

Abstract: Superconductivity was discovered in 1911, even before the theory of quantum mechanics was formulated in 1925. The physics of superconducting qubits was conceived in 1980, even before quantum information science was widely acknowledged in the 1990s. From history, we learn how difficult it is to predict the progress of science and technology as well as the future of our lives. However, the past tells us that breakthroughs often occur at a level beyond our imagination.
Now, at the International Year of Quantum Science and Technology (IYQ2025), a quarter century after the first demonstration of coherent control of a superconducting qubit, superconducting quantum computers exist to our surprise (or not?). They are still small-scale, error-prone, and not yet drastically outperforming classical computers. Anyways, it is fantastic that hundreds of qubits are controlled coherently in a programmable manner.
There remain, not surprisingly, many challenges to be overcome before realizing a large-scale, fault-tolerant superconducting quantum computer, on which numerous groups worldwide are working actively. Control and readout of qubits must be fast and high-fidelity, and the overall scalability must be ensured from quantum processor units to packaging, wiring, cryogenics, control electronics, error correction, and software. Nevertheless, new ideas are emerging rapidly, and technology is evolving quickly.

9:30-9:55 | **Arno Rauschenbeutel**
Invited Talk | Humboldt University of Berlin

Title: Rethinking Resonance Fluorescence: Fundamental Insights and Emerging Quantum Technologies

Abstract: Resonance fluorescence - the light emitted by a coherently driven two-level quantum emitter - has long served as a paradigm in quantum optics. In this talk, I will present two recent experimental investigations that reveal both the fundamental richness and the technological potential of this seemingly simple system. In the first part, I revisit the textbook notion that a single atom cannot scatter two photons simultaneously. Our results provide direct experimental evidence for an alternative quantum interference-based explanation, in which antibunching emerges from the coherent superposition of distinct two-photon scattering amplitudes. By selectively suppressing the coherently scattered component of the fluorescence spectrum, we isolate photon pairs that are simultaneously scattered by the atom, thereby validating a decades-old theoretical prediction. In the second part, I will show how resonance fluorescence can be harnessed as a highly efficient source of time-bin entangled photon pairs. Using a beam splitter followed by a coincidence detection, we transform the emission from a single atom into a stream of maximally entangled photon pairs, achieving a strong violation of a Bell inequality. Together, these experiments illustrate how resonance fluorescence - traditionally viewed as a fundamental textbook example - can be reimagined as a powerful resource for quantum information science.

9:55-10:20 | **James K. Thompson**
Invited Talk (online) | JILA / University of Colorado, Boulder

Title: Photon-mediated interactions for quantum sensing and simulation

Abstract: Harnessing photons to mediate interactions between atoms is a powerful approach for quantum simulation and quantum sensing. I will discuss experimental work in three different cavity-QED experiments using laser-cooled rubidium and strontium atoms. In these systems, we have recently realized a broad range of cavity-mediated interactions including all-to-all XYZ Hamiltonians, two-axis counter twisting, 3- and 4-body interactions, and collective gap protection of coherence in both a matterwave interferometer and an optical clock transition. If time permits, I will also discuss a selection of additional topics including entanglement-enhanced matterwave interferometers and optical clocks, the development of superradiant lasers, and simulations of the dynamical phases of BCS superconductors.

10:50-11:15 | **Martin Zwierlein**
Invited Talk (online) | Massachusetts Institute of Technology

Title: TBD

Abstract: TBD

11:15-11:40 | **Zeyang Li**
Invited Talk | Stanford University

Title: Cavity-Enabled Quantum Interfaces: Transduction, Entanglement, and Fast Qubit Control

Abstract: Cavities are indispensable tools in advancing both foundational quantum physics and scalable quantum technologies. In this talk, I will present two intertwined lines of research where the cavity-mediated interactions and cavity-enhanced optics pave the way for robust, scalable quantum information processing.
The first topic explores a cryogenic cavity QED system, where atoms interact strongly with a superconducting cavity. I will discuss a recent demonstration of efficient transduction between microwave and optical photons via a phase-matched atomic ensemble, enabling hybrid quantum networks. I will also outline ongoing work toward using the superconducting cavity's coherence properties to generate entanglement between atomic qubits. While currently in a proof-of-principle phase, this approach builds on a series of successful experiments in optical cavity platforms and has the potential to beat the record of entanglement-assisted metrology.
The second topic focuses on a new apparatus: the development of a stabilized, virtually imaged phased array (VIPA) for quantum control. This architecture extends the concept of cavity-stabilized modes to enable fast operation and high-fidelity qubit addressing, thereby overcoming the limitations of current tweezer-array systems, which are constrained by AOD-induced aberrations.

11:40-12:05 **Antoine Browaeys**
Invited Talk Institut d' Optique / CNRS

Title: Quantum magnetism in dipolar Rydberg atom arrays

Abstract: This talk will present two recent experiments where we explore quantum magnetism in a synthetic system consisting of Rydberg atoms arranged in arrays of various geometries. The atoms interact by the resonant dipole interaction.

In a first experiment, we implement the XY spin ½ model on a square array. Preparing the system out of equilibrium, we monitor the spread of the spin correlations across the system during the quenched dynamics. From their analysis, we extract the dispersion relation and observe the predicted anomalous behavior in the ferromagnetic case, a consequence of the dipolar interactions [Chen et al., Science 2025].

In a second experiment, we explore the dynamics of hole in a spin background, implementing a bosonic version of the t-J model usually introduced to describe the properties of doped magnets. To do so, we use the resonant dipole interaction between Rydberg atoms in tweezer arrays and rely on three Rydberg states in each atom to encode the spin and the hole. Varying the ration t/J, we observe in a one dimensional chain the binding of holes and the influence of the dipolar tail of the interaction on the propagation of the holes [Qiao et al., Nature 2025].

14:15-15:05 **Jaw-Shen Tsai**
Plenary Talk Tokyo University of Science / RIKEN

Title: Superconducting Kerr Parametric Oscillators based Bosonic Qubit

Abstract: In quantum information processing, two primary research directions have emerged: one based on discrete variables (DV) and the other on the structure of quantum states in a continuous-variable (CV) space. Integrating these two approaches could unlock new potential, overcoming their respective limitations. Here, we show that such a DV-CV hybrid approach, applied to superconducting Kerr parametric oscillators (KPOs), we successfully carried out X-gate and Z gate operations [1]. Moreover, the similar approach enables us to entangle a pair of Schrödinger's cat states by two methods. The first involves the entanglement-preserving conversion between Bell states in the Fock-state basis (DV encoding) and those in the cat-state basis (CV encoding). The second method implements a gate between two cat states following the procedure for Fock-state encoding. This simple and fast gate operation completes a universal quantum gate set in a KPO system. Our work offers powerful applications of DV-CV hybridization and marks a first step toward developing a multi-qubit platform based on planar KPO systems [2].

References:

[1] D. Iyama, et al. "Observation and manipulation of quantum interference in a superconducting Kerr parametric oscillator". Nat Commun 15, 86 (2024).

[2] Daisuke Hoshi, et al, "Entangling Schrödinger's cat states by bridging discrete- and continuous-variable encoding", Nature Communications 16, 1309 (2025).

15:05-15:30 **Marcos Curty**
Invited Talk University of Vigo

Title: The Security of Practical Quantum Key Distribution

Abstract: In theory, quantum key distribution (QKD) enables the secure exchange of keys through an insecure channel, offering a solution for long-term communication security. In practice, however, this is not the case because most QKD security proofs rely on assumptions that are not met by real-world implementations, meaning that the security statements no longer hold. In particular, they usually depend on precise mathematical models that describe the behaviour of QKD equipment; however, these models fail to account for real-world imperfections and side channels. These discrepancies invalidate the theoretical claims and can compromise the security of the distributed keys by creating vulnerabilities that can be exploited. Furthermore, accurately describing how a QKD transmitter or receiver functions when an adversary can interact with it poses a significant challenge, as evidenced by the extensive literature on quantum hacking. In this talk, we will discuss the various recent results achieved by my research group in our efforts to bridge the gap between theory and practice in QKD and restore the security of its implementations.

15:30-15:55 **Da-Wei Wang**
Invited Talk Zhejiang University

Title: Realizing the Haldane model in thermal atoms

Abstract: Topological materials hold great promise for developing next-generation devices with transport properties that remain resilient in the presence of local imperfections. However, their susceptibility to thermal noise has posed a major challenge. In particular, the Haldane model, a cornerstone in topological physics, generally requires cryogenic temperatures for experimental realization, limiting both the investigation of topologically robust quantum phenomena and their practical applications. In this talk, I will introduce a room-temperature realization of the Haldane model using atomic ensembles in momentum-space superradiance lattices, a platform intrinsically resistant to thermal noise. The topological phase transition is revealed through the superradiant emission contrast between two timed Dicke states in the lattice. Crucially, the thermal resilience of this platform allows us to access a deep modulation regime, where topological transitions to high Chern number phases emerge—going beyond the traditional Haldane model. Our results not only deepen the understanding of exotic topological phases, but also offer a robust, reconfigurable, and room-temperature-compatible platform that connects quantum simulation to real-world quantum technologies.

16:25-16:50 **Michel Brune**
Invited Talk Laboratoire Kastler Brossel / CNRS / Collège de France

Title: Trapped Circular Rydberg Atoms for Quantum Simulation: Quantum Non-Demolition Detection and Optical Manipulations

Abstract: Neutral atoms trapped in optical tweezers and promoted to Rydberg states are one of the most promising platforms for quantum simulation. Due to their exceptional lifetime, circular Rydberg atoms additionally offer an unprecedented potential for being trapped over timescales of tenth of milliseconds

at the temperature of 4K as compared to the 100μs lifetime of the low angular momentum Rydberg levels involved in present neutral atom based quantum simulators. We will present a state-selective and non-destructive detection method for single trapped circular atoms of Rubidium in optical tweezer. The method is based on a "dual-Rydberg" architecture combining arrays of circular atoms as computational qubits and of low angular momentum ancilla Rydberg atom for readout. The scheme also allows for optically addressing individual circular atoms. We will also present another circular-atom-based quantum simulator using strontium atoms with the advantage of potential optical manipulation of the second valence electron once the first one is promoted to a circular state.

16:50-17:15 ***Invited Talk***

Francesco Petruccione
NITheCS / Stellenbosch University

Title: Automated Variational Ansatz Design

Abstract: One way around the many-body problem is coming up with a good ansatz - a simplified functional form that captures the essential physical features of a system of interest. Finding one that provides qualitative insights while maintaining quantitative accuracy is challenging and is often left to guesswork. In this talk I present a framework for the systematic design of ansatzes. By blending ideas from variational many-body physics, tensor-network theory and algorithmic architecture search, we show that compact and interpretable ansatzes can be discovered and written down in closed form by a computer-driven search. I will demonstrate the application of our framework to quantum phase recognition, ground-state ansatz discovery, and quantum algorithm development.

17:15-17:40 ***Invited Talk***

Zong-Quan Zhou
University of Science and Technology of China

Title: Metropolitan-scale distributed quantum computing and quantum repeaters networks

Abstract: Quantum repeaters can overcome exponential photon loss in optical fibers, enabling heralded entanglement between distant quantum memories. However, recent metropolitan-scale demonstrations based on single-photon interference (SPI) schemes have been limited to generating low-quality entanglement, falling short of Bell nonlocality certification [1,2]. Here, I will present our recent works on constructing metropolitan-scale quantum-computing networks [3] and quantum-repeater networks [4,5] in Hefei. We achieve the heralded entanglement distribution between two solid-state quantum memories separated by 14.5 km [5], using a two-photon interference (TPI) scheme based on time measurements combined with large-capacity temporal multiplexing [4]. We generate a Bell state with a fidelity of 78.6 (2.0) %, achieving a CHSH-Bell inequality violation by 3.7 standard deviations. Our architecture effectively combines the high heralding rate of SPI schemes with the phase robustness of TPI schemes, enabling autonomous quantum node operation without the need for fiber channel phase stabilization, thus providing a practical framework for scalable quantum-repeater networks.

References:

[1] JL Liu et al., Nature, 629, 579 (2024).
[2] A. J. Stolk et al., Sci. Adv., 10, eadp6442 (2024).
[3] X. Liu et al., Nature Communications 15, 8529 (2024).
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[5] T.-X. Zhu et al., arXiv:2508.17940.

Monday, September 22

8:40-9:30 ***Plenary Talk***

Xiaobo Zhu
University of Science and Technology of China

Title: Advances in superconducting quantum computing

Abstract: Quantum computing is widely regarded as the next generation of computing technology because of its overwhelming advantage over classical computers in the processing power of certain problems, so it has attracted widespread attention. Superconducting solutions are currently attracting attention due to their good scalability, and major companies are investing in this field. This report will focus on the current status of superconducting quantum computing and its short-term and medium-term goals, and introduce a series of progress we have made in this direction.

9:30-9:55 ***Invited Talk***

Ernst Maria Rasel
Leibniz University Hannover

Title: Quantum gases in microgravity: new perspectives for ground based research

Abstract: Free-fall allows to study quantum degenerate gases in new, text-book like settings. Moreover, extending free fall of quantum degenerate gases promise to boost the sensitivity and accuracy of inertial matter-wave interferometers. These sensors are employed in fundamental physics as well as are studied for applications in navigation or geodesy. Only recently, atom interferometers have been demonstrated aboard the Chinese space station for testing the equivalence principle and as gyroscopes. Exploiting quantum degenerate gases for high-precision interferometry places high demands on their control and manipulation. So far, apart from experiments in space aboard sounding rockets and the international space station, we took benefit of the microgravity environment in the Bremen drop tower. New perspectives arise in elevators such as the Bremen Gravitower as well as the Einstein elevator in Hannover, providing many experimental runs per day. We exploit them to study for the first time quantum degenerate mixtures in microgravity on ground and perform interferometry on extended time scales.

9:55-10:20 ***Invited Talk***

Giacomo Roati
CNR-INO / LENS / University of Florence

Title: Vortex dynamics in strongly interacting Fermi superfluids

Abstract: Topological defects are central to the dynamics of out-of-equilibrium physical and biological systems across a wide range of scales. They shape structures and behaviors in planetary atmospheres, turbulent flows of classical and quantum fluids, and electrical signaling in excitable biological media [1]. In superfluids and superconductors, the motion of quantized vortices is directly linked to the onset of dissipation, which sets a fundamental limit to superflow [2]. Yet, understanding vortex dynamics remains a major challenge because of the intricate interplay among vortices, disorder, and dimensionality.

We address this challenge by investigating vortex matter in strongly interacting Fermi superfluids of ultracold atoms [3]. By engineering controlled vortex configurations and tracking vortex trajectories with high spatial resolution, we establish an ideal quantum laboratory for probing the fundamental mechanisms underlying vortex-driven instabilities and dissipation [4,5]. Our approach opens the door to new insights into vortex-matter phenomena in strongly correlated superfluids.

References:

[1] Spiral and Vortices, K. Tsuji and S. C. Müller (eds.), Springer Nature (2019).

[2] B. I. Halperin, G. Refael, and E. Demler, Int. J. Mod. Phys. B 24, 20n21 (2010).

[3] W. J. Kwon et al., Nature 600, 64 (2021).

[4] D. Hernandez-Rajkov et al., Nat. Phys. 20, 845 (2024).

[5] N. Grani et al., arXiv:2503.21628v1 (2025).

10:50-11:15 | **Fernando Luis**
Invited Talk | Instituto de Nanociencia y Materiales de Aragón / CSIC-Universidad de Zaragoza

Title: Wiring up molecular spins with quantum superconducting circuits

Abstract: Scaling up quantum processors remains very challenging, even for today's most successful platforms, on account of the need of mitigating and, eventually, correcting errors. Magnetic molecules can provide some competitive advantages, due to their exquisite reproducibility and the ability of tuning their relevant properties, or even scaling up quantum resources, by chemical design [1]. Exploiting them calls for a solid-state platform able to initialize, control and read-out the molecular spins, and of establishing the communication channels between remote spins that are need for scalability [2]. I'll discuss recent experiments aimed at achieving this goal by coupling molecular spins to chips hosting multiple LC superconducting resonators and transmission lines [3-5]. Results performed on molecular spin ensembles provide proof-of-concept implementations of the basic quantum operations. Also, we find that the circuit can mediate effective interactions between distinct spin ensembles located on separately addressable remote resonators. In addition, I'll discuss different strategies, based on the optimization of either the circuit [6] or the molecular integration [7], for extending this approach to address individual molecular spins.

References:

[1] G. Aromí, D. Aguilà, P. Gamez, F. Luis, and O. Roubeau, Chem. Soc. Rev., 2012, 41, 537; A. Gaita-Ariño, F. Luis, S. Hill, and E. Coronado, Nature Chem., 2019, 11, 301; S. Carretta, D. Zueco, A. Chiesa, Á. Gómez-León, and F. Luis, Appl. Phys. Lett., 2021, 118, 240501; A. Chiesa, E. Garlati, P. Santini, F. Luis and S. Carretta, Rep. Prog. Phys. 87, 034501 (2024).

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11:15-11:40 | **Yoshiro Takahashi**
Invited Talk | Kyoto University

Title: Quantum Science with Ultracold Ytterbium

Abstract: A system of ultracold atoms in an optical lattice or an optical tweezer array is an ideal experimental system for studying fundamental aspects of quantum science such as quantum simulation of strongly-correlated quantum many-body systems, quantum metrology / precision measurement, and quantum computing. Ultracold ytterbium (Yb) offers unique possibilities in these studies owing to several unique features.

In this talk, I will report our recent experiments of quantum sensor for new physics beyond the Standard Model, and quantum computing. Owing to the existence of ultranarrow optical transitions between the ground and metastable states and many isotopes we search for a new hypothetical particle mediating a force between an electron and a neutron, through precision isotope-shift measurements using ultracold bosonic Yb atoms in a magic-wavelength lattice. Towards quantum computation, we recently perform experiments using Yb atom tweezer array, such as a hybrid atom tweezer array with nuclear spin qubits and optical clock qubits, useful for quantum-error correction, and 3D array system with novel plane selectivity.

11:40-12:05 | **Jinfeng Jia**
Invited Talk | Shanghai Jiao Tong University / Southern University of Science and Technology

Title: Majorana zero mode for topological quantum computing

Abstract: Majorana zero mode (MZM), which behaves like Majorana fermion and can be used in fault-tolerant quantum computation relying on their non-Abelian braiding statistics, attracts lots of attentions recently. As predicted, MZM in the vortex of topological superconductor appears as a zero energy mode with a cone like spatial distribution. Also, MZM can induce spin selective Andreev reflection (SSAR), a novel magnetic property which can be used to detect the MZMs. Here, I will show you that the $Bi_2Te_3/NbSe_2$ hetero-structure is an ideal artificial topological superconductor and all the three features are observed for the MZMs inside the vortices on the $Bi_2Te_3/NbSe_2$. Especially, by using spin-polarized scanning tunneling microscopy/spectroscopy (STM/STS), we observed the spin dependent tunneling effect, which is a direct evidence for the SSAR from MZMs, and fully supported by theoretical analyses. More importantly, all evidences are self-consistent. Recently, the strong proximity effect was found in SnTe-Pb heterostructure. The bulk pairing gap and multiple in-gap states induced by topological surface states can be clearly distinguished. The superconductivity of SnTe is consistent with a new type of topological superconductors under the protection of lattice symmetries. Under lattice-symmetry protection, the superconducting SnTe is proven to possess multiple MZMs in a single vortex. This system provides a platform to study the coupling of multiple MZMs without the need of real space movement of a vortex. Finally, the segmented Fermi surface induced by the Cooper pair momentum was observed in the $Bi_2Te_3/NbSe_2$ system.

References:

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