ICEQT 2019

INTERNATIONAL CONFERENCE ON EMERGING QUANTUM TECHNOLOGY

Handbook

About ICEQT

The International Conference on Emerging Quantum Technology (ICEQT) will be held during September 15-20, 2019, by the CAS Center for Excellence in Quantum Information and Quantum Physics, University of Science and Technology of China. The predecessor of ICEQT was the International Conference on Quantum Foundation and Quantum Technology (ICQFT), which has been held four times in the past thirteen years:

- The 1st ICQFT, 2006, Hangzhou
- The 2nd ICQFT, 2009, Shanghai
- The 3rd ICQFT, 2012, Dunhuang
- The 4th ICQFT, 2016, Shanghai

As planned, ICEQT will become a biennial international conference series on quantum information technology.

On September 18, the Micius Quantum Prizes will be awarded. The Micius Quantum Prizes 2018 go to the field of quantum computation with six laureates, Ignacio Cirac, David Deutsch, Peter Shor, Peter Zoller, Rainer Blatt and David Wineland, whilst the Micius Quantum Prizes 2019 go to the field of quantum communication with six laureates, Charles Bennett, Gilles Brassard, Artur Ekert, Stephen Wiesner, Jian-Wei Pan and Anton Zeilinger. 10 laureates will participate this conference to give prize talks.

Scope of the ICEQT 2019

- Quantum Cryptography
- Quantum Communication
- Quantum Computing
- Quantum Information Theory
- Implementations of Quantum Information Processing and Quantum Simulations (with photons, superconducting qubits, trapped ions, solid states, optical lattices, etc.)
- Quantum Photonic Network (quantum repeaters, quantum memory, free space, etc.)
- Quantum Measurement
- Quantum Metrology
- Quantum Foundations

Organized by

- CAS Center for Excellence in Quantum Information and Quantum Physics
- Hefei National Laboratory for Physical Sciences at Microscale, University of Science and Technology of China

Supported by

- The Chinese Academy of Sciences
- University of Science and Technology of China

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Micius Prize Talks

- Charles H. Bennett (Thomas J. Watson Research Center, IBM)
- Rainer Blatt (University of Innsbruck)
- Gilles Brassard (Université de Montréal)
- Ignacio Cirac (Max Planck Institute of Quantum Optics)
- Artur Ekert (University of Oxford)
- Jian-Wei Pan (University of Science and Technology of China)
- Peter Shor (Massachusetts Institute of Technology)
- David J. Wineland (University of Oregon)
- Anton Zeilinger (University of Vienna)
- Peter Zoller (University of Innsbruck)

Invited Speakers

- Romain Alléaume (Télécom ParisTech)
- Mete Atature (University of Cambridge)
- Koji Azuma (NTT Basic Research Laboratories)
- Mohamed Bourennane (Stockholm University)
- Julien Claudon (CEA)
- Qijin Chen (Zhejiang University)
- Xian-Hui Chen (University of Science and Technology of China)
- Roger Colbeck (University of York)
- Hong Ding (Institute of Physics, CAS)
- Jonathan Dowling (Louisiana State University)
- Jiangfeng Du (University of Science and Technology of China)
- Lu-Ming Duan (Tsinghua University)
- Heng Fan (Institute of Physics, CAS)
- David Gershoni (Technion Israel Institute of Technology)
- Thomas Jennewein (University of Waterloo)
- Chuan-Feng Li (University of Science and Technology of China)
- Yeong-Cherng Liang (National Cheng Kung University)
- Ren-Bao Liu (The Chinese University of Hong Kong)
- Xiong-Jun Liu (Peking University)
- W. Vincent Liu (University of Pittsburgh)
- Peter Lodahl (University of Copenhagen)
- Chao-Yang Lu (University of Science and Technology of China)
- Zheng-Tian Lu (University of Science and Technology of China)
- Xiaosong Ma (Nanjing University)
- Vadim Makarov (Russian Quantum Center)
- Naoto Namekata (Nihon University)
- Axel Pelster (Technische Universität Kaiserslautern)
- Thore Posske (University of Hamburg)

- Armando Rastelli (Johannes Kepler Universität Linz)
- Barry Sanders (University of Calgary)
- Nicolas Sangouard (University of Basel)
- Jörg Schmiedmayer (TU Wien)
- Reinhard Scholl (International Telecommunication Union)
- Alexander Streltsov (University of Warsaw)
- Hiroki Takesue (NTT)
- Rupert Ursin (University of Vienna)
- Giuseppe Vallone (University of Padova)
- Jianwei Wang (Peking University)
- Xiang-Bin Wang (Tsinghua University)
- Ya Wang (University of Science and Technology of China)
- Matthias Weidemüller (Universität Heidelberg)
- Jörg Wrachtrup (University of Stuttgart)
- Guihua Zeng (Shanghai Jiao Tong University)
- Hui Zhai (Tsinghua University)
- Jing Zhang (Shanxi University)
- Qiang Zhang (University of Science and Technology of China)
- Yanbao Zhang (NTT Basic Research Laboratories)
- Bo Zhao (University of Science and Technology of China)

Conference Program

Monday September 16	Tuesday September 17	Wednesday September 18	Thursday September 19	Friday September 20
Session Chair: W. Vincent Liu	Session Chair: Peter Lodahl	Session Chair: Jörg Schmiedmayer	Session Chair: Ren-Bao Liu	Session Chair: Barry Sanders
Opening Ceremony (8:30-8:40)				
Peter Zoller (8:40-9:30)	**Peter Shor** (8:40-9:30)	**Charles H. Bennett** (8:40-9:30)	**Artur Ekert** (8:40-9:30)	**Ignacio Cirac** (8:40-9:30)
Luming Duan (9:30-9:55)	Jonathan Dowling (9:30-9:55)	Xiang-Bin Wang (9:30-09:55)	Vadim Makarov (9:30-9:55)	Jing Zhang (9:30-9:55)
Matthias Weidemüller (9:55-10:20)	Ya Wang (9:55-10:20)	Xiong-Jun Liu (9:55-10:20)	Axel Pelster (9:55-10:20)	Alexander Streltsov (9:55-10:20)
Group photo & coffee break (10:20-10:50)	Coffee break (10:20-10:40)			
Session Chair: Rupert Ursin	Session Chair: Xiaosong Ma	Session Chair: Axel Pelster	Session Chair: Giuseppe Vallone	Session Chair: Jing Zhang
Qijin Chen (10:50-11:15)	Hong Ding (10:40-11:05)	Jörg Wrachtrup (10:40-11:05)	Roger Colbeck (10:40-11:05)	Barry Sanders (10:40-11:05)
Julien Claudon (11:15-11:40)	Heng Fan (11:05-11:30)	Zheng-Tian Lu (11:05-11:30)	Yanbao Zhang (11:05-11:30)	Guihua Zeng (11:05-11:30)
Yeong-Cherng Liang (11:40-12:05)	Hiroki Takesu (11:30-11:55)	Ren-Bao Liu (11:30-11:55)	Reinhard Scholl (11:30-11:55)	Giuseppe Vallone (11:30-11:55)
Naoto Namekata (12:05-12:30)	Hui Zhai (11:55-12:20)	Jörg Schmiedmayer (11:55-12:20)	David Gershoni (11:55-12:20)	Bo Zhao (11:55-12:20)
Lunch break(12:20-14:00)				
Session Chair: Luming Duan	Session Chair: Jonathan Dowling	Micius Prize Ceremony (14:30-15:40)	Session Chair: David Gershoni	
Rainer Blatt (14:00-14:50)	**Anton Zeilinger** (14:00-14:50)		**Gilles Brassard** (14:00-14:50)	
Xian-Hui Chen (14:50-15:15)	Qiang Zhang (14:50-15:15)		Chao-Yang Lu (14:50-15:15)	
W. Vincent Liu (15:15-15:40)	Xiaosong Ma (15:15-15:40)			
Coffee break(15:40-16:00)				
Session Chair: Matthias Weidemüller	Session Chair: Hiroki Takesue	Session Chair: Jörg Wrachtrup	Poster session (16:00-17:40)	
Rupert Ursin (16:00-16:25)	Peter Lodahl (16:00-16:25)	**David J. Wineland** (16:00-16:50)		
Chuan-Feng Li (16:25-16:50)	Armando Rastelli (16:25-16:50)			
Pavel Sekastki (16:50-17:15)	Jianwei Wang (16:50-17:15)	**Jian-Wei Pan** (16:50-17:40)		
Koji Azuma (17:15-17:40)	Thore Posske (17:15-17:40)			
Buffet dinner (18:30-)	Buffet dinner (18:30-)	Banquet (18:30-)	Buffet dinner (18:00-)	
			Micius Salon (19:00-21:00 in USTC)	

(orange)	Prize talk (45+5 minutes)
(blue)	Invited talk (22+3 minutes)

Monday, September 16

8:40-9:30
Peter Zoller (University of Innsbruck)
Micius Prize Talk

9:30-9:55
Luming Duan (Tsinghua University)
Quantum machine learning and quantum network
Abstract: In this talk, I will briefly discuss some of our recent works on quantum machine learning, in particular on a quantum generative model that offers potential exponential advantages in the representational power and in the inference and learning speeds. If time allows, I will also briefly discuss some of our recent experimental progress on realization of multiplexed quantum memories, multipartite entanglement between different memory cells, and long-distance (~10km) entanglement between multiplexed quantum memories and a telecom photon pulse.

9:55-10:20
Matthias Weidemüller (Universität Heidelberg & University of Science and Technology of China)
Universal Glassy Dynamics in a Rydberg Spin System *
Abstract: Out of equilibrium spin systems with disorder can show extremely slow dynamics as known, e.g., for spin glasses, where the magnetization relaxes slowly over several orders of magnitude in time. To investigate such dynamics in the presence of quantum fluctuations we implement an isolated disordered spin system composed of long-range interacting Rydberg atoms which can be described by a Heisenberg XXZ spin model [1]. We present an experiment which disentangles the role of fluctuations stemming from disorder and quantum fluctuations. The spin system is represented by two atomic Rydberg states in a "frozen" gas of ultracold atoms under the influence of dipolar interactions ranging over macroscopic distances. We find strong deviation from the mean field prediction of the magnetization. Instead, the magnetization relaxes with a universal non-exponential decay much slower than the timescale associated with the exchange coupling strength. Such dynamics, which bears similarities to spin glasses, is in good agreement with a discrete truncated Wigner approximation revealing that the evolution is determined by the build-up of entanglement driven by quantum fluctuations. We will also discuss the spin dynamics under the presence of an external field.
1. Piñeiro Orioli et al., Phys. Rev. Lett. 120, 63601 (2018).
** Work done in collaboration with Adrien Signoles (now at Institut d'Optique, Orsay, France), Titus Franz, Renato Ferracini Alves, Asier Piñeiro Orioli, Martin Gärttner, Jürgen Berges, Gerhard Zürn (all Heidelberg University), and Shannon Whitlock (University of Strasbourg, France)*

10:50-11:15

Qijin Chen (Zhejiang University & University of Science and Technology of China)

Destruction and Enhancement of superfluidity: Unusual effects of population imbalance in a continuum-lattice mixed system of atomic Fermi gases

Abstract: We study the superfluid behavior of population imbalanced ultracold atomic Fermi gases with a short range attractive interaction (characterized by $1/KFa$) in a continuum-lattice mixed system, in particular, a 1D optical lattice, using a pairing fluctuation theory. Due to the lattice-continuum mixing, population imbalance now has highly unusual effects. Besides the widespread pseudogap and intermediate temperature superfluid phenomena, the superfluid phase, including in the BEC regime, may be readily destroyed by increasing the lattice constant d and/or decreasing the lattice hopping integral t, in the presence of imbalance p. The superfluid phase exists only in a very restricted region in the multi-dimensional phase space of ($T, 1/KFa$, p, t, d), mostly for relatively small p, small d and large t. While the transition T_c in the balanced case decreases as $T_c \propto KFa$ in the BEC regime, it approaches a constant BEC asymptote in the imbalanced case, when the BEC superfluid does exist. Therefore, a small population imbalance may strongly enhance the superfluidity by raising T_c to the constant BEC asymptote. Furthermore, in a BEC superfluid, not all minority atoms are paired up. These unusual behaviors can be tested in future experiments.

Reference: arXiv:1904.09576

11:15-11:40

Julien Claudon (CEA)

Nanowire antennas for quantum optics: recent developments

Abstract: Tapered nanowire antennas have recently emerged as a versatile solid-state platform for quantum optics. These broadband photonic structures efficiently funnel the spontaneous emission of an embedded quantum dot (QD) into a directive free-space beam. They find application in the realization of bright sources of quantum light [1,2], and enable the implementation of giant optical non-linearities, at the single-photon level [3].

In this talk, I will discuss advances aiming at further optimizing this light-matter interface. In particular, recent measurements revealed that the thermal excitation of a single nanowire vibration mode can have a sizeable influence on the QD optical linewidth [4]. This motivated a comprehensive theoretical analysis, which shows that the thermally-driven vibrations of the nanowire have a major impact on the QD light emission spectrum. Even at liquid helium temperatures, these prevent the emission of indistinguishable photons. To overcome this intrinsic limitation, we propose several designs that restore photon indistinguishability thanks to a specific engineering of the mechanical properties of the nanowire. We anticipate that such a mechanical optimization will also play a key role in the development of other high-performance light-matter interfaces based on nanostructures.

References:

1. *J. Claudon, et al., Nature Photon. 4, 174 (2010).*

2. *M. Munsch et al., Phys. Rev. Lett. 110, 177402 (2013).*
3. *Nguyen, et al., Phys. Rev. B 97, 201106(R) (2018).*
4. *M. Munsch, et al., Nat. Commun. 8, 76 (2017).*
5. *Artioli et al., submitted.*

11:40-12:05

Yeong-Cherng Liang (National Cheng Kung University)

A (strengthened) no-go theorem on Wigner's friend's paradox

Abstract: Does quantum theory apply to observers? A resurgence of interest in the long-standing Wigner's friend paradox has shed new light on this fundamental question. Brukner introduced a scenario with two separated but entangled "friends". Here, building on that work, we rigorously prove that if quantum evolution is controllable on the scale of an observer, then one of the following three assumptions must be false: "freedom of choice", "parameter-independence", or "observer-independent facts" (i.e. that every observed event exists absolutely, not relatively). We show that although the violation of Bell inequalities in such scenarios is not in general sufficient to demonstrate the contradiction between those assumptions, new Bell-like inequalities that are sufficient for this purpose can be derived, which are violated by quantum correlations. We demonstrate this in a proof-of-principle experiment where a photon's path is deemed an observer. We discuss how this new theorem places strictly stronger constraints on quantum reality than Bell's theorem.

12:05-12:30

Naoto Namekata (Nihon University)

Quantum walk in a plasmonic waveguide lattice structure

Abstract: Quantum walks (QWs) simulate quantum mechanical behaviors of particles, which exhibit time evolutions completely different from the classical random walks. QWs offer quantum physical simulations and the novel approach to build quantum computers. Currently on-chip photonic devices implementing QWs have been intensively developed, and they were realized using photonic circuits based on silica waveguide platforms.

In this work, we experimentally demonstrated the QW in one-dimensional lattice structures based on the long-range surface plasmon polariton (LR-SPP) waveguide platform. The LR-SPP waveguide allows a single-polarization mode, and has relatively low optical losses. The quantum interference can be realized in a LR-SPP waveguide circuit with a high visibility as well. Furthermore, the LR-SPP waveguide platform will realize two-dimensional waveguide lattice structures with a high reliability. Thus, the LR-SPP waveguide is the potential platform to construct large-scale and high-dimension QW simulators.

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14:00-14:50

Rainer Blatt (University of Innsbruck)

Micius Prize Talk

14:50-15:15

Xian-Hui Chen (University of Science and Technology of China)

Electric-Field-Controlled Superconductor-Ferromagnetic Insulator Transition in (Li,Fe)OHFe(Se,S)

Abstract: High-temperature (Tc) superconductivity typically develops from antiferromagnetic insulators, and superconductivity and ferromagnetism are always mutually exclusive. In this talk, I will report on the recent observations of an electric-field controlled reversible transition from superconductor to ferromagnetic insulator in (Li,Fe)OHFeSe and (Li,Fe)OHFeS thin flakes by using a new type of FET, in which solid ion conductor (SIC) was adopted as the gate dielectric. By this new developed gating technique, Li ions can be driven into or extracted out from the thin flakes by electric field. In (Li,Fe)OHFeSe, a dome-shaped superconducting phase with optimal Tc of 43 K is continuously tuned into a ferromagnetic insulating phase, which exhibits an electric-field-controlled quantum critical behavior. The origin of the ferromagnetism is ascribed to the order of the interstitial Fe ions expelled from the (Li,Fe)OH layers by gating-controlled Li injection. In (Li,Fe)OHFeS thin flake, a rich electric-field-driven phase diagram, involving superconductivity, soft ferromagnetism and hard ferromagnetism, was mapped out, which can be ascribed to the variable dominating types of magnetic interactions in the process of the simultaneous tuning of carrier density and magnetic Fe-ion concentration by the Li-ion injection. These surprising findings offer a unique platform to study the relationship between superconductivity and ferromagnetism in Fe-based superconductors. This work also demonstrates the superior performance of SIC-FET in manipulating the physical properties of layered crystals and its potential applications for multifunctional devices.

15:15-15:40

W. Vincent Liu (University of Pittsburgh & Shanghai Jiao Tong University)

From real to imaginary time crystal

Abstract: Quantum time crystal has been an intriguing many-body "time" state that has received much attention and debate since its early prediction. In this talk, first, I will construct a class of concrete "clean" Floquet models to answer the open question on the role of disorder and many-body localization. Second, by observing the equivalent role of the space and imaginary time in the path integral formalism, I will present the finding that hard-core bosons coupled to a thermal bath may exhibit the order of "imaginary spacetime crystal".

References:

1. *B. Huang, Y.-H. Wu, W. V. Liu, Phys. Rev. Lett. 120, 110603 (2018).*
2. *Z. Cai, Y. Huang, W. V. Liu, arXiv:1902.09747.*

16:00-16:25

Rupert Ursin (University of Vienna)

Quantum Networks with four and eight nodes fully connected

Abstract: We present a proof-of-principle experiment consisting of four users in a novel network architecture which enables scalable quantum communication based on

polarization-entangled photon pairs at telecommunications wavelength. Our scheme uses frequency multiplexing [3, 2] to share 6 two-photon entangled states between each pair of clients in a mesh-like network topology using only one fiber per client. As clients need minimal resources – one polarization detection module and single-mode fiber each, the physical topology of the network scales linearly if a user is added, while the logical topology scales quadratically within (n−1) network connections between users. The quantum correlations and physical topology will be illustrated. The source employs type-0 spontaneous parametric down-conversion centered at 1550 nm, pumped by a continuous-wave laser. The resulting 60 nm-wide spectrum is split symmetrically into 6 pairs of wavelength-correlated channels similar to Aktas et al. [1]. Each client receives 3 channels which are polarization-entangled with the channels sent to each of the other clients. Every client measures all three channels in a single polarization analyzer in either the HV or DA basis and records the results using a time tagging unit. Photon pairs were identified by their relative arrival times. We successfully implemented a 4 client network with uncorrected polarization correlation visibilities>85% in both bases and for all pairs of clients [4]. These visibilities and count rates are sufficient to obtain secure key rates between 2and 15 bits/s. distributed computation tasks or problems like the millionaire's problem could be implemented on this network.

References

1. *D. Aktas, B. Fedrici, F. Kaiser, T. Lunghi, L. Labont ́e, and S. Tanzilli. Entanglement distribution over 150 km in wavelength division multiplexed channels for quantum cryptography.Laser & Photonics Reviews, 10(3):451–457, 2016.*
2. *I. Herbauts, B. Blauensteiner, A. Poppe, T. Jennewein, and H. Hübel. Demonstration of active routing of entanglement in a multi-user network. Opt. Express, 21(23):29013–29024, 2013.*
3. *H. C. Lim, A. Yoshizawa, H. Tsuchida, and K. Kikuchi.Broadbandsource of telecom-band polarization-entangled photon-pairs for wavelength-multiplexed entanglement distribution.Optics express, 16(20):16052–16057,2008.*
4. *Wengerowsky S, Joshi SK, Steinlechner F, Hübel H, Ursin R. An entanglement-based wavelength-multiplexed quantum communication network. Nature. 12;564(7735):225–8. 2018*

16:25-16:50

Chuan-Feng Li (University of Science and Technology of China)

Quantum network based on solid state quantum memory

Abstract: I will first give a brief introduction on the development of quantum network and then report on some of our recent experimental progress on quantum network based on solid state quantum memory: 1) Realized high-fidelity sandwich-like solid state memory for photonic polarization qubit with storage process fidelity up to 99.9%. 2) Demonstrated solid state memory of three-dimensional orbital-angular-momentum entanglement. The memory was shown to be highly reliable for 51spatial modes. 3) Realized the storage of multiple single-photon pulses (up to 100 modes) emitted from a quantum dot. 4) Created a multiple- degree-offreedom (DOF) memory with high

multimode capacity through the combination of spatial DOF with temporal and spectral DOF. Our work will be helpful in the construction of efficient quantum repeaters based on all-solid-state devices.

16:50-17:15
Pavel Sekastki (University of Basel)
Towards a fully device-independent certification of quantum networks
Abstract: The common usage of quantum physics consists of building a quantum model of a setup in order to predict the relation between the classical inputs and outputs of measurements. In this talk we will show how this link can be inverted -- a quantum model of the setup can be recovered from the sole knowledge of measurement statistics -- a framework know as self-testing or device independent certification. By construction such certification methods have the highest degree of reliability, and are particularly welcome in adversarial scenarios (e.g. quantum communication) or situation where the full physical description of a setup becomes too heavy (e.g. fault tolerant implementation of a quantum circuit). In this talk we will review our recent resutls on noise tolerant self-tesitng of quantum instruments in general and have a look on some particular examples: certification of quantum memories, entangling gates, Bell-state measurements and weak measurements. Finally, we will present the first experimental device-independent certification of an elementary quantum network link.

17:15-17:40
Koji Azuma (NTT Basic Research Laboratories)
All-optical quantum internet
Abstract: If a world-wide quantum network is established only with optical devices, it leads to a cost-efficient high-speed quantum internet in the future. It is natural to imagine that such an all-optical network is composed of various protocols specialized in intracity, intercity and intercontinental quantum communication. Here I will talk about recent rapid progress on this kind of all-optical approach towards the quantum internet.
This research is, in part, supported by CREST, JST JP-MJCR1671 and PREST, JST JP-MJPR1861.

Tuesday, September 17

8:40-9:30
Peter Shor (Massachusetts Institute of Technology)
Micius Prize Talk

9:30-9:55
Jonathan Dowling (Louisiana State University)
Practical figures of merit and thresholds for entanglement distribution in large-scale quantum repeater networks

Abstract: Before global-scale quantum networks become operational, it is important to consider how to evaluate their performance so that they can be suitably built to achieve the desired performance. In this work, we consider three figures of merit for the performance of a quantum network: the average global connection time, the average point-to-point connection time, and the average largest entanglement cluster size. These three quantities are based on the generation of elementary links in a quantum network, which is a crucial initial requirement that must be met before any long-range entanglement distribution can be achieved. We evaluate these figures of merit for a particular class of quantum repeater protocols consisting of repeat-until-success elementary link generation along with entanglement swapping at intermediate nodes in order to achieve long-range entanglement. We obtain lower and upper bounds on these three quantities, which lead to requirements on quantum memory coherence times and other aspects of quantum network implementations. Our bounds are based solely on the inherently probabilistic nature of elementary link generation in quantum networks, and they apply to networks with arbitrary topology.

9:55-10:20

Ya Wang (University of Science and Technology of China)

Quantum control of hybrid spin system in diamond: towards scalable quantum network

Abstract: The realization of quantum network is an important goal in quantum information due to its great potential in secure quantum communication and promising scalability in quantum computing. Building quantum network requires quantum systems with long coherence time, efficient optical interface as well as ability to scale-up. Point defects in solids with individual controllable spin come into focus in recent years. One most promising candidate system is nitrogen vacancy in diamond. In this talk, I will present our recent progress in developing hybrid quantum node composed of NV electron spin and surrounding nuclear spins, including the ways to control them and high quality diamond sample preparation.

10:40-11:05

Hong Ding (Institute of Physics, CAS)

Topological superconductivity and Majorana zero mode in Fe-based superconductors

Abstract: In this talk I will report our recent discoveries of topological superconductivity and Majorana zero mode in Fe-based superconductors. We have observed a superconducting topological surface state of Fe(Te, Se) with Tc ~ 14.5K by using low-temperature ARPES [1], and a pristine Majorana zero mode (MZM) inside a vortex core of this material by using low-temperature STM [2]. We have also observed a half-integer level shift of vortex bound states [3] and quantized Majorana conductance [4] in this material, which are hallmarks of MZMs. In addition, we have also found that most of Fe-based superconductors [5], including monolayer Fe(Te, Se)/STO [6], have similar topological electronic structures. One of them, CaKFe4As4, an Fe-As bilayer superconductor (Tc ~ 35K), is found to possess MZM and other bound states that can

be well reproduced by a simple theoretical model [7]. Our observations offer a new, robust platform for realizing and manipulating MZMs, which can be used for quantum computing at a relatively high temperature.

References

1. *Peng Zhang et al., Science 360, 182 (2018)*
2. *Dongfei Wang et al., Science 362, 334 (2018)*
3. *Lingyuan Kong et al., arXiv:1901.02293, accepted by Nature Physics*
4. *Shiyu Zhu et al., arXiv:1904.06124*
5. *Peng Zhang et al., Nature Physics 15, 41 (2019)*
6. *Xun Shi et al., Science Bulletin 62, 503 (2017)*
7. *Wenyao Liu et al., arXiv:1907.00904*

11:05-11:30

Heng Fan (Institute of Physics, CAS)

Quantum simulation of many-body systems by superconducting quantum processor

Abstract: The superconducting quantum processor is promising for quantum simulation, in particular, about various phenomena of many-body systems. In this talk, I will introduce our recent experimental work about strongly correlated quantum walks in a one-dimensional 12-qubit system, (Science'19). We show entanglement propagation and antibunching for excitations in the system.

11:30-11:55

Hiroki Takesue (NTT)

Coherent Ising machine for solving combinatorial optimization problems

Abstract: Recently, several approaches to find solutions to the Ising model using artificial spin systems have been studied intensively. Such systems include superconducting quantum bit systems developed by a Canadian company called D-Wave, with which one can solve complex Ising problems. A coherent Ising machine (CIM) is one of such systems in which the binary phase states of degenerate optical parametric oscillators (DOPO) are used to represent Ising spins. By using a long-distance (typically 1 km) fiber cavity that contains a phase sensitive amplifier, we can generate thousands of time-multiplexed DOPO pulses. Couplings between the DOPO pulses can be implemented by using a measurement-feedback scheme, with which we can effectively realize flexible mutual injection of lights among thousands of DOPO pulses. The networked DOPOs are most likely to oscillate at a phase configuration that best stabilize the whole network, which gives the solution to the given Ising problem. In the talk, I will detail the current status of the large-scale CIMs developed by NTT.

11:55-12:20

Hui Zhai (Tsinghua University)

Realizing the Hayden-Preskill Protocol with Dicke Model

Abstract: During quantum thermalization, the information of the initial state is lost and can not be recovered by local measurements. Hayden and Preskill prove that in

principle, it is possible to decode the information of the initial by using a maximally entangled state of the original system. Recently, Yoshida and Kitaev prove a concrete protocol of this decoding that requires maximumly chaotic quantum dynamics and two identical copies of a quantum system. Here we present a physical realization by using coupled Dicke model. With this physical realization, we can address the important issue of the stability of this protocol, by studying how the decoding efficiency depends on model parameters.

14:00-14:50
Anton Zeilinger (University of Vienna)
Micius Prize Talk

14:50-15:15
Qiang Zhang (University of Science and Technology of China)
Device Independent Quantum Random Number Generation, Expansion and Beacon
Abstract: Randomness is important for many information processing applications, including numerical modelling and cryptography. Device-independent (DI) quantum random-number generation based on the loophole-free violation of a Bell inequality produces genuine, unpredictable randomness without requiring any assumptions about the inner workings of the devices, and is therefore an ultimate goal in the field of quantum information science. Here, we developed hight efficient entangled photon pairs with an 81% heralding efficiency from creation to detection at a distance of about 200 metres that closed both detection and locality loopholes for a Bell test. Then, we demonstrate a series device independent quantum randomness experiment, including DI quantum random number generation, expansion and beacon test.

15:15-15:40
Xiaosong Ma (Nanjing University)
Harnessing single photons in quantum technology
Abstract: Quantum technology employs the 'spooky' phenomena of quantum physics such as superposition, randomness and entanglement to process information in a novel way. Quantum photonics provides a promising path for both exploring fundamental physics and delivering quantum-enhanced technologies. In this talk, I will introduce our recent work on quantum delayed-choice experiment based on multiphoton entangled states, which shows that a photon can not only be a particle or wave, but the superposition of them, even under Einstein's locality condition. In the second part of my talk, I will talk about our recent endeavors in developing functional nodes for quantum information processing based on integrated optics architecture and their potential applications in a metropolitan fiber network.

16:00-16:25
Peter Lodahl (University of Copenhagen)
Deterministic spin-photon interfaces

Abstract: Semiconductor quantum dots embedded in photonic nanostructures offer a highly efficient and coherent deterministic photon-emitter interface [1]. By introducing and controlling a single spin in the quantum dot, a coherent and deterministic spin-photon interface is obtained. We review recent experimental progress on coherent spin control of quantum dots in nanophotonic waveguides [2] enabled by the growth of low-noise heterostructures and subsequent fabrication of planar photonic structures [3].We demonstrate a photonic switch that is operated by controlling a single spin [4], which is a fundamental building block for photonic quantum gates. Furthermore, we present chiral photon-emitter interaction as a mean to construct non-reciprocal photonic devices [5,6]. We finally point out potential applications of this new quantum hardware for constructing a deterministic Bell-state analyzer [7] for photons or one-way quantum repeaters [8] towards photonic quantum networks [9].

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16:25-16:50

Armando Rastelli (Johannes Kepler Universität Linz)

Generation and teleportation of photonic entanglement using semiconductor nanostructures

Abstract: Semiconductor quantum dots (QDs) obtained by epitaxial growth are regarded as one of the most promising solid-state sources of triggered single and entangled photons for applications in emerging quantum communication and photonic quantum-information-processing.

In this talk, we will focus on GaAs QDs in AlGaAs matrix [1,2], which show a unique combination of appealing features: fast radiative rates of ~5 GHz, capability of generating near perfectly entangled photon pairs [3] with good indistinguishability [4], ultralow multiphoton emission probability [5], high brightness [6], as well as wavelength (~800 nm) suitable for free-space quantum communication. Some of these properties were recently used to implement photonic quantum teleportation and entanglement swapping using photons sequentially emitted by the same quantum dot [7].

Because of the statistical fluctuations in the optical properties of different QDs in an ensemble, scaling up the QD hardware is still an open challenge. Realistic strategies and encouraging results relying on post-growth tuning of the QD properties [8-11] will be discussed.

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16:50-17:15

Jianwei Wang (Peking University)

Integrated silicon-photonic quantum technologies

Abstract: On-chip generating, controlling and detecting quantum states of light with large-scale silicon-photonic circuits opens the way to realizing complex quantum technologies for applications in the fields of computing, simulation and communication. In this talk we present recent progress in large-scale integrated photonic circuit for quantum information processing. We will discuss a large silicon-photonic device that is able to generate, manipulate and measure high-dimensional entanglement with high controllability and universality. The generation and manipulation of multi-photon genuine multipartite entanglement and intra-chip/inter-chip quantum teleportation have been realized in a programmable device. We will further show the demonstrations of scattershot and Gaussian Boson sampling up to eight photons states in a single silicon device. With the developed quantum photonic hardware it allows us to benchmark the simulation and characterizations of electron spin systems and molecular systems with photons. These results show silicon-integrated quantum photonic circuits as a versatile testbed for new quantum algorithms and as a route towards large-scale quantum information processing, pointing the way to applications in fundamental science and quantum technologies.

17:15-17:40

Thore Posske (University of Hamburg)

Prospects on topological qubit manipulation in quantum spin helices

Abstract: A magnetic helix can be wound into a classical Heisenberg chain by fixing one end while rotating the other one. We discover that in quantum Heisenberg chains, the magnetization normally slips through before establishing a helix. This shows how avoided level crossings undermine classical topological protection. For half-integer spin chains of odd length, a nontrivial spin slippage states is protected. Together with the ground state, a spin chain qubit is defined that exhibits a non-trivial Berry connection similar to a Majorana fermion.

Wednesday, September 18

8:40-9:30
Charles H. Bennett (Thomas J. Watson Research Center, IBM)
Micius Prize Talk

9:30-09:55
Xiang-Bin Wang (Tsinghua University)
Development of practical quantum key distribution
Abstract: Based on the twin-field quantum key distribution (TFQKD) protocol, we proposed the send-or-not-send (SNS) protocol. Since the component for distilling the final key in the protocol is the twin-field single-photon state, the dependence of the key rate on the channel's transmittance η is $O(\sqrt{\eta})$. So, in a QKD communication with a long distance, the key rate of SNS protocol is much higher than that of the previous QKD protocols. At the same time, we use the operation of "sending or not sending" by the two users to encode the key, so there is no need for single-photon interference in Z-basis. Therefore, the error rate in Z-basis is low, so that our protocol can tolerate large misalignment error for single-photon interference in X-basis. Even if the misalignment error is as high as 35%, the secure distance can be more than 500 km. Based on the SNS protocol, we introduced the four-intensity decoy state method and considered its finite key size effect to obtain a pratical SNS protocol that can be implemented under real conditions. We proposed an improved SNS protocol with post selection with two-way classical communications, which reduces the requirement of the dark count rate of detectors and improves the performance of the protocol in a long-distance communication. Also, based on the idea of twin-field, we proposed a side-channel-free (SCF) TFQKD protocol, which can avoid any security vulnerabilities caused by the difference of the side-channel of encoding states and improve the security of the QKD protocol by one level. Our SCF protocol is entirely based on mature technology, and the secure distance can exceed 200 km.

9:55-10:20
Xiong-Jun Liu (Peking University)
Progress of quantum simulation with 2D and 3D spin-orbit coupled quantum gases
Abstract: Recent years have witnessed the considerable progresses in quantum simulation with spin-orbit coupled quantum gases. In the particular, the realization of 2D spin-orbit coupling for ultracold atoms in optical lattices opens up the quantum simulation for non-Abelian synthetic gauge fields. In this talk I will introduce the latest progresses of the theoretical and experimental studies of topological quantum gases with 2D and 3D spin-orbit couplings. In particular, we start with the proposal and realization of 2D and 3D spin-orbit couplings with high controllability and long lifetime, with which several novel topological states, including the 3D Weyl semimetal with minimal number of Weyl points, are first achieved in experiment. We further introduce the dynamical classification of topological quantum phases, with the theory being built

on the so-called dynamical bulk-surface correspondence, which leads to the high-precision detection of topological phases. The application of the dynamical schemes to observing high-dimensional topological phases in experiment is presented. We finally discuss the new developments and also future interesting issues in this promising field, including the realization of dynamical non-Abelian gauge fields in optical lattice, which may facilitate the study of a few outstanding problems in both theory and experiment.

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10:40-11:05

Jörg Wrachtrup (University of Stuttgart)

Quantum algorithm enhanced sensing

Abstract: Quantum sensing, especially when combined with nanoscale or microscale spatial resolution promises to provide entirely novel measurement tools for a wide range of applications. Recent demonstrations include nanoscale nuclear magnetic resonance on biological specimens as well as measurements on low dimensional magnetic and electron systems. Most of these accomplishments have been achieved with a single qubit sensing the external parameter. Yet, there is opportunity to employ multiple qubits for sensing to increase sensitivity bandwidth and dynamic range. In my talk, I will highlight the application of weak measurements to increase spectral resolution [1,2] as well as multi qubit algorithms for online quantum fourier transformation.

1. *M Pfender et al., Nature Comm. 10, 594 (2019)*
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3. *V. Vorobev et al. in preparation (2019)*

11:05-11:30

Zheng-Tian Lu (University of Science and Technology of China)

Atom Trap Trace Analysis: method and applications in the earth sciences

Abstract: Due to its simple production and transport processes in the environment, the long-lived noble-gas isotope 81Kr (half-life = 230 kyr) is the ideal tracer for studying old water and ice in the age range of 105-106 years, a range beyond the reach of 14C. 81Kr dating, a concept pursued in the past five decades, is finally available to the earth science community at large. This is made possible by the development of the Atom Trap Trace Analysis (ATTA) method, in which a magneto-optical trap is used to selectively capture and detect individual atoms of 81Kr, and measure 81Kr/Kr isotope ratios of environmental samples in the range of 10-14-10-12. ATTA is unique among all trace analysis techniques in that it is free of interferences from any other isotopes, isobars, atomic or molecular species. So far, 81Kr dating has been performed on hundreds of samples, extracted from six different continents, to study water circulation in the deep underground and address issues of groundwater resource management. It is also used to search for the oldest ice in Antarctica.

Google "ATTA primer" for more information.

11:30-11:55

Ren-Bao Liu (The Chinese University of Hong Kong)

Measuring classical and quantum many-body correlations

Abstract: A question fundamental in quantum physics and useful in quantum technology is to separate genuine quantum correlations from the classical ones. The correlations are also key information to understanding many-body physics, especially in mesoscopic systems (such as cold atom systems and nanoscale spin systems). A recent work shows that the correlations of quantum fluctuations in a many-body system may be fully simulated by classical noises if the classical quantities are continuated from the real axis to the complex numbers [1]. We present a systematic method based on sequential weak measurement [2] for extracting the classical and quantum correlations to arbitrary orders [3]. The possibility to obtain the high-order correlations in a quantum many-body system provides new opportunities for quantum sensing and for testing the foundation of quantum mechanics.

This work was supported by Hong Kong RGC Project 14300119.

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11:55-12:20

Jörg Schmiedmayer (TU Wien)

Higher-order correlations and what we can learn about quantum many body problems from experiments

Abstract: The knowledge of all correlation functions of a system is equivalent to solving the corresponding quantum many-body problem. If one can identify the relevant degrees of freedom, the knowledge of a finite set of correlation functions is in many cases enough to determine a sufficiently accurate solution of the corresponding field theory. Complete factorization of the correlation functions is equivalent to identifying the relevant degrees of freedom where the Hamiltonian becomes diagonal.

Interference in a pair of tunnel-coupled one-dimensional atomic super-fluids, which realize the quantum Sine-Gordon / massive Thirring models, allows us to study if, and under which conditions, the higher correlation functions factorize [1]. This allows us to characterize the essential features of the model solely from our experimental measurements: We detect the relevant quasi-particles, their interactions and the different topologically distinct vacuum-states. The experiment thus provides a comprehensive insight into the components needed to solve a non-trivial quantum field theory.

In addition I will report on our recent progress towards extracting the parameters of the underlying effective field theory model through evaluation of the irreducible 1PI correlations.

This establishes a general method to analyse quantum systems through experiments. It thus represents a crucial ingredient towards the implementation and verification of quantum simulators.

Work performed in collaboration with the groups of Th. Gasenzer und J. Berges (Heidelberg). Supported by the Wittgenstein Prize, the DFG-FWF: SFB ISOQUANT: and the EU: ERC-AdG QuantumRelax

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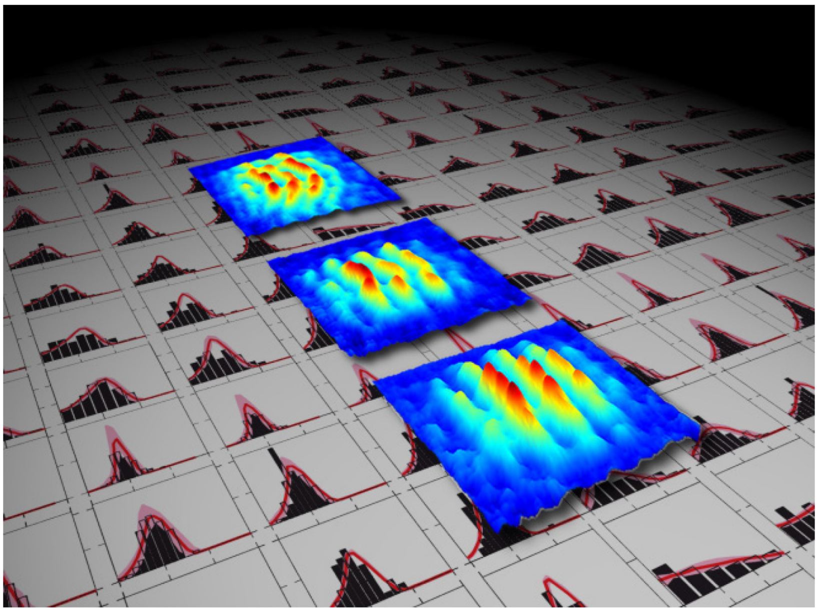

16:00-16:50
David J. Wineland (University of Oregon)
Micius Prize Talk

16:50-17:40
Jian-Wei Pan (University of Science and Technology of China)
Micius Prize Talk

Thursday, September 19

8:40-9:30
Artur Ekert (University of Oxford)
Micius Prize Talk

9:30-9:55
Vadim Makarov (Russian Quantum Center)
Improving security of a QKD system via an external audit
Abstract: I report methodology for security evaluation of a QKD system, which we have recently applied to several commercial devices. Results from one of them, a sub-carrier wave QKD system developed by ITMO University, will be shown [1]. Our audit and the follow-up work by the manufacturer have led to a marked improvement in implementation quality.
1. *S. Sajeed, P. Chaiwongkhot, A. Huang, H. Qin, V. Egorov, A. Kozubov, A. Gaidash, V. Chistiakov, A. Vasiliev, A. Gleim, and V. Makarov, manuscript in preparation.*

9:55-10:20
Axel Pelster (Technische Universität Kaiserslautern)
Superfluidity in Strong Dipolar Quantum Gases
Abstract: We discuss the prospects of using ultracold large magnetic lanthanides, such as dysprosium and erbium, as well as heteronuclear molecules in the quantum degenerate regime as a platform for quantum sensors. To this end we theoretically analyze the emergence of superfluidity for strong dipolar quantum gases, which represents a hallmark of quantum many-body physics. One focus is on studying dipolar fermions in a harmonic confinement, where the Fermi sphere has already been shown to be deformed into an ellipsoid, which follows the orientation of the dipoles. We investigate to which degree also the spatial distribution is rotated towards the dipolar preference direction. This allows us to study how the critical dipolar strength, up to which the Fermi gas could be confined, depends on the interplay of trap geometry and dipolar orientation. Based on these results we then come to the major question how the superfluid pairing in a single- and two-component component dipolar Fermi gas is modified by the deformation of the Fermi sphere. Here it is of interest to study how the emergent superfluidity as well as its anisotropic order parameter and its critical temperature are tunable by both the trap geometry and the dipolar orientation.

In addition, we review the current quest for a better understanding of the anisotropic superfluid properties of dipolar quantum droplets, which arise in a strong dipolar Bose gas and which reveal a high degree of sensitivity. On the one hand, we investigate how quantum fluctuations affect the stability of dipolar quantum droplets and their anisotropic velocity of sound. On the other hand, we are interested in the emergence of quantum droplets in fast-rotating dipolar Bose-Einstein condensates and consider whether the presence of vortices in the system enhances this process. Here we explore if it is possible to generate quantum droplets with angular momentum using this protocol and study how this affects both the formation and the shape of the droplet crystals, as well as their phase coherence.

10:40-11:05

Roger Colbeck (University of York)

Device Independent Quantum Randomness Expansion: new protocols with higher rates

Abstract: I will explain the idea behind device-independent quantum random number generators and their motivation. While most proofs use the CHSH protocol, I will discuss new protocols whose aim is to get more randomness per shared entangled state. I will explain how existing proofs need to be adapted to these and show that a simple modification of the CHSH protocol can robustly yield up to two bits of randomness per shared entangled pair.

11:05-11:30

Yanbao Zhang (NTT Basic Research Laboratories)

Certifying device-independent quantum randomness with high finite-data efficiency

Abstract: Applications of randomness such as private key generation and public randomness beacons require small blocks of certified random bits on demand. Device-independent quantum random number generators can produce such random bits, but existing quantum-proof protocols and loophole-free implementations suffer from high latency, requiring many hours to produce any random bits. Here we develop a broadly applicable method, quantum probability estimation, for yielding efficient quantum-proof protocols. The method is general and encompasses techniques from previous works [Miller and Shi, SIAM Journal on Computing 46, 1304 (2017); Arnon-Friedman et al., Nature Communications 9, 459 (2018)]. Quantum probability estimation can adapt to changing experimental conditions, allows stopping the experiment as soon as the prespecified randomness goal is achieved, and can tolerate imperfect knowledge of the input distribution. Moreover, we demonstrate device-independent quantum randomness generation from a loophole-free Bell test with quantum probability estimation, obtaining multiple blocks of 512 random bits with an average experiment time of less than 5 minutes per block and with certified error bounded by $2^{-64} \approx 5.42 \times 10^{-20}$.

11:30-11:55

Reinhard Scholl (International Telecommunication Union (ITU))

Why we should care about standards in quantum information technology?

Abstract: The talk highlights the importance of standards activities in Quantum Information Technologies and gives an overview of the standards activities taking place in various standards organizations.

11:55-12:20

David Gershoni (Technion-Israel Institute of Technology)

Complete state tomography of a quantum dot confined spin qubit and cluster states of entangled photons*

Abstract: Semiconductor quantum dots are probably the preferred choice for interfacing anchored, matter spin qubits and flying photonic qubits. While full tomography of a flying qubit or light polarization is in general straightforward, matter spin tomography is a challenging and resource-consuming task. Here we present a novel all optical method for conducting full tomography of a semiconductor quantum dot confined spin. We excite the spin qubit using short resonantly tuned, polarized optical pulses, which coherently convert the qubit to an excited qubit. We then use polarization sensitive time resolved measurements of the emitted light for determining the initial state of the excited spin qubit. The latter depends on the state of the unexcited qubit and the polarization of the exciting pulse. This way, by using two different, orthogonally linearly polarized excitations, followed by time resolved measurements of the degree of circular polarization of the emitted light, full tomography of the spin qubit is obtained. Our method can be applied for tomography of confined spin qubits formed by conduction-band electrons, valence-band holes and electron-hole pairs – bright and dark excitons. Using our novel method, we demonstrate full tomography of a confined spin qubit with a fidelity of 0.94.

The new method was further used for characterization of the process map of a quantum dot based knitting machine device, which can deterministically produce strings of about 1200 photons at a rate of above 1GHZ and entanglement length of about 5 photons. Moreover, Full state tomography of entangled spin and two photons was demonstrated for the first time.

**Work done in collaboration with Dan Cogan, Giora Penaikov and Zu-En Su*

14:00-14:50

Gilles Brassard (Université de Montréal)

Micius Prize Talk

14:50-15:15

Chao-Yang Lu (University of Science and Technology of China)

Toward "quantum supremacy" with single photons

Abstract: Quantum computers can in principle solve certain problems faster than classical computers. Despite substantial progress in the past decades, building quantum machines that can actually outperform classical computers for some specific tasks—a

milestone termed as "quantum supremacy"—remained challenging. Boson sampling has been considered as an intermediate step for linear optical quantum computing, and a strong candidate to demonstrate the quantum computational supremacy.

The experimental challenge for realizing a large-scale boson sampling mainly lies in the lack of a perfect single-photon sources. In this talk, I will report two routes towards building boson sampling machines with many photons. In the first path, we developed parametric down-conversion two-photon source with simultaneously a collection efficiency of 97% and an indistinguishability of 96% between independent photons [PRL 121, 250505 (2018)]. With this, we demonstrate genuine entanglement of 12 photons, scattershot boson sampling, and Gaussian boson sampling. We also made efforts to generate efficient and indistinguishable entangled photons from quantum dots [PRL 122, 113602 (2019)].

In the second path, using a quantum dot-micropillar, we produced single photons with high purity (>99%), near-unity indistinguishability for >1000 photons, and high extraction efficiency—all combined in a single device compatibly and simultaneously [PRL 116, 020401 (2016)]. The highest-quality single photons allowed us to perform quantum interference with sunlight with 80% raw visibility, which proved the quantum nature of thermal light [PRL 123, 080401 (2019)]. We developed bichromatic laser excitation [Nature Physics online 2019] and elliptical microcavites [Nature Photonics online 2019] to overcome the polarization filtering to create truly optimal single photon sources. We build few photon boson sampling machines which runs 5-7 orders of magnitudes faster than all the previous experiments [Nature Photonics 11, 365 (2017)]. Plan is to achieve boson sampling with 20-30 photons in the near term.

Friday, September 20

8:40-9:30

Ignacio Cirac (Max Planck Institute of Quantum Optics)

Micius Prize Talk

9:30-9:55

Jing Zhang (Shanxi University)

Artificial gauge field of One-Dimensional Superradiance Lattices in Ultracold Atoms

Abstract: There have been significant recent advances in realizing band structures with geometrical and topological features in experiments on cold atomic gases. We experimentally realize one-dimensionally superradiance lattice (SL) with 87Rb Bose-Einstein condensate (BEC) based on electromagnetically induced transparency (EIT). Based on one-dimensional SL in standing wave-coupled electromagnetically induced transparency, a far-detuned standing wave field is introduced to synthesize a magnetic field. The relative spatial phase between the two standing wave coupling fields introduces a magnetic flux in the sawtooth loop transitions of the lattice. This flux determines the moving direction of excitations created in the SL and results in nonsymmetric reectivities when the SL is probed in two opposite directions. Our work

demonstrates an in-situ technique to synthesize and detect topological matter in cold atoms..

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9:55-10:20

Alexander Streltsov (University of Warsaw)

Quantum coherence and state conversion: theory and experiment

Abstract: The resource theory of coherence studies the operational value of superpositions in quantum technologies. A key question in this theory concerns the efficiency of manipulation and inter-conversion of the resource. We solve this question completely for qubit states by determining the optimal probabilities for mixed state conversions via stochastic incoherent operations. Extending the discussion to distributed scenarios, we introduce and address the task of assisted incoherent state conversion where the process is enhanced by making use of correlations with a second party. Building on these results, we demonstrate experimentally that the optimal state conversion probabilities can be achieved in a linear optics set-up. This paves the way towards real world applications of coherence transformations in current quantum technologies. For more details see Wu et al., arXiv:1903.01479.

10:40-11:05

Barry Sanders (University of Calgary)

Machine learning for quantum control

Abstract: We develop a framework that connects reinforcement learning with classical and quantum control, and this framework yields adaptive quantum-control policies that beat the standard quantum limit, inspires new methods for improving quantum-gate design for quantum computing, and suggest new ways to apply classical and quantum machine learning to control.

11:05-11:30

Guihua Zeng (Shanghai Jiao Tong University)

Quantum Sensing and Information Security

Abstract: Quantum sensing is a distinct and rapidly growing branch of research within the area of quantum science and technology, which is expected to provide new opportunities with regard to high sensitivity and precision in applied physics and many other areas of science.

Firstly, we focus on employing the quantum weak measurement to produce ultimate sensitive quantum sensors. We study the fundamental problems that impede the practical applications of quantum weak measurement. Several new methods are

proposed, e.g., a new scheme achieving Heisenberg limit with assistance of quantum entanglement, an upgraded adaptive method for extending the dynamic range, a machine learning algorithm for approximately modeling the long-term correlated noises, a new way to implement high sensitive interferometry, a new approach for dramatically increasing the signal intensity while remaining ultra-high sensitivity, and so on. With the help of these new proposals, the practical performance of weak measurement based metrological schemes can be significantly improved, and the applications outside of laboratory are much less challenging. Several useful applications have been experimentally demonstrated, e.g., measurement optical time-delay with sensitivity of sub-attosecond, measuring third-order optical nonlinearity with resolution of 7.5×10^{-7} rad, sensing temperature change with precision of 3×10^{-6} ^{o}C, and so on. Our experimental results pave the way for developing new type of quantum sensors, such as ultra-high precision temperature sensor and ultra-sensitive acoustic pressure sensor.

Secondly, we focus on the well-known ghost imaging which can eliminate the needs for focal plane array detector and enhance the sensing capability of the imaging system. A computational ghost imaging system even can perform imaging with merely one single pixel detector without raster scan. Single photon detector is one special type of single pixel detector which has already reached extreme sensitivity. Our group is dedicated to explore the extreme performance of ghost imaging system with single photon detection in the photon starved situation. We developed a photon limited ghost imaging system which could capture an image with about 0.01 photon per pixel for the target at 100 km far away. One or two orders of magnitude in the consumption of total light power and acquisition time could been saved compared with the state-of-the-art imaging technique. Moreover, even when the object could not be imaged because of the extreme limitation of the reflected photons from the object. A non-imaging object classification method is developed while we combined machine learning algorithm.

Finally, to guarantee the communication security between different sensors, we have investigated the continuous variable quantum key distribution (CVQKD). For the CVQKD in optical fiber channel, we achieved a high-key-rate CVQKD with a real LO, which can reach 3.14 Mbps @25 km secure secret key rate. This work makes a new record of secure secret key rate of CVQKD within the metropolitan area. Then, a classical carrier phase estimation (CPE) algorithm is firstly proposed to simultaneously realize CVQKD and classical communication by using the same communication infrastructure and on a single wavelength. Furthermore, a novel polarization-state tracking (PST) scheme based on Kalman filter and a high-precision phase compensation scheme based on optimal iteration algorithm for CVQKD are realized. The results show that PST scheme can resist the interference of state of polarization rotation at 1 krad/s and the phase compensation scheme can reach 10^{-4} rad precision level while simultaneously ensuring the efficiency. These works pave the way for the implementation of high-performance CVQKD under harsh channel conditions. For the CVQKD in free-space channel, we have investigated the CVQKD against background noises. The results indicate the effective resistance against background noises, which demonstrates feasibility of all-day free-space quantum communication using coherent detection. Then we successively proposed two parameter estimation (PE) methods, i.e., the maximum-likelihood PE and blind PE for CVQKD over atmospheric link, which fill the blank of PE method for implementation of practical atmospheric CVQKD. For the practical security of CVQKD system, we have investigated the practical security of the CVQKD systems under reduced optical attenuation attack and laser seeding attack by injecting extra light into the optical attenuator and laser diodes of the light source, respectively. To resist these attacks, corresponding countermeasures are suggested. Then, a long-distance continuous-variable measurement-device-independent quantum key distribution protocol with discrete modulation is proposed, which has a simpler implementation and outperforms previous protocols in terms of achievable maximal transmission distance.

11:30-11:55

Giuseppe Vallone (University of Padova)

Secure Quantum Random Number Generators for Quantum Communication*

Abstract: The generation of random numbers is of fundamental importance for applications related to information technology and for scientific simulations. Quantum Random Number Generators (QRNG) exploits intrinsic probabilistic quantum processes to generate true random numbers. While the randomness of the obtained numbers is assessed by applying statistical tests on the output bits, a posteriori statistical tests cannot certify that the numbers are not known to someone possessing side information. In a "trusted-device" framework, the amount of randomness that can be extracted for each measurement is the so called classical min-entropy. In a scenario in which the privacy and the security of the generated number is a concern, any imperfection in the physical realization of the QRNG may leak information correlated with the generated numbers, the so-called side information. Such classical or quantum correlations could be exploited by an eavesdropper to correctly guess the measurement outcomes. In this case, the maximal amount of randomness that can be extracted in presence of such side it is given by the socalled quantum conditional min-entropy. A trade-off between security and practicality is represented by the so-called Semi-Device-Independent (SDI) protocols [1]: they allow to enhance the security with respect to standard "fully trusted" QRNGs, but they also achieve fast generation rate. SDI protocols require some weaker assumptions to bound the quantum min-entropy with respect to fully-trusted QRNGs.

Here we report on our recent proposals and experimental demonstrations of efficient protocols for the secure generation of random numbers in the SDI framework. We will present the QRNGs based on a trusted measurement devices and complete untrusted sources, in a source-device-independent scenario. The QRNG can be based to continuous variables [2-4] or discrete variables [5]. We also present an efficient method that allows to estimate the quantum min-entropy for a multi-detector QRNG array. In this latter case, we considered a scenario in which an attacker can control the efficiency of the detectors and knows the emitted number of photons [6].

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11:55-12:20

Bo Zhao (University of Science and Technology of China)

Observation of atom-molecule Feshbach resonances at ultracold temperatures

Abstract: Ultracold molecules offer great opportunities to study molecular collisions in the quantum regime. At ultralow temperatures, the de Broglie wavelength of the collision partners is much larger than the range of molecular interaction potential, and only the lowest possible partial wave of relative orbital angular momentum dominates the collision process. Therefore, the collisions at ultracold temperatures are highly quantum mechanical. Scattering resonances are among the most remarkable quantum phenomena. They are extremely sensitive to the details of molecule interaction potential and thus offer a unique probe of the potential energy surface governing the collision dynamics. I will talk about our recent work on the observation of magnetically tunable Feshbach resonances in ultracold collisions between potassium-40 (40K) atoms and sodium-23–potassium-40 (23Na40K) molecules in the rovibrational ground state. We have observed 11 resonances in the magnetic field range of 43 to 120 gauss. The observed atom-molecule Feshbach resonances at ultralow temperatures probe the three-body potential energy surface with exceptional resolution and will help to improve understanding of ultracold collisions.

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