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한·중 양자정보 협력 워크샵 ----- 韩·中量子信息学术交流研讨会

Korea-China Workshop on Quantum Information, 2019

Nov 28 (Thursday) - Nov 29 (Friday), 2019

Nov 29 (Friday) is Invitation Only.

KIAS [Rm 1503, Bldg 1], **Seoul, Korea**

Hosted by **KOSTEC**

Organized by **KIAS, QuIST**, and **NRF**

*** There is no registration fee,

*** but the registration is required for admission.

KOSTEC: Korea-China Science & Technology Cooperation Center http://kostec.re.kr

KIAS: Korea Institute for Advanced Study http://www.kias.re.kr

QuIST: Korean Association of Quantum Information Science and Technology http://quist.or.kr

NRF: National Research Foundation of Korea http://nrf.re.kr

Invited Speakers

Qiongyi He (Peking U)

Heng Fan (CAS)

Kihwan Kim (Tsinghua U)

Xiang-Bin Wang (Tsinghua U)

Yonuk Chong (KRISS)

Taehyun Kim (SNU)

Jinhyoung Lee (Hanyang U)

Su-Yong Lee (ADD)

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Quantum key distribution in practice:
the decoy state method, the MDIQKD, and the Twin-field QKD

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Optical quantum metrology in lossy interferometry

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Entangled or squeezed input states can outperform any classical input states in quantum metrology. It can achieve the Heisenberg limit which is the fundamental limit by quantum mechanics, whereas the best classical input state can attain the standard quantum limit. In this seminar, I introduce the basic concept of quantum metrology. Then I show the change of the precision limit in lossy optical interferometry.

Quantifying the mesoscopic nature of the Einstein-Podolsky-Rosen nonlocality

Qiongyi He (何琼毅)

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Evidence for Bell's nonlocality is so far mainly restricted to microscopic systems, where the elements of reality that are negated predetermine results of measurements to within one spin unit. Any observed nonlocal effect (or lack of classical predetermination) is then limited to no more than the difference of a single photon or electron being detected or not (at a given detector). In this paper, we analyze experiments that report Einstein-Podolsky-Rosen (EPR) steering form of nonlocality for mesoscopic photonic or Bose-Einstein condensate (BEC) systems. Using an EPR steering parameter, we show how the EPR nonlocalities involved can be quantified for four-mode states, to give evidence of nonlocal effects corresponding to a two-mode number difference of 105 photons, or of several tens of atoms (at a given site). We also show how the variance criterion of Duan-Giedke-Cirac and Zoller for EPR entanglement can be used to determine a lower bound on the number of particles in a pure two-mode EPR entangled or steerable state, and apply to experiments.

Joint measurability by W measures

Jinhyoung Lee (이진형)

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We consider joint measurability of two measurements by introducing W measure. W measure is a Hermitian operator-valued measure, which is unnecessarily positive, contrary to a positive operator-valued measure (POVM) for representing general quantum measurement. Incompatible measurements are a fundamental ingredient to reveal quantum phenomena including uncertainty relation and Bell theorem. It is known that some measurements show no genuine quantum effects, even though they are incompatible. This can be explained by their joint measurability, saying that there exists a mother POVM whose marginals are the very POVMs of those measurements. For instance, Bell theorem implies that a Bell inequality is violated by quantum model. When the local measurements are joint measurable, however, they do not violate any Bell inequalities. We study joint measurability of two measurements with a W measure. We start by assigning a W measure, as a mother measure, to the measurements. We prove that two given measurements are joint measurable if and only if the W measure is a POVM. Based on W measure, we also propose a measure of negativity to quantify the degree of joint measurability. We apply our method to dichotomous measurements and to trichotomous measurements for qubits.

Toward large scale quantum simulations with fully-controlled trapped ion-qubits

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The performance of a physical quantum device for quantum computation can be evaluated by the following three criteria; the coherence time of a qubit, the fidelity of a logical gate, and number of qubits involved in coherent operations. In this seminar, I will discuss our experimental efforts to realize a large scale quantum computation and simulation in these three aspects as follows.

1) Coherence time: We have demonstrated the coherence time of a single 171Yb+ ion-qubit over 600 s [1] and recently extended it to close to an hour.

2) Number of qubits in coherent operations: We have developed a five-qubit programmable system and realized a scalable global quantum gate. In the system, we propose and implement a scalable scheme to realize the global entangling gates, important more than two qubit gates, on multiple 171Yb+ ion-qubits [2].

3) Fidelity of logical qubit gates: We apply a scheme of quantum error mitigation based on probabilistic error cancellation [3]. We benchmark the performance of the protocol in our trapped-ion system and clearly observe that effective gate fidelities exceed physical fidelities [4].

[1] Ye Wang, et al., Nature Photon. 11, 646 (2017).

[2] Yao Lu, Shuaining Zhang, Kuan Zhang, et al., Nature 572, 363 (2019).

[3] Y. Li and S. C. Benjamin, Phys. Rev. X 7, 021050 (2017).

[4] Shuaining Zhang, et al., arXiv:1905.10135

Quantum information processing based on photons and trapped ions

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Entangled states shared between two remote parties have important roles both in fundamental science and in quantum information applications. In this talk, I will give an overview about two different approaches to generate entangled states between two remote sites, and provide old and recent results using photons and trapped ions.

Quantum simulation with superconducting quantum circuits

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Superconducting quantum circuits are promising for simulation of various physical phenomena. In this talk, I will present our recent results about quantum simulation and entanglement generation. We realize the strongly correlated quantum walks in a 1D array of 12-qubit superconducting quantum processor. The one- and two-particle quantum walks are realized by time evolution of quantum states by flipping one qubit or two qubits after initialization. For one-particle quantum walks, the propagations of quantum information including entanglement are shown precisely. We can find that the propagations of different physical quantities can be described by Lieb-Robinson bounds which are analogous to light-cone phenomenon. The anti-bunching is shown in two-particle quantum walks due to strongly correlated excitations. Results about simulation of localizations for a Bose-Hubbard ladder model by 20 superconducting qubits, generation of 20-qubit Schrodinger cat states and 18-qubit GHZ state with superconducting qubits will be presented.

References:

[1] C. Song et al., Science 365, 574-577 (2019).

[2] Z. Yan et al., Science 364, 753-756 (2019).

[3] Y. Ye et al., Phys. Rev. Lett. 123, 050502 (2019).

Superconducting qubit and related researches in KRISS

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Here we introduce our quantum research activities in KRISS (Korea Research Institute of Standards and Science). Based on our superconducting Josephson electronics capability, including SQUIDs and Voltage standards, we are now working on superconducting qubit technology for quantum information science. We will introduce our 3D transmon works in general, our qubit performances, and our recent demonstration of the entanglement with the all-microwave control. In a related quantum technology, we will briefly introduce our research in superconducting single photon detector, and some of related single photon activities.

	Nov 28, Thursday	Nov 29, Friday	Nov 30, Saturday
	Registration		Departure
9.30-9.40	Opening		
9.40-10.20	Talk 1. Xiang-Bin Wang(Tsinghua U) Development of practical quantum key distribution	Forum: [Speakers and Organizers] Future of Korea-China Science & Technology Cooperation	
10.20-11.00	Talk 2. Su-Yong Lee (ADD) Optical quantum metrology in lossy interferometry		
11.00-11.20	Break		
11.20-12.00	Talk 3. Qiongyi He (Peking U) Quantifying the mesoscopic nature of the Einstein-Podolsky-Rosen nonlocality		
12.00-12.40	Talk 4. Jinhyoung Lee (Hanyang U) Joint measurability by W measures		
12.40-14.00	Lunch		
14.00-14.40	Talk 5. Kihwan Kim (Tsinghua U) Toward large scale quantum simulations with fully-controlled trapped ion-qubits	Forum: [Speakers and Organizers] Visiting Korean Institutes	
14.40-15.20	Talk 6. Taehyun Kim (SNU) Quantum information processing based on photons and trapped ions		
15.20-15.40	Break		
15.40-16.20	Talk 7. Heng Fan (CAS) Quantum simulation with superconducting quantum circuits		
16.20-17.00	Talk 8. Yonuk Chong (KRISS) Superconducting qubit and related researches in KRISS		
17.00-17.20	Break		
17.20-18.00	Forum: Korea-China Cooperation for the Future of Quantum Technology		