2nd International Workshop on Quantum Information Engineering (QIE2025)

Seaside House, Okinawa Institute of Science and Technology (OIST), Okinawa, Japan
8 – 10 October 2025

Program and Abstracts

Program at a Glance

		October 8 (Wed)		October 9 (Thu)		October 10 (Fri)
9:00–9:20			3. Electron and Defect-Based Qubits (H. Kosaka)	E. Kawakami (RIKEN)	7. Quantum Algorithms and Quantum Applications (M. Hirokawa)	H. Kuji (TUS)
9:20–9:40						M. Mandal (BITS)
9:40–10:00				M. Belianchikov (OIST)		T. Yoshida (TUS)
10:00–10:10				K. W. Yip (OIST)		M. Sanino (São Paulo State Univ.)
10:10–10:20		Openning				
10:20–10:40	1. Atomic and Ionic Quantum Computing (H. Takahashi)	K. Ohmori (IMS)		R. Kitagawa (Fujitsu)		A. Ali (Hamad Bin Khalifa Univ.)
10:40–11:00				Coffee break		Coffee break
11:00–11:40		N. Linke (Duke Univ.)	4. Nonequilibrium Quantum Dynamics and Phases (K. Koshino)	K. Takasan (U-Tokyo)	8. Coherence and Dynamics on Superconducting Devices (S. Saito)	L. V. Abdurakhimov (IQM)
11:40–12:00		R. Ohira (QuEL)		J. Gao (U-Tokyo)		K. Shinjo (RIKEN)
12:00–13:30		Lunch		Photo, Lunch		Lunch
13:30–14:10	2. Fault-Tolerant Quantum Computing and Precision Control (T. Yamashita)	H. Goto (RIKEN)	5. Superconducting Bosonic Qubits (Y. Kubo)	M. Matheny (AWS)	9. Silicon Spin Qubits (A. Oiwa)	M. De Smet (TU Delft)
14:10–14:30		U. G. Subramanian (IIT)		T. Mikawa (NTT)		A. Noiri (RIKEN)
14:30–14:50		Y. Kondo (Kindai Univ.)		T. Takenaka (NTT)		
14:50–15:10		S. Kukita (NDAJ)		Coffee break		Closing
15:10–15:30		Coffee break	6. Optical Quantum Computing and Networks (S. Iwamoto)	S. Takeda (U-Tokyo)		
15:30–15:50		Poster session				15:30 bus for the airport
15:50–16:10				S. Pickup (OIST)		
16:10–17:00				Free discussion		
17:00–18:00		Free discussion				
18:00–20:00		Dinner		Banquet		
20:00–		Free discussion		Free discussion		

Overview

We are excited to have the 2nd International Workshop on Quantum Information Engineering (QIE2025) organized by Quantum Information Engineering Professional Group, the Japan Society of Applied Physics. This event will bring together fifty world-class scientists, engineers, researchers, and students in the field of quantum information engineering. Participants will present their latest research as well as engage in active discussions on the current state of the field and its future prospects.

Organizer

Quantum Information Engineering Professional Group, the Japan Society of Applied Physics (JSAP)

Co-organizers

Okinawa Institute of Science and Technology (OIST)
Quantum Information Research Center (QIC), Yokohama National University
Quantum Electronics Professional Group, the Japan Society of Applied Physics (JSAP)
Moonshot Research and Development Program Goal 6, Japan Science and Technology Agency

Sponsor

The Physical Society of Japan (JPS)

Scope

Quantum Computing
Quantum Networks
Quantum Algorithms
Quantum Simulations
Quantum Sensing
Quantum Middleware
Novel Quantum Systems for Quantum Devices

Committee

Chair: Shiro Saito (NTT, Inc.)
Shiro Kawabata (Hosei University)
Kazuki Koshino (Institute of Science Tokyo)
Taro Yamashita (Tohoku University)
Haruki Kiyama (Kyushu University)
Shinichiro Fujii (RIKEN)
Masao Hirokawa (Kyushu University)
Satoshi Iwamoto (The University of Tokyo)
Kenichi Kawaguchi (Fujitsu Ltd.)
Hideo Kosaka (Yokohama National University)
Yuimaru Kubo (OIST)
Hiroki Kutsuma (Tohoku University)
Nobuyuki Matsuda (Tohoku University)
Fumiaki Matsuoka (OIST)
Raisei Mizokuchi (Institute of Science Tokyo)
Kae Nemoto (OIST & NII)
Akira Oiwa (The University of Osaka)
Shintaro Sato (Fujitsu Ltd.)
Hiroki Takahashi (OIST)
Tsuyoshi Yamamoto (NEC)
Fumiki Yoshihara (Tokyo University of Science)

Invited Speakers

Leonid V. Abdurakhimov (IQM) "Engineering Superconducting Transmon Qubits with High Coherence and High Fidelities"

Hayato Goto (RIKEN) "Many-Hypercube Codes and Related Topics"

Maxim De Smet (TU Delft) "High-Fidelity Transport and Quantum Logic of Mobile Spin Qubits in Silicon"

Erika Kawakami (RIKEN) "Long-Coherence-Time Charge Qubits with Electrons on Solid Neon"

Norbert Linke (Duke University) "Hybrid Quantum Simulation and City-Scale Quantum Networking with Trapped Ions"

Matthew Matheny (AWS) "Hardware-Efficient Quantum Error Correction via

Concatenated Bosonic Qubits"

Akito Noiri (RIKEN) "Recent Advances in High-Fidelity Operations and Scalability of Silicon Spin Qubits"

Kenji Ohmori (Institute for Molecular Science) "Ultrafast Quantum Computing with Ultracold Atom Arrays at Quantum Speed Limit"

Kazuaki Takasan (Univ. Tokyo) Quantum Active Matter: Advancing the Frontiers of Nonequilibrium Phases of Matter

Shuntaro Takeda (Univ. Tokyo) "Programmable Continuous-Variable Photonic Quantum Computing in the Time Domain"

Presentations

Invited talks: 40 minutes (including 5 minutes for discussion)

Contributed talks: 20 minutes (including 5 minutes for discussion)

Poster presentations: Poster board size is W900 × H1200 mm (equivalent to A0 size).

Meals

Breakfast and lunch will be provided on all three days of the workshop.

Dinner will be served on 8 October.

Banquet

The banquet will take place at the OIST Seaside House on 9 October, beginning at 18:00. Participation is limited to those who have paid the banquet fee in advance.

Taxi Service between Hotel and Seaside House

For participants staying at the **Moon Beach Museum Resort Hotel**, taxis have been arranged between the hotel and Seaside House.

- On **8 October**, taxis will depart from the hotel at 9:30.
- On **9 and 10 October**, taxis will depart from the hotel at 8:30.
- Between 20:00 and 20:30 each evening, two taxis will shuttle participants from Seaside House back to the Moon Beach Museum Resort Hotel. The taxis will operate as a shuttle service, making multiple trips to accommodate approximately 20 participants.

Bus transportation to Naha airport (10 October)

After the workshop concludes, complimentary bus transportation to **Naha Airport** will be available. No reservation is required.

- **Capacity:** 50 seats (sufficient for nearly all participants)
- **Departure:** The bus will leave Seaside House at 15:30 and go directly to Naha Airport.

Homepage

https://annex.jsap.or.jp/qie/QIE2025/

Contact

For inquiries, please contact: qie2025@ml.ntt.com

October 8 (Wednesday)

Session 1 Atomic and Ionic Quantum Computing (H. Takahashi)

We-01： Ultrafast quantum computing with ultracold atom arrays at quantum speed limit
(Invited) Kenji Ohmori
Institute for Molecular Science, National Institutes of Natural Sciences, Japan

We-02： Hybrid quantum simulation and city-scale quantum networking with trapped ions
(Invited) Norbert Linke, Anton T. Than, Mika Zalewski, Denton Wu, Alaina Green, Zohreh Davoudi
Duke Quantum Center, Duke University/ Joint Quantum Institute, University of Maryland

We-03： Progress toward a Control System for Electric-Based Trapped-Ion Quantum Processors
Ryutaro Ohira, Yoshinori Kurimoto, Masanari Miyamoto, Shinichi Morisaka, Ippei Nakamura, Atsushi Noguchi, Utako Tanaka, Takefumi Miyoshi
QuEL, Inc.

Session 2 Fault-Tolerant Quantum Computing and Precision Control (T. Yamashita)

We-04： Many-hypercube codes and related topics
(Invited) Hayato Goto
RIKEN Center for Quantum Computing

We-05： Converse for Fault tolerant Quantum Computation
G. Subramanian
Indian Institute of Technology (at the time of work; currently at OIST)/ University of Illinois Urbana-Champaign/Indian Institute of Technology Madras

We-06： Dynamically Corrected Quantum Gates Designed Geometrically
Yasushi Kondo, Shingo Kukita
Department of Physics, Kindai University / Department of Computer Science, National Defense Academy of Japan

We-07： Suppression of detuning error in entanglement-enhanced sensing
Shingo Kukita, Yuichiro Matsuzaki
National Defense Academy of Japan/ Chuo University

October 9 (Thursday)

Session 3 Electron and Defect-Based Qubits (H. Kosaka)

Th-01： Long-Coherence-Time Charge Qubits with Electrons on Solid Neon
(Invited) J. Wang, Y. Tian, A. Jennings, I. Grytsenko, O. Rybalko, X. Zhou, D. Jin, H. Terai, and E. Kawakami
RIKEN Center for Quantum Computing/ Cluster for Pioneering Research, RIKEN/B. Verkin Institute for Low Temperature Physics and Engineering/ Department of Physics and Astronomy, University of Notre Dame/ Advanced ICR Research Institute, National Institute of Information and Communications Technology

Th-02： MM-wave tomography of electron chain in on-chip microtrap
Mikhail Belianchikov, Natalia Morais, and Denis Konstantinov
Okinawa Institute of Science and Technology

Th-03： Experimental Study of Electron Mobility on the surface of Neon
Ka Wing Yip, Tomoyuki Tani, Jui-Yin Lin, Mikhail Belianchikov, Denis Konstantinov
Okinawa Institute of Science and Technology

Th-04： Creation and observation of strained single tin vacancy center in diamond nano pillar

Ryota Kitagawa, Toshiki Iwai, Yang Yeting, Tetsuya Miyatake, Teruya Ishihara, Satoshi Iwamoto, Toshiyuki Miyazawa, Kenichi Kawaguchi, Ryoichi Ishihara, Shintaro Sato

Quantum Laboratory, Fujitsu Ltd./ Research Center for Advanced Science and Technology, The University of Tokyo/ QuTech, Delft University of Technology

Session 4 Nonequilibrium Quantum Dynamics and Phases (K. Koshino)

Th-05： Quantum Active Matter: Advancing the Frontiers of Nonequilibrium Phases of Matter

(Invited) Kazuaki Takasan

The University of Tokyo

Th-06： Non-equilibrium Dynamics of Three-Level Absorption Refrigerator at Third-Order Liouvillian Exceptional Points

Jingyi Gao, Naomichi Hatano

Department of Physics, University of Tokyo/Institute of Industrial Science, the University of Tokyo

Session 5 Superconducting bosonic qubits (Y. Kubo)

Th-07： Hardware-efficient quantum error correction via concatenated bosonic qubits

(Invited)

Harald Putterman, Kyungjoo Noh, Connor T. Hann, Gregory S. MacCabe, Shahriar Aghaeimeibodi, Rishi N. Patel, Menyoung Lee, William M. Jones, Hesam Moradinejad, Roberto Rodriguez, Neha Mahuli, Jefferson Rose, John Clai Owens, Harry Levine, Emma Rosenfeld, Philip Reinhold, Lorenzo Moncelsi, Joshua Ari Alcid, Nasser Alidoust, Patricio Arrangoiz-Arriola, James Barnett, Przemyslaw Bienias, Hugh A. Carson, Cliff Chen, Li Chen, Harutiun Chinkezian, Eric M. Chisholm, Ming-Han Chou, Aashish Clerk, Andrew Clifford, R. Cosmic, Ana Valdes Curiel, Erik Davis, Laura DeLorenzo, J. Mitchell D'Ewart, Art Diky, Nathan D'Souza, Philipp T. Dumitrescu, Shmuel Eisenmann, Essam Elkhouly, Glen Evenbly, Michael T. Fang, Yawen Fang, Matthew J. Fling, Warren Fon, Gabriel Garcia, Alexey V. Gorshkov, Julia A. Grant, Mason J. Gray, Sebastian Grimberg, Arne L. Grimsmo, Arbel Haim, Justin Hand, Yuan He, Mike Hernandez, David Hover, Jimmy S. C. Hung, Matthew Hunt, Joe Iverson, Ignace Jarrige, Jean-Christophe Jaskula, Liang Jiang, Mahmoud Kalaee, Rassul Karabalin, Peter J. Karalekas, Andrew J. Keller, Amirhossein Khalajhedayati, Aleksander Kubica, Hanho Lee, Catherine Leroux, Simon Lieu, Victor Ly, Keven Villegas Madrigal, Guillaume Marcaud, Gavin McCabe, Cody Miles, Ashley Milsted, Joaquin Minguzzi, Anurag Mishra, Biswaroop Mukherjee, Mahdi Naghiloo, Eric Oblepias, Gerson Ortuno, Jason Pagdilao, Nicola Pancotti, Ashley Panduro, JP Paquette, Minje Park, Gregory A. Peairs, David Perello, Eric C. Peterson, Sophia Ponte, John Preskill, Johnson Qiao, Gil Refael, Rachel Resnick, Alex Retzker, Omar A. Reyna, Marc Runyan, Colm A. Ryan, Abdulrahman Sahmoud, Ernesto Sanchez, Rohan Sanil, Krishanu Sankar, Yuki Sato, Thomas Scaffidi, Salome Siavoshi, Prasahnt Sivarajah, Trenton Skogland, Chun-Ju Su, Loren J. Swenson, Stephanie M. Teo, Astrid Tomada, Giacomo Torlai, E. Alex Wollack, Yufeng Ye, Jessica A. Zerrudo, Kailing Zhang, Fernando G. S. L. Brandão, Matthew H. Matheny and Oskar Painter

AWS Center for Quantum Computing

Th-08： Encoding and gate operations of binominal code using a superconducting cavity
Takumi Mikawa, Takaaki Takenaka, Kosuke Kakuyanagi, Shiro Saito
NTT Basic Research Laboratories

Th-09： High-Q 3D niobium λ/4 coaxial cavities for Quantum Applications inspired by SRF technologies
Takaaki Takenaka, Takayuki Kubo, Imran Mahboob, Takayuki Saeki, Shiro Saito
NTT Basic Research Laboratories/ High Energy Accelerator Research Organization

Session 6 Optical Quantum Computing and Networks (S. Iwamoto)

Th-10： Programmable Continuous-Variable Photonic Quantum Computing in the Time Domain
(Invited) Shuntaro Takeda
The University of Tokyo

Th-11： Quantum Teleportation Relative to Quantum Reference Frames
Samuel P. Pickup, Philipp A. Hoehn
Okinawa Institute of Science and Technology, Graduate University

October 10 (Friday)

Session 7 Quantum Algorithms and Quantum Applications (M. Hirokawa)

Fr-01： Robust phase estimation of the ground-state energy without controlled time evolution on a quantum device

Hiroki Kuji, Yuta Shingu, Tetsuro Nikuni, Takashi Imoto, Kenji Sugisaki, Yuichiro Matsuzaki

Department of Physics, Tokyo University of Science /Department of Electrical, Electronic, and Communication Engineering, Faculty of Science and Engineering, Chuo University/ Global Research and Development Center for Business by Quantum-AI Technology (G-QuAT), AIST / Graduate School of Science and Technology, Keio University / Quantum Computing Center, Keio University/ Sustainable Quantum Artificial Intelligence Center (KSQAIC), Keio University/Centre for Quantum Engineering, Research and Education

Fr-02： A Quantum Differential Attack on ChaCha and Related Resources Estimation

Mintu Mandal, Hirendra Kumar Garai, Sabyasachi Dey

Birla Institute of Technology and Science/ Nanyang Technological University

Fr-03： Hardware-efficient quantum annealing with error mitigation via classical shadow

Takaharu Yoshida, Yuta Shingu, Chihaya Shimada, Tetsuro Nikuni, Hideaki Hakoshima, Yuichiro Matsuzaki

Department of Physics, Tokyo University of Science / Graduate School of Engineering Science, The University of Osaka/ Center for Quantum Information and Quantum Biology, The University of Osaka/ Department of Electrical Electronic and Communication Engineering Faculty of Science and Engineering, Chuo University

Fr-04： Single-site diagonal quantities capture off-diagonal long-range order

M. Sanino, I. D'Amico, V. V. França, I. M. Carvalho
São Paulo State University (UNESP), Institute of Chemistry / School of Physics, Engineering and Technology, University of York

Fr-05： Quantum Mpemba Effect in Bose Hubbard Model under Stark Potential and Quenched Disorder

Asad Ali, MI Hussain, Saif Al-kuwari
Qatar Center for Quantum Computing, College of Science and Engineering, Hamad Bin Khalifa University

Session 8 Coherence and Dynamics on Superconducting Devices (S. Saito)

Fr-06： Engineering superconducting transmon qubits with high coherence and high fidelities

(Invited)

Leonid V. Abdurakhimov
IQM Quantum Computers

Fr-07： Unveiling prethermal two-dimensional discrete time crystals on a digital quantum computer

Kazuya Shinjo, Kazuhiro Seki, and Seiji Yunoki
RIKEN Center for Emergent Matter Science (CEMS)/ Quantum Computational Science Research Team, RIKEN Center for Quantum Computing (RQC)/ Computational Materials Science Research Team, RIKEN Center for Computational Science (R-CCS)/ Computational Condensed Matter Physics Laboratory, RIKEN Cluster for Pioneering Research (CPR)

Session 9 Silicon Spin Qubits (A. Oiwa)

Fr-08： High-Fidelity Transport and Quantum Logic of Mobile Spin Qubits in Silicon

(Invited) M. De Smet, Y. Matsumoto, A.M.J. Zwerver, L. Tryputen, S.L. de Snoo, S.V. Amitonov, S.R. Katiraee-Far, A. Sammak, N. Samkharadze, Ö. Gül2, R. N. M. Wasserman, E. Greplova, M. Rimbach-Russ, G. Scappucci, and L.M.K. Vandersypen

QuTech and Kavli Institute of Nanoscience, Delft University of Technology/ QuTech and Netherlands Organization for Applied Scientific Research (TNO)

Fr-09： Recent Advances in High-Fidelity Operations and Scalability of Silicon Spin Qubits

(Invited) Akito Noiri

RIKEN Center for Emergent Matter Science (CEMS)

Posters

PWe-01： Efficient quantum model for strongly-driven Josephson junctions

Ivan Iakoupov, William J. Munro
Okinawa Institute of Science and Technology Graduate University

PWe-02： Fabrication of gate-defined Quantum dot in a Bull's Eye optical cavity towards efficient Photon-Spin conversion

Hosumi Sato, Sangmin Ji, Yuta Konishi, Rio Fukai, Masayoshi Mori, Takafumi Fujita, Satoshi Iwamoto, Haruki Kiyama, Arne Ludwig, Andress D. Wieck, Akira Oiwa
SANKEN, The University of Osaka/ Research Center for Advanced Science and Technology, The University of Tokyo/ Center for Quantum Information and Quantum Biology, The University of Osaka/ Graduate School and Faculty of Information Science and Electrical Engineering, Kyushu University/ Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitaetsstrasse

PWe-03： Non-Destructive Spin-Photon Entanglement Generation with the Nitrogen Nuclear Spin Memory of a Diamond NV Center

Taichi Fujiwara, R. Reyes, Y. Sekiguchi, H. Kato, T. Makino, H. Kosaka
Department of Physics, Graduate School of Engineering Science, Yokohama National University/Quantum Information Research Center (QIC), Yokohama National University/ Institute of Advanced Sciences, Yokohama National University /National Institute of Advanced Industrial Science and Technology

PWe-04： A resonant microwave-to-optical quantum transducer based on a diamond color center

Kyosuke Goto, Hodaka Kurokawa, Hideo Kosaka, and Kazuki Koshino
Department of Physics, Graduate School of Engineering Science, Yokohama National University / Quantum Information Research Center, Institute of Advanced Sciences, Yokohama National University /Institute for Liberal Arts, Institute of Science Tokyo

PWe-05： Fabrication of Gate-defined Quantum Dots × In-Plane p-i-n Junction Devices for Single-Photon Generation

Taiki Kurose, Kazuma Haruna, Genki Fukuda, Takafumi Fujita, Ayato Miura, Andreas Wieck, Arne Ludwig, Akira Oiwa
SANKEN, The University of Osaka/ Ruhr-Universität Bochum

PWe-06： Optical Characterization of a Diamond Optomechanical Crystal Coupled to a SiN Waveguide

Masaki Yoshioka, Kiyotaka Sato, Hodaka Kurokawa, Yuhei Sekiguchi, Mikiya Kamata, Shoji Hachuda, Masaki Kunii, Takemasa Tamanuki, Satomi Ishida, Hidetsugu Matsukiyo, Natthajuks Pholsen, Masao Nishioka, Sangmin Ji, Hideo Otsuki, Kosuke Kimura, Kouta Takenaka, Shinobu Onoda, Toshihiko Baba, Satoshi Iwamoto, Hideo Kosaka
Department of Physics, Graduate School of Engineering Science, Yokohama National University/Department of Electrical and Computer Engineering, Yokohama National University / Quantum Information Research Center (QIC), Yokohama National University / Research Center for Advanced Science and Technology (RCAST), The University of Tokyo / Institute of Industrial Science (IIS), The University of Tokyo/ National Institutes for Quantum Science and Technology (QST)

PWe-07： Quantum signal processing on a Hilbert-space fragmented system

Naoya Egawa, Kaoru Mizuta, and Joji Nasu
Department of Physics, Tohoku University/ Department of Applied Physics, Graduate School of Engineering, The University of Tokyo/ Photon Science Center, Graduate School of Engineering, The University of Tokyo / RIKEN Center for Quantum Computing

PWe-08： High-Performance Simulation Platform for Bosonic Quantum System Integrating HPC and Machine Learning

Ryo Maekura, Shotaro Shirai, Genta Ando, Yusuke Tominaga, Atushi Noguchi
Komaba Institute for Science, The University of Tokyo / RIKEN Center for Quantum Computing/Inamori Research Institute for Science, Organization

PWe-09： Adiabatic optical fiber coupling for diamond quantum nanophotonic devices
Keitaro Aoyama, M. Kamata, S. Hachuda, M. Kunii, T. Tamanuki, S. Ishida, H. Matsukiyo, N. Pholsen, M. Nishioka, S. Ji, H. Otsuki, K. Kimura, K. Takenaka, S. Onoda, T. Baba, S. Iwamoto, H. Kosaka
Grad. Sch. Sci. Eng. Yokohama National University / Institute of Advanced Sciences, Yokohama National University/ Quantum Information Research Center, Yokohama National University/ Research Center for Advanced Science and Technology, The University of Tokyo/ Institute of Industrial Science, The University of Tokyo /National Institutes for Quantum Science and Technology

PWe-10： Spin readout using Pauli spin blockade in an In As gate-defined quadruple quantum dot
Yuki Yokoyama, Nozomu Hayashi, Jason T. Dong, Mihir Pendharkar, Takafumi Fujita, Rio Fukai, Chris J. Palmstrøm, Akira Oiwa, Haruki Kiyama
Graduate School and Faculty of Information Science and Electrical Engineering, Kyushu University / SANKEN, The University of Osaka/ Materials Department, University of California Santa Barbara/ Department of Electrical and Computer Engineering, University of California/ Center for Quantum Information and Quantum Biology, The University of Osaka

PWe-11： Linear ion trap with an integrated fiber Fabry-Perot cavity: Shielded Design and Adaptive Mirror Fabrication
Shuma Oya, Soon Teh, Zhenghan Yuan, Ezra Kassa, Shaobo Gao, Vishnu Kavungal, Daichi Okuno, Hiroki Takahashi
Experimental Quantum Information Physics (EQuIP) Unit, Okinawa Institute of Science and Technology

PWe-12： Properties of computational entanglement measures
Ilia Ryzov, Faedi Loulidi, David Elkouss
Okinawa Institute of Science and Technology

PWe-13： Log-Likelihood Ratio for Improving Accuracy in Silicon Spin Qubit Readout
Raisei Mizokuchi, R. Wada, R. Matsuoka, S. Ota, I. Yanagi, T. Mine, R. Tsuchiya, D. Hisamoto, H. Mizuno, and T. Kodera
Institute of Science Tokyo/ Hitachi, Ltd

PWe-14： Ferromagnetic Josephson junctions with NbN/GdN/NbN trilayer for high-coherence superconducting qubits

Daiki Kurihara, Yugo Mori, Koki Honda, Hiroki Kutsuma, and Taro Yamashita
Department of Applied Physics, Graduate School of Engineering,
Tohoku University

We-01

Ultrafast quantum computing with ultracold atom arrays at quantum speed limit

Kenji Ohmori

Institute for Molecular Science, National Institutes of Natural Sciences, Japan

Neutral-atom quantum computers use the arrays of ultracold atoms assembled with optical tweezers, in which each single atom serves as a high-quality qubit, whereas the whole system operates at room temperatures. We use rubidium (Rb) atoms as qubits and have various core competences including ultrafast laser technologies that allows for an ultrafast two-qubit gate operating in nanoseconds, faster than any other two-qubit gates with neutral atoms by two orders of magnitude. This disruptive progress has been made possible not only by the ultrafast laser technologies, but also by our ultra-precise optical tweezers array and high-NA microscope technologies. We have also been developing underlying technologies that would improve the fidelity of this ultrafast gate, such as a stable gate-operation laser and an automated system for ultraprecise initialization of many qubits.

In another direction of our R&D, we are currently developing a full-stack quantum computer system installed in its dedicated clean room newly constructed at IMS, where various stacks from software and control systems to QPU are all integrated. This would be Japan's first full-stack quantum computer with neutral atoms, and one of very few in the world, scheduled to start operating in this year 2025.

We-02

Hybrid quantum simulation and city-scale quantum networking with trapped ions

Norbert Linke[1,2], Anton T. Than[1], Mika Zalewski[2], Denton Wu[2], Alaina Green[1], Zohreh Davoudi[1]

[1]Duke Quantum Center, Duke University, Durham, NC 27705, USA
[2]Joint Quantum Institute, University of Maryland, College Park, MD 20742, USA

High-energy physics models are computationally challenging due to the bosonic Hilbert space and the complex interactions involved. Trapped-ions are a powerful platform for quantum computing but mapping boson modes to qubits is costly. The motional modes of trapped ions are a quantum resource that can be used directly for the efficient simulation of bosons. We describe first results from an analog-digital hybrid quantum simulation of the Yukawa model that employs digital gates and qubits in combination with motional modes along multiple directions [1].

Secondly, we present a quantum network node based on Strontium ions that emit photons at 1092 nm with a polarization state that is entangled with a meta-stable D-level qubit in the emitting ion. The wavelength transmits through optical fiber with moderate loss allowing for quantum network links of a few kilometers for a city-scale quantum network. We present the first set of results from this experiment transmitting the photons over commercial optical fiber, 2.8 km in length, deployed in the field, stretching between two buildings in a downtown area [2].

[1] A. Than et al., arXiv:2509.11477
[2] M. Zalewski et al., arXiv:2506.11257

We-03

Progress toward a Control System for Electric-Based Trapped-Ion Quantum Processors

Ryutaro Ohira[1], Yoshinori Kurimoto[1], Masanari Miyamoto[2], Shinichi Morisaka[1,3],
Ippei Nakamura[4], Atsushi Noguchi[4,5,6], Utako Tanaka[2,3,7], and Takefumi Miyoshi[1,2,8]

[1]QuEL, Inc.,
[2]Graduate School of Engineering Science, The University of Osaka,
[3]Center for Quantum Information and Quantum Biology, The University of Osaka,
[4]Komaba Institute for Science (KIS), The University of Tokyo,
[5]RIKEN Center for Quantum Computing (RQC),
[6]Inamori Research Institute for Science (InaRIS),
[7]National Institute of Information and Communications Technology,
[8]e-trees. Japan, Inc.

Electric control of trapped-ion qubits provides improved scalability compared to laser-driven schemes. In this talk, we present recent efforts on developing dedicated control electronics for this approach.

We-04

Many-hypercube codes and related topics

Hayato Goto

RIKEN Center for Quantum Computing

In the field of fault-tolerant quantum computing (FTQC), high-encoding-rate quantum codes, such as quantum low-density parity-check (qLDPC) codes, have recently been the hottest topic [1]. As a new high-rate code family suitable for FTQC, last year I proposed "many-hypercube (MHC) codes," which are defined as concatenated [[n,n-2,2]] quantum error-detecting codes [2]. The advantage of MHC codes is high encoding rates, about 30% or 20%, even higher than qLDPC codes. To achieve universal FTQC with the MHC codes, I generalized my magic-state preparation method for concatenated codes [3], which is similar to the recently proposed magic state cultivation [4], another hot topic in the field of FTQC. In this talk, I will present the basics of the MHC codes together with related topics, namely, high-rate codes and magic state preparation.

[1] S. Bravyi et al., Nature 627, 778 (2024).
[2] H. Goto, Science Advances 10, adp6388 (2024).
[3] H. Goto, Sci. Rep. 4, 7501 (2014).
[4] C. Gidney et al., arXiv:2409.17595 (2024).

We-05

Converse for Fault tolerant Quantum Computation

Uthirakalyani G, Anuj K. Nayak, Avhishek Chatterjee

Indian Institute of Technology (at the time of work; currently at OIST),
University of Illinois Urbana-Champaign, Indian Institute of Technology Madras

Though quantum computers, in theory, are exponentially faster than their classical counterparts, the presence of noise in real systems stands on their way to practical realization. This led to the flowering of the exciting area of quantum fault tolerance. As techniques for fault-tolerant quantum computation keep improving, it is natural to ask: what is the fundamental lower bound on space overhead? In this work, we obtain a lower bound on the space overhead required for reliable implementation of a large class of operations that includes unitary operators. For the practically relevant case of sub-exponential depth and sub-linear gate size, our bound on space overhead is tighter than the known lower bounds. We obtain this bound by connecting fault-tolerant computation with a set of finite block-length quantum communication problems whose accuracy requirements satisfy a joint constraint. The lower bound on space overhead obtained here leads to a strictly smaller upper bound on the noise threshold for noise that are not degradable. Our bound directly extends to the case where noise at the outputs of a gate are correlated but noise across gates are i.i.d.

We-06

Dynamically Corrected Quantum Gates Designed Geometrically

Yasushi Kondo[1] and Shingo Kukita[2]

[1]Department of Physics, Kindai University, Higashi-Osaka 577-8502, Japan
[2]Department of Computer Science, National Defence Academy of Japan, Yokosuka 239-8686, Japan

The foundation of quantum technologies lies in the precise control of quantum systems. It is crucial to implement dynamically corrected quantum gates (DCQG), which compensate for individual quantum gate errors to make them more resilient (robust) to errors alongside quantum error correction. Typical errors include Pulse Length Error (PLE), which refers to errors in the duration or intensity of a pulse, and Off Resonance Error (ORE), which pertains to calibration errors in the energy scale of a quantum system. To construct DCQGs, the effects of these errors are expanded in a series, and the gates are designed so that the coefficients of these terms become zero.

We geometrically designed new DCQGs that are robust against ORE up to the second-order one by modifying a Short-CORPSE, which is a typical first-order ORE robust DCQG according to geometrical considerations. Introducing the new DCQGs for quantum system control is straightforward and helpful for systems that require resilience to ORE.

We will discuss the design principle for the new DCQGs and compare the infidelity of three pulse sequences, a Square-Pulse (without ORE correction), a Short-CORPSE (with first-order ORE correction), and a new DCQG (with second-order ORE correction) based on geometric considerations, when ORE exists.

We-07

Suppression of detuning error in entanglement-enhanced sensing

Shingo Kukita[1], Yuichiro Matsuzaki[2]

[1]National Defense Academy of Japan,
1-10-20, Hashirimizu, Yokosuka-shi, Kanagawa, 239-8686, Japan
[2]Chuo University, 1-13-27, Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan

Quantum sensing is a promising technology in the near future. It is well known that we can enhance sensing precision using quantum properties such as quantum entanglement. The Greenberger–Horne–Zeilinger(GHZ) state is a famous entangled state and is often exploited for high-precision sensing. The sensing using the GHZ state (GHZ sensing) achieves the so-called Heisenberg-limited precision, which is far beyond the standard quantum limit. There have been many studies on the GHZ sensing subject to noises, which are described by the Lindblad equations and prevent the GHZ sensing from achieving the Heisenberg limit. Meanwhile, the effects of imperfection on the control during the sensing have been less investigated. Such an imperfection causes systematic errors. In this paper, we investigate the effect of detuning error, which is caused by deviation of the resonance frequencies of spins from their ideal values, on the performance of the GHZ sensing. It is shown that this error prevents the GHZ sensing from achieving the Heisenberg limit. To compensate for this effect, we design a composite-pulse control protocol. We show that this protocol mitigates the effect of the detuning error on the GHZ sensing.

Th-01

Long-Coherence-Time Charge Qubits with Electrons on Solid Neon

J. Wang[1], Y. Tian[1], A. Jennings[1], I. Grytsenko[1], O. Rybalko[1,3], X. Zhou[1], D. Jin[4], H. Terai[5], and E. Kawakami[1,2]

[1]RIKEN Center for Quantum Computing, RIKEN, Wako, 351-0198, Japan
[2]Cluster for Pioneering Research, RIKEN, Wako, 351-0198, Japan
[3]B. Verkin Institute for Low Temperature Physics and Engineering of the NAS of Ukraine, Kharkiv, 61103, Ukraine
[4]Department of Physics and Astronomy, University of Notre Dame, USA
[5]Advanced ICR Research Institute, National Institute of Information and Communications Technology, 588-2 Iwaoka, Nishi, Kobe 651-2492, Japan"

Floating electrons on the surface of liquid helium or solid neon provide a promising two-dimensional electron system for qubits, owing to the long coherence of both their charge and spin states. Here we present the trapping of electrons on solid neon and their coupling to a superconducting resonator. The microcircuit is fabricated on a NbTiN layer deposited on a silicon substrate, and electrons are coupled to the resonator via the electric field. Neon gas is deposited at 24 K and then cooled to 10 mK, after which electrons are introduced and stably confined above the solid neon surface. Transmission spectroscopy with a vector network analyzer reveals an anticrossing between a microwave photon and a trapped electron. We also realized a charge qubit with an energy relaxation time of about 11 μs. This result demonstrates the viability of solid-neon-based electrons for quantum information processing. In future work, we aim to apply an inhomogeneous magnetic field to couple the spin and charge degrees of freedom of a trapped electron, enabling access to long-lived spin qubits.

Th-02

MM-wave tomography of electron chain in on-chip microtrap

Mikhail Belianchikov[1], Natalia Morais[1], and Denis Konstantinov[1]

[1]Quantum Dynamics Unit, Okinawa Institute of Science and Technology (OIST)
Graduate University, Okinawa, Japan

Electrons-on-helium quantum platform offers a seamless scalability yet high fidelity with its mobile qubits architecture, infinitesimal qubit size and naturally pure environment [1]. In the presented work, we advance the development of a hybrid spin-Rydberg electron qubit above superfluid helium [2]. In the experiment, a two-dimensional electron gas is confined above the surface of liquid helium using a FET-type microchannel device. A small cluster of electrons is isolated within a 1.7 μm × 10 μm linear microtrap embedded in the microchannel. The Rydberg transition of the electrons in the cluster are probed via the image-charge detection [3], measured as a function of the trap electrode voltages. By simulating Rydberg spectra using energy minimization solver, we were able to reconstruct the ground-state configuration of the electron cluster at a specific microtrap electrode voltages. This result proves the feasibility of addressing and detecting a single electron Rydberg transition, a crucial milestone for realization of a hybrid spin-Rydberg electron qubit.

[1] W. Guo, D. Konstantinov, and D. Jin, Progress in Quantum Electronics, 99, 100552 (2025).
[2] E. Kawakami, J. Chen, M. Benito, and D. Konstantinov, Phys. Rev. Applied, 20, 054022 (2023).
[3] M. Belianchikov, N. Morais, and D. Konstantinov, Phys. Rev. Applied, 23, 054026 (2025).

Th-03

Experimental Study of Electron Mobility on the surface of Neon

Ka Wing Yip[1], Tomoyuki Tani[1], Jui-Yin Lin[1], Mikhail Belianchikov[1] and Denis Konstantinov[1]

[1]Quantum Dynamics Unit, Okinawa Institute of Science and Technology,
Onna, 904-0412, Okinawa, Japan

Recent research suggested that using electron floating on the surface of solid neon as qubits is a possible candidate for quantum computing. Zhou et al. achieved the first electron-on-solid-neon qubit, demonstrating high readout and gate fidelities of the electron qubit on the neon system, reaching up to 99.97%. Although previous research studied some properties of electrons on the surface of solid neon, the effect of surface roughness and surface preparation in solid neon is not well understood, which is essential to achieve the large-scale electron qubits on solid neon for quantum computing.

We present our latest progress in measuring the mobility of electrons floating on neon surface over a wide temperature range, with different surface preparation methods. Standard Sommer-Tanner method is used for the electron mobility measurement on neon surface. We attempt to anneal the solid neon sample after solidification and compare the results of electron resistance with and without annealing. The capacitance of solid neon samples decreases exponentially in fixed temperature, likely indicating recrystallization and smoother surface formation. In terms of electron resistance, our findings suggest that annealing solid neon in high temperature improve the surface conditions and consequently, enhances the electron transport on solid neon. Electron mobility and density on solid neon surface are also obtained. Further investigations such as cyclotron resonance measurements, are required for more evidence.

Th-04

Creation and observation of strained single tin vacancy center in diamond nano pillar

Ryota Kitagawa[1], Toshiki Iwai[1], Yang Yeting[1], Tetsuya Miyatake[1], Teruya Ishihara[2], Satoshi Iwamoto[2], Toshiyuki Miyazawa[1], Kenichi Kawaguchi[1], Ryoichi Ishihara[3] and Shintaro Sato[1]

[1]Quantum Laboratory, Fujitsu Limited,
10-1 Morinosato-Wakamiya, Atsugi, Kanagawa 243-0197, Japan,
[2]Research Center for Advanced Science and Technology, The University of Tokyo,
Meguro, Tokyo 153-8505, Japan ,
[3]QuTech, Delft University of Technology Mekelweg 4, 2628 CD Delft, the Netherlands

Tin-vacancy (SnV) in diamond is promising as a qubit for a scalable quantum computer owing to its excellent optical properties. To utilize SnVs as spin qubits, i.e. to control the spin states using microwaves, strain application is necessary. Here, we successfully created strained single SnVs in diamond nanopillar. We fabricated SnVs in diamond nanopillars by ion implantation, annealing, and a dry-etching process, and measured the photoluminescence (PL) at 9K. The pillar enhanced the PL collection efficiency by up to 5 times, which is beneficial in quantum measurements. The probability of finding SnVs over tens of pillars reveals an Sn-to-SnV activation ratio of 0.8%, comparable to the previously reported one. Moreover, three SnVs exhibit ground-state splitting widths of 1696, 839, and 816 GHz, estimated from the energy difference between two PL peaks (known as C and D transitions) around 619 nm. Their second-order correlation g2(0), are 0.24, 0.06, and 0.4, respectively. These results indicate they are single SnVs whose relative strain is ~10^-3, ~10^-4, 0 (894, 99, and 0 GHz in terms of energy), respectively. The strain of ~10^-3 is sufficient for using SnVs as spin qubits. Our results demonstrate SnVs in nanofabricated diamonds are applicable to quantum computers.

Th-05

Quantum Active Matter: Advancing the Frontiers of Nonequilibrium Phases of Matter

Kazuaki Takasan

Department of Physics, The University of Tokyo, Hongo, Tokyo 113-0033, Japan

Active matter is an ensemble of self-propelled entities, such as flocks of birds and schools of fish, that has attracted much attention because of phase transitions and pattern formation not present in equilibrium systems [1]. While the physics of active matter has been studied extensively in statistical physics and biophysics, most studies have been limited to classical systems, and the possibility of active matter in quantum systems has rarely been considered. However, recent developments in atomic, molecular, and optical systems allow us to study the complex dynamics of quantum many-body systems in a highly controlled manner, and it may be possible to design quantum many-body systems that behave like active matter. Stimulated by this, the study of a quantum analog of active matter has only recently begun [2–8]. In particular, we have studied quantum phase transitions analogous to the nonequilibrium phase transitions of active matter [2,8].

In this talk, I would like to present our work on quantum active matter. We have studied two-component (spin-1/2) hard-core bosons with spin-dependent asymmetric hopping, corresponding to the motility of each active particle. This is expected to be realized with ultracold atoms in a dissipative optical lattice. We have shown that this model can be regarded as a quantum generalization of classical active matter models defined on a lattice, and that it exhibits various phase transitions, including nonequilibrium phase transitions unique to active matter, such as motility-induced phase separation [2]. In more recent work [8], we have shown that the combination of activity and repulsive interactions induces ferromagnetism, based on both numerical and analytical analyses. This activity-induced ferromagnetism can be considered as a quantum counterpart of flocking. While the flocking transition in classical systems requires a microscopic alignment interaction, this mechanism does not require such an interaction and thus may be unique to quantum active matter.

We believe that our work extending active matter physics to quantum systems helps broaden the perspective on nonequilibrium phases of matter beyond conventional paradigms. At the same time, this might be useful for future quantum information processing. I will also discuss these future perspectives.

[1] M. C. Marchetti et al., Rev. Mod. Phys. 85, 1143 (2013).
[2] K. Adachi, KT, K. Kawaguchi, Phys. Rev. Research 4, 013194 (2022).
[3] M. Yamagishi, N. Hatano, H. Obuse, Sci. Rep. 15, 4509 (2025).
[4] Y. Zheng, B. Liebchen, H. Löwen, Phys. Rev. Research 7, 033008 (2025).
[5] R. Khasseh, S. Wald, R. Moessner, C. A. Weber, M. Heyl, arXiv:2308.01603.
[6] H. Yuan, L. X. Cui, L.T. Chen, C.P. Sun, arXiv:2407.09860.
[7] A.-G. Penner, L. Viotti, R. Fazio, L. Arrachea, F. v. Oppen, arXiv:2503.07751.
[8] KT*, K. Adachi*, K. Kawaguchi, Phys. Rev. Research 6, 023096 (2024). (*co-first)

Th-06

Non-equilibrium Dynamics of Three-Level Absorption Refrigerator at Third-Order Liouvillian Exceptional Points

Jingyi Gao [1], Naomichi Hatano[2]

[1] Department of Physics, University of Tokyo,
5-1-5 Kashiwanoha, Kashiwa, Chiba, 277-8574, Japan
[2] Institute of Industrial Science, the University of Tokyo,
5-1-5 Kashiwanoha, Kashiwa, Chiba, 277-8574, Japan

In this talk, we show that quantum absorption refrigerators (QARs) can exceed their steady-state performance when operated in the non-equilibrium regime. By adjusting system parameters, they can transfer more heat from the cold to the hot bath with less energy from the work bath and achieve optimal cold-bath absorption through suitable initial states. We also examine non-Hermitian effects, revealing that Liouvillian exceptional points (LEPs) strongly shape non-equilibrium dynamics. For third-order LEPs, we identify and confirm a critical damping condition enabling the fastest, smoothest relaxation from arbitrary initial states to equilibrium.

While quantum thermal machines—especially heat engines—have received much attention, QARs remain less explored. Comprising an internal system coupled to three baths, they are typically studied in steady state. In practice, preparing a steady state from the outset is difficult, making non-equilibrium dynamics inevitable. Unlike cyclic machines, our QAR operates continuously with all baths in constant contact, allowing non-equilibrium effects to persist even after equilibrium is reached.

Jingyi Gao and Naomichi Hatano, arXiv:2507.18261

Th-07

Hardware-efficient quantum error correction via concatenated bosonic qubits

Harald Putterman, Kyungjoo Noh, Connor T. Hann, Gregory S. MacCabe, Shahriar Aghaeimeibodi, Rishi N. Patel, Menyoung Lee, William M. Jones, Hesam Moradinejad, Roberto Rodriguez, Neha Mahuli, Jefferson Rose, John Clai Owens, Harry Levine, Emma Rosenfeld, Philip Reinhold, Lorenzo Moncelsi, Joshua Ari Alcid, Nasser Alidoust, Patricio Arrangoiz-Arriola, James Barnett, Przemyslaw Bienias, Hugh A. Carson, Cliff Chen, Li Chen, Harutiun Chinkezian, Eric M. Chisholm, Ming-Han Chou, Aashish Clerk, Andrew Clifford, R. Cosmic, Ana Valdes Curiel, Erik Davis, Laura DeLorenzo, J. Mitchell D'Ewart, Art Diky, Nathan D'Souza, Philipp T. Dumitrescu, Shmuel Eisenmann, Essam Elkhouly, Glen Evenbly, Michael T. Fang, Yawen Fang, Matthew J. Fling, Warren Fon, Gabriel Garcia, Alexey V. Gorshkov, Julia A. Grant, Mason J. Gray, Sebastian Grimberg, Arne L. Grimsmo, Arbel Haim, Justin Hand, Yuan He, Mike Hernandez, David Hover, Jimmy S. C. Hung, Matthew Hunt, Joe Iverson, Ignace Jarrige, Jean-Christophe Jaskula, Liang Jiang, Mahmoud Kalaee, Rassul Karabalin, Peter J. Karalekas, Andrew J. Keller, Amirhossein Khalajhedayati, Aleksander Kubica, Hanho Lee, Catherine Leroux, Simon Lieu, Victor Ly, Keven Villegas Madrigal, Guillaume Marcaud, Gavin McCabe, Cody Miles, Ashley Milsted, Joaquin Minguzzi, Anurag Mishra, Biswaroop Mukherjee, Mahdi Naghiloo, Eric Oblepias, Gerson Ortuno, Jason Pagdilao, Nicola Pancotti, Ashley Panduro, JP Paquette, Minje Park, Gregory A. Peairs, David Perello, Eric C. Peterson, Sophia Ponte, John Preskill, Johnson Qiao, Gil Refael, Rachel Resnick, Alex Retzker, Omar A. Reyna, Marc Runyan, Colm A. Ryan, Abdulrahman Sahmoud, Ernesto Sanchez, Rohan Sanil, Krishanu Sankar, Yuki Sato, Thomas Scaffidi, Salome Siavoshi, Prasahnt Sivarajah, Trenton Skogland, Chun-Ju Su, Loren J. Swenson, Stephanie M. Teo, Astrid Tomada, Giacomo Torlai, E. Alex Wollack, Yufeng Ye, Jessica A. Zerrudo, Kailing Zhang, Fernando G. S. L. Brandão, Matthew H. Matheny & Oskar Painter

AWS Center for Quantum Computing, Pasadena, CA, USA

To solve problems of practical importance, quantum computers will likely need to incorporate quantum error correction, where a logical qubit is redundantly encoded in many noisy physical qubits. The large physical-qubit overhead typically associated with error correction motivates the search for more hardware-efficient approaches. In this talk we will present and characterize a superconducting circuit which realizes a logical qubit memory

formed from the concatenation of encoded bosonic cat qubits with an outer repetition code of distance d=5. The bosonic cat qubits are passively protected against bit flips by two photon dissipation. The phase-flip correcting repetition code operates below threshold, with logical phase-flip error decreasing with code distance from d=3 to d=5. Concurrently, the logical bit-flip error is suppressed with increasing cat-qubit mean photon number. The minimum measured logical error per cycle is on average 1.75(2)% for the distance-3 code sections, and 1.65(3)% for the longer distance-5 code. We will tie our results to the longer term opportunities for reaching computationally relevant error rates with concatenated bosonic qubits.

Th-08

Encoding and gate operations of binominal code using a superconducting cavity

Takumi Mikawa, Takaaki Takenaka, Kosuke Kakuyanagi, and Shiro Saito

Basic Research Laboratories, NTT Inc.
Atsugi, Kanagawa, 243-0198 Japan

Bosonic codes, which exploit the redundancy of infinite-dimensional Fock states in a cavity, have attracted considerable attention as a promising approach to hardware-efficient fault-tolerant quantum computing. In particular, the lowest-order binomial code, denoted bin (1, 1), offers distinct advantages—such as high-fidelity bosonic encoding and gate operations—due to its simplicity [2]. In this study, we successfully encoded the bin(1, 1) code and implemented the corresponding gate operations in a superconducting cavity.
Our device was comprised of a three-dimensional storage cavity with a long lifetime ($T_1 \approx$ 200 μs) and an ancilla qubit ($T_1 \approx 16$ μs, $T_2 \approx 4$ μs), coupled via a dispersive shift of −1.37 MHz. Numerically optimized pulses were applied separately to the storage and the ancilla for encoding and gate operations. Then, we measured the Wigner functions to verify performance. Moreover, we evaluated the lifetime of bin(1, 1) to be 34 μs via process tomography [2] compared to the lifetimes of the ancilla and the Fock-0/1 states of 4.8 μs and 184 μs, respectively.

We acknowledge H. Toida with fruitful discussion. This work was supported by JST Moonshot R&D, Grant Number JPMJMS2067.

[1] M. H. Michael et al., Phys. Rev. X 6, 031006 (2016).
[2] Z. Ni et al., Nature 616, 56 (2023).

Th-09

High-Q 3D niobium λ/4 coaxial cavities for Quantum Applications inspired by SRF technologies

Takaaki Takenaka[1], Takayuki Kubo[2], Imran Mahboob[1], Takayuki Saeki[2], and Shiro Saito[1]

[1]NTT Basic Research Laboratories, NTT Corporation,
3-1 Morinosato-Wakamiya, Atsugi, Kanagawa 243-0198, Japan
[2]High Energy Accelerator Research Organization (KEK), Tsukuba, Ibaraki 305-0801, Japan

High-Q three-dimensional (3D) superconducting cavities are often used for quantum applications, including dielectric constant measurement, quantum memory, and dark photon dark matter searches [*]. In these experiments, a high-Q cavity is integrated with a superconducting qubit, yielding a circuit-based Quantum Electrodynamics (cQED) architecture. Most 3D cQED platforms employ a λ/4 coaxial cavity [*] which enables sufficiently strong qubit-cavity coupling to manipulate the quantum state of the cavity while maintaining internal Q factor (Qint) of 1e9[**]. However, this value remains at least one order of magnitude lower than that achieved in 3D cavities for particle accelerators. The origin of the reduced Qint has not yet been fully clarified, but losses due to two-level systems (TLSs) arising from oxide defects on the cavity surface are considered a primary cause.
Here we investigate various surface treatments and demonstrate Qint > 3e9 in a 5.5 GHz coaxial cavity - twice the highest Qint ever reported for coaxial cavities [**]. Our findings are not only useful for 3D cQED applications but could also help realizing long-lived Nb-based superconducting qubits.

[*] K. Nakazono, et al., arXiv:2505.15619 (2025).
[**] A. Oriani, et al., arXiv:2403.00286 (2024)."

Th-10

Programmable Continuous-Variable Photonic Quantum Computing in the Time Domain

Shuntaro Takeda

The University of Tokyo

We present our recent advances in time-domain continuous-variable photonic quantum computing [1]. First, we report progress in developing a programmable continuous-variable photonic quantum computing platform. Recently, we integrated non-Gaussian states of light into our platform and demonstrated multi-step quantum gates acting on these states [2]. This advancement marks a significant step toward universal continuous-variable quantum computing. Second, we introduce a programmable quantum light source capable of generating various non-Gaussian states with arbitrary temporal waveforms without modifying its hardware configuration [3]. This flexibility enables the tailoring of optical quantum states for diverse applications, not only strengthening our quantum computing platform but also advancing broader quantum photonic technologies, including quantum sensing and communication.

[1] S. Takeda and A. Furusawa, APL Photonics 4, 060902 (2019).
[2] T. Yoshida et al., PRX Quantum 6, 010311 (2025).
[3] H. Tomoda et al., Phys. Rev. A 110, 033717 (2024).

Th-11

Quantum Teleportation Relative to Quantum Reference Frames

Samuel P. Pickup[1], Philipp A. Hoehn[1,2]

[1]Okinawa Institute of Science and Technology, Graduate University,
1919-1 Tancha, Onna-son, Okinawa 904-0495, Japan A
[2]Okinawa Institute of Science and Technology Graduate University,
1919-1 Tancha, Onna-son, Okinawa 904-0495, Japan B

Quantum teleportation allows Alice to communicate quantum information (QI) to Bob by sending purely classical information (CI). Remarkable as this result is, the information that can be teleported is limited to speakable information (SI)- information for which the means of encoding is not important. However, the information content of a quantum state is not purely speakable. It contains unspeakable information (UI), such as spin direction for example, that cannot be represented abstractly (as a string of 0's and 1's) and requires a specific physical system to be defined; a reference frame (RF) is required. Therefore, if Alice and Bob don't share a classical RF (CRF), the full information content of Alice's unknown state cannot be reconstructed by Bob from purely CI, using conventional teleportation schemes. We present a new teleportation protocol which allows all the information content, SI and UI, of Alice's unknown state to be reconstructed in Bob's CRF, from the same amount of CI as required in conventional schemes. We show that QI, defined relative to a specific CRF, can be reconstructed in any CRF by LOCC. This is possible if Alice and Bob not only share an EPR state as a nonlocal resource, but they also share an entangled pair of Quantum Reference Frames (QRFs). We exploit the perspective neutral theory of QRFs, allowing us the flexibility to switch between external CRF and internal QRF perspectives. A remarkable result of our protocol is that Alice can communicate unspeakable quantum information to Bob, by sending purely speakable classical information.

Fr-01

Robust phase estimation of the ground-state energy without controlled time evolution on a quantum device

Hiroki Kuji[1,2], Yuta Shingu[1], Tetsuro Nikuni[1], Takashi Imoto[3], Kenji Sugisaki[4,5,6,7], and Yuichiro Matsuzaki[2]

[1]Department of Physics, Tokyo University of Science,
1-3 Kagurazaka, Shinjuku, Tokyo, 162-8601, Japan
[2]Department of Electrical, Electronic, and Communication Engineering,
Faculty of Science and Engineering, Chuo University
[3]Global Research and Development Center for Business by Quantum-AI Technology (G-QuAT), AIST, Central2, 1-1-1Umezono, Tsukuba, Ibaraki 305-8568, Japan
[4]Graduate School of Science and Technology, Keio University,
7-1 Shinkawasaki, Saiwai-ku, Kawasaki, Kanagawa 212-0032, Japan
[5]Quantum Computing Center, Keio University,
3-14-1 Hiyoshi, Kohoku-ku, Yokohama, Kanagawa 223-8522, Japan
[6]Keio University Sustainable Quantum Artificial Intelligence Center (KSQAIC),
Keio University, 2-15-45 Mita, Minato-ku, Tokyo 108-8345, Japan
[7]Centre for Quantum Engineering, Research and Education,TCG Centres for Research and Education in Science and Technology, subspace V, Salt Lake, Kolkata 700091, India

Estimating the ground-state energy of Hamiltonians in quantum systems is an important task. In this work, we demonstrate that the ground-state energy can be accurately estimated without controlled time evolution by using adiabatic state preparation (ASP) and Ramsey-type measurement. By considering the symmetry of the Hamiltonian governing the time evolution during ASP, we can prepare a superposition of the ground state and reference state whose eigenvalue is known. This enables the estimation of the ground-state energy via Ramsey-type measurement. Furthermore, our method is robust against non-adiabatic transitions, making it suitable for use with early fault-tolerant quantum computers and quantum annealing.

Fr-02

A Quantum Differential Attack on ChaCha and Related Resources Estimation

Mintu Mandal[1], Hirendra Kumar Garai[2], Sabyasachi Dey[3]

[1]Birla Institute of Technology and Science, Pilani, India
[2]Nanyang Technological University, Singapore
[3] Birla Institute of Technology and Science, Pilani, India

Existing classical cryptanalytic techniques against ChaCha primarily rely on differential cryptanalysis, leveraging probabilistic neutral bits (PNBs) introduced by Aumasson et al. Separately, Bathe et al. proposed a quantum brute force search attack using Grover's algorithm with complexity 2^128. However, since the setups for brute force attacks and differential attacks with probabilistic neutral bits differ significantly, the feasibility of applying Grover's algorithm to the existing differential attacks on ChaCha remained unclear. In this paper, we demonstrate for the first time that a quantum setup for a PNB-based differential attack is indeed possible on ChaCha, where we can utilize the power of Grover's algorithm to improve further. By combining Grover's algorithm with PNB-based differential attack, we propose a quantum algorithm for PNB based differential attack and present a quantum attack on 6-round ChaCha that provides more than a quadratic speedup. Specifically, our attack achieves a complexity of 2^70, surpassing the quadratic speedup of the brute-force attack applying Grover's algorithm, proposed by Bathe et al. We achieve a circuit depth of 2^83 with our algorithm, marking a substantial advancement in efficiency.

Fr-03

Hardware-efficient quantum annealing with error mitigation via classical shadow

Takaharu Yoshida[1], Yuta Shingu[1], Chihaya Shimada[1], Tetsuro Nikuni[1],
Hideaki Hakoshima[2,3] and Yuichiro Matsuzaki[4]

[1]Department of Physics, Tokyo University of Science, Shinjuku Tokyo 162-8601 Japan
[2]Graduate School of Engineering Science, The University of Osaka,
1-3 Machikaneyama Toyonaka Osaka 560-8531 Japan
[3]Center for Quantum Information and Quantum Biology, The University of Osaka,
1-2 Machikaneyama Toyonaka Osaka 560-0043 Japan
[4]Department of Electrical Electronic and Communication Engineering Faculty of Science
and Engineering Chuo University, 1-13-27 Kasuga Bunkyo-ku Tokyo 112-8551 Japan

Quantum annealing (QA) is an efficient method for finding the ground-state energy of the problem Hamiltonian. However, in practical implementation, the system suffers from decoherence. On the other hand, recently, ``Localized virtual purification" (LVP) was proposed to suppress decoherence in the context of noisy intermediate-scale quantum (NISQ) devices. Suppose observables have spatially local support in the lattice. In that case, the requirement for LVP is to calculate the expectation value with a reduced density matrix on a portion of the total system. In this work, we propose a method to mitigate decoherence errors in QA using LVP. The key idea is to use the so-called classical shadow method to construct the reduced density matrix. Thanks to the CS, unlike the previous schemes to mitigate decoherence error for QA, we do not need either two-qubit gates or mid-circuit measurements, which means that our method is hardware-efficient.

Fr-04

Single-site diagonal quantities capture off-diagonal long-range order

M. Sanino[1], I. D'Amico[2], V. V. França[1], I. M. Carvalho[1]

[1]São Paulo State University (UNESP), Institute of Chemistry,
14800-090, Araraquara, São Paulo, Brazil
[2]School of Physics, Engineering and Technology, University of York,
York YO10 5DD, United Kingdom

Quantum phase transitions are typically marked by changes in quantum correlations across various spatial scales within the system. A key challenge lies in the fact that experimental probes are generally restricted to diagonal quantities at the single-site scale, which are widely believed to be insufficient for detecting phases with off-diagonal long-range order, such as superconducting states. In a striking departure from conventional expectations, we show that single-site diagonal descriptors — charge and spin fluctuations, occupation probabilities, and entanglement — can capture the emergence of off-diagonal long-range order in the one-dimensional extended Hubbard model at halffilling. These single-site quantities display clear critical signatures of the superconducting transition, preceded by a continuous breaking of particle-hole symmetry, consistent with a second-order phase transition. While this symmetry breaking has a negligible effect on single-site descriptors, it allows a direct connection between local fluctuations and nonlocal correlations.

Fr-05

Quantum Mpemba Effect in Bose Hubbard Model under Stark Potential and Quenched Disorder

Asad Ali, MI Hussain, Saif Al-kuwari

Qatar Center for Quantum Computing, College of Science and Engineering, Hamad Bin Khalifa University, Doha, Qatar

We study the quantum Mpemba effect (QME) in a one-dimensional Bose–Hubbard model across clean and disordered regimes using exact simulations of a four-site lattice under Lindblad dynamics with local dephasing. By tuning hopping, onsite interactions, Stark potentials, and quenched disorder, we analyze relaxation to a common steady state via trace distance, relative entropy, entanglement asymmetry, and L1 norm of coherence. QME emerges prominently in the clean interacting regime, where many-body correlations induce nonlinear relaxation, allowing initially distant states to surpass closer ones. In contrast, non-interacting systems follow standard thermalization, while Stark fields and disorder suppress QME by creating localization barriers—the latter yielding weaker slowdowns than the strong inhibition from Stark potentials. Entanglement asymmetry is especially most sensitive to symmetry-restoration processes driving QME. Our results highlight the pivotal role of interactions in anomalous relaxation and suggest pathways for controlling quantum thermalization in ultracold atomic platforms.

Fr-06

Engineering superconducting transmon qubits with high coherence and high fidelities

Leonid Abdurakhimov

IQM Quantum Computers

Superconducting qubits are one of the most developed hardware platforms for quantum computing, with commercial systems now available that consist of hundreds of physical qubits. In this talk, I will cover basic engineering aspects of implementing high-coherence high-fidelity superconducting transmon qubits, highlighting recent advances made at IQM Quantum Computers. I will begin by discussing the limitations on coherence in isolated qubits, and I will show how improved fabrication and design can allow one to reach coherence times up to 1 ms [1]. Next, I will explain how coherence and fidelity optimization framework can be applied to the development of quantum processing units (QPUs), and, as a demonstration of that approach, I will present results on the performance of QPU-compatible devices with gate fidelities exceeding 99.9% [2]. At the end of my talk, I will briefly discuss how coherence considerations inform choices on the selection of QPU architectures such as the star topology [3] and quantum codes such as tile codes [4].

[1] IQM press release on 15th July 2024.
[2] F. Marxer, J. Mrożek et al., arXiv:2508.16437 (2025).
[3] M. Renger, J. Verjauw, N. Wurz et al., arXiv:2503.10903 (2025).
[4] V. Steffan, S. H. Choe, et al., arXiv:2504.09171 (2025).

Unveiling prethermal two-dimensional discrete time crystals on a digital quantum computer

Kazuya Shinjo[1], Kazuhiro Seki[2], and Seiji Yunoki[1,2,3,4]

[1]RIKEN Center for Emergent Matter Science (CEMS), Wako, Saitama 351-0198, Japan
[2]Quantum Computational Science Research Team,
RIKEN Center for Quantum Computing (RQC), Wako, Saitama 351-0198, Japan
[3]Computational Materials Science Research Team, RIKEN Center for
Computational Science (R-CCS), Kobe, Hyogo 650-0047, Japan
[4]Computational Condensed Matter Physics Laboratory, RIKEN Cluster for
Pioneering Research (CPR), Saitama 351-0198, Japan

In periodically driven (Floquet) systems, evolution typically results in an infinite-temperature thermal state due to continuous energy absorption over time. However, before reaching thermal equilibrium, such systems may transiently pass through a meta-stable state known as a prethermal state. This prethermal state can exhibit phenomena not commonly observed in equilibrium, such as prethermal discrete time crystals (DTCs), making it an intriguing platform for exploring out-of-equilibrium dynamics. Here, we investigate the relaxation dynamics of initially prepared product states under periodic driving in a kicked Ising model using the IBM Quantum processors, comprising superconducting qubits arranged on a heavy-hexagonal lattice. We identify the presence of a prethermal regime characterized by magnetization measurements oscillating at twice the period of the Floquet cycle and demonstrate its robustness against perturbations to the transverse field. These observations provide strong evidence for the realization of a prethermal DTC in a two-dimensional system, corroborated by tensor-network and state-vector simulations. Our findings deepen the understanding of prethermal DTCs in higher dimensions and underscore the potential of digital quantum computers for simulating quantum many-body dynamics beyond the reach of state-of-the-art classical methods.

Fr-08

High-Fidelity Transport and Quantum Logic of Mobile Spin Qubits in Silicon

M. De Smet[1], Y. Matsumoto[1], A.M.J. Zwerver[1], L. Tryputen[2], S.L. de Snoo[1], S.V. Amitonov[2], S.R. Katiraee-Far[1], A. Sammak[2], N. Samkharadze[2], Ö. Gül[2], R. N. M. Wasserman[2], E. Greplova[1], M. Rimbach-Russ[1], G. Scappucci[1], and L.M.K. Vandersypen[1]

[1]QuTech and Kavli Institute of Nanoscience, Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands
[2]QuTech and Netherlands Organization for Applied Scientific Research (TNO), Delft, The Netherlands

Spin qubits in semiconductor quantum dots present a promising pathway toward scalable quantum computation, with recent demonstrations of high-fidelity gates. However, achieving high connectivity for fault-tolerant quantum computing remains challenging. Transport-based architectures, where qubits are physically shuttled, offer compelling solutions through reconfigurable connectivity.

This talk presents recent advances in coherent spin shuttling using conveyor-mode transport, where traveling-wave potentials move electrons smoothly through a linear Si/SiGe quantum dot array. We demonstrate spin transport by back-and-forth shuttling up to 10 μm with 99.5% fidelity, outperforming bucket-brigade shuttling approaches.

Building on this foundation, I discuss three developments. First, two-qubit operations between spins in separate traveling potentials, achieving ~99% CZ gate fidelity through tunable exchange interaction. Second, extending to lower magnetic fields, single-spin control via resonant conveyor EDSR or spin-diabatic shuttling through regions with a quantization axis tilt. Third, quantization axis tilts with shuttling velocity control enable switchable two-qubit gates: adiabatic shuttling yields a CZ or SWAP gate, while diabatic shuttling generates CX through frame changes.

Fr-09

Recent Advances in High-Fidelity Operations and Scalability of Silicon Spin Qubits

A. Noiri[1]

[1]RIKEN Center for Emergent Matter Science (CEMS),
2-1 Hirosawa, Wako-shi 351-0198 Saitama, Japan

Electron spin qubits in silicon quantum dots provide a promising platform for building scalable quantum computers. In this talk, we present our recent progress in enhancing the fidelities of fundamental operations, including state preparation and measurement [1], as well as single- [2] and two-qubit gates [3], through improvements in device structure, operating conditions, and calibration protocols. These advances have enabled fidelities to exceed 99% across all fundamental operations, surpassing the error-correction threshold.
With such high-fidelity control now demonstrated in systems with a small number of qubits, the central challenge toward realizing a practical fault-tolerant quantum computer has shifted to large-scale integration. To address this, we introduce our approach based on phase-coherent qubit shuttling. As a first step, we demonstrate a two-qubit gate between spatially separated qubits using the shuttling technique [4].

[1] K. Takeda et al., npj Quantum Information 10, 22 (2024)
[2] Y.-H. Wu et al., arXiv:2507.11918
[3] A. Noiri et al., Nature 601, 338–342 (2022)
[4] A. Noiri et al., Nature Communications 13, 5740 (2022)

PWe-01

Efficient quantum model for strongly-driven Josephson junctions

Ivan Iakoupov, William J. Munro

Quantum Engineering and Design Unit, Okinawa Institute of
Science and Technology Graduate University,
1919-1 Tancha, Onna-son, Okinawa 904-0495, Japan

We combine our earlier work of simulating open quantum systems with basis size of up to 2^16 [1] with a time-dependent displacement transformation [2] to simulate a strongly driven system consisting of a Josephson junction (transmon) and a resonator. Resonator states with both a large average photon number and significant deviations from a coherent state can be represented, while the Josephson junction (with its shunt capacitor) is represented in the charge basis. We use the matrix-free operators and superoperators to reach large basis sizes, but it is also possible to have a hybrid version, where the resonator operators are matrix-free, but the Josephson junction is represented in the diagonal basis with the junction-resonator couplings using dense matrices. The hybrid version could be used for the more complicated circuits consisting of more than one Josephson junction. We show results on approaching the regime of the high-power transmon measurement. We also expect that the same approach will be useful in studying measurement-induced state transitions in the dispersive regime and perhaps even Josephson-junction-based amplifiers.

[1] arXiv:2409.11956
[2] Phys. Rev. A 108, 033722 (2023)

PWe-02

Fabrication of gate-defined Quantum dot in a Bull's Eye optical cavity towards efficient Photon-Spin conversion

Hosumi Sato[1], Sangmin Ji[2], Yuta Konishi[1], Rio Fukai[1], Masayoshi Mori[1], Takafumi Fujita[1,3], Satoshi Iwamoto[2], Haruki Kiyama[4], Arne Ludwig[5], Andress D. Wieck[5], and Akira Oiwa[1,3]

[1]SANKEN, The University of Osaka, 8-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan
[2]Research Center for Advanced Science and Technology, The University of Tokyo, 4-6-1 Komaba, Meguro, Tokyo 153-8505, Japan
[3]Center for Quantum Information and Quantum Biology, The University of Osaka
[4]Graduate School and Faculty of Information Science and Electrical Engineering, Kyushu University, 744 Motooka, Nishi-ku, Fukuoka, Fukuoka 819-0395, Japan
[5]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitaetsstrasse, 15044801 Bochum, Germany

Semiconductor spin qubits based on gate-defined quantum dots (GDQD) are promising for quantum computing and communication owing to the precise electrical control, scalability, and potential for complete Bell-state measurement. Photon-spin conversion is important for quantum repeater, but conventional GDQD showed very low conversion efficiency (10^{-5}–10^{-4}). The aim of this work is to significantly enhance the efficiency by combining a GDQD with a nanoscale Bull's-eye optical cavity. Our approach employs a concentric circular grating cavity. With optimized cavity geometry, absorption at the target wavelength is enhanced by ~410 times compared with devices without cavities in the simulation. Air-bridged cavity–GDQD hybrids were fabricated using RIE dry etching and HF wet etching. Electrode delamination, a major problem in previous processes, was suppressed by slightly widening fine gates. To ensure conductivity, the quantum well wafer was designed with relatively high carrier density (~10^{12} cm^{-2}). So, both the depletion and pinch-off voltages were largely shifted to negative. The pinch-off behaviors were sometime masked by the gate leakage lowered to around -3 V.

PWe-03

Non-Destructive Spin-Photon Entanglement Generation with the Nitrogen Nuclear Spin Memory of a Diamond NV Center

T. Fujiwara, R. Reyes, Y. Sekiguchi, H. Kato, T. Makino, H. Kosaka

Department of Physics, Graduate School of Engineering Science,
Yokohama National University
Quantum Information Research Center (QIC), Yokohama National University
Institute of Advanced Sciences, Yokohama National University
National Institute of Advanced Industrial Science and Technology (AIST)

We investigate a diamond nitrogen-vacancy (NV) center as a promising platform for realizing a microwave-optical interface in superconducting qubit networks. The A_2 orbital transition enables spin-photon entanglement generation between the electron spin and the polarization of emitted photons1, while the electron spin can be coherently controlled via microwave fields. In addition, the intrinsic nitrogen nuclear spin offers a highly coherent quantum memory, making the NV center an attractive candidate for a quantum interface with built-in memory functionality.
For such memory-integrated operation, it is crucial that the coherence of the nuclear spin memory be preserved during the optical emission process. However, since the hyperfine interaction depends strongly on the orbital state, optical excitation may induce decoherence of the nuclear spin.
In this work, we show that excitation-induced decoherence of the nitrogen nuclear spin is significantly suppressed, with coherence retained at 87% fidelity even after up to 10 repeated optical excitations. This robustness exceeds expectations from simple estimates based on the difference in hyperfine coupling between orbital states.
Our findings indicate that orbital excitation has only a limited effect on the nuclear spin memory, allowing for repeated spin-photon entanglement generation. These results open a path toward memory-enhanced, high-efficiency microwave-optical quantum interfaces based on diamond NV centers.

PWe-04

A resonant microwave-to-optical quantum transducer based on a diamond color center

Kyosuke Goto[1], Hodaka Kurokawa[2], Hideo Kosaka[1,2], and Kazuki Koshino[3]

[1]Department of Physics, Graduate School of Engineering Science,
Yokohama National University,
[2]Quantum Information Research Center, Institute of Advanced Sciences,
Yokohama National University,
[3]Institute for Liberal Arts, Institute of Science Tokyo

Scaling fault-tolerant quantum computers to millions of qubits is limited by hardware constraints, making distributed architectures essential. For superconducting qubits, microwave-to-optical transduction is key, but balancing high efficiency with low noise is challenging due to strong optical pumping. We propose a resonant transducer using diamond color centers with double-resonant energy levels. A single color center couples a microwave resonator (via a phononic crystal) and an optical cavity (via a photonic crystal). Microwave photons drive a phonon, which, with optical pumping, excites the color center to emit an optical photon. Input–output analysis shows efficient conversion with bandwidth control and reduced noise. Importantly, pump power is lowered by orders of magnitude compared to optomechanical methods, highlighting the feasibility of scalable diamond color center–based quantum transducers.

PWe-05

Fabrication of Gate-defined Quantum Dots × In-Plane p-i-n Junction Devices for Single-Photon Generation

Taiki Kurose[1], Kazuma Haruna[1], Genki Fukuda[1], Takafumi Fujita[1], Ayato Miura[1], Andreas Wieck[2], Arne Ludwig[2], and Akira Oiwa[1]

[1]SANKEN, The University of Osaka, Osaka, Japan
[2]Ruhr-Universität Bochum, Bochum, Germany

Electron spins in lateral quantum dots offer relatively long coherence times, high electrical controllability, and high fidelity, attractive for photon-spin quantum interfaces. However, coherent conversion from the spin states to polarized photon states, has not been studied. By combining the concepts of gate-defined quantum dots and in-plane p-i-n junction, we aim to realize quantum state conversion from a single electron spin to a single polarized photon via recombination emission.

In devices fabricated using an undoped GaAs/AlGaAs quantum well substrate, carrier-induced defects from the n-type ohmic contact and leakage through the insulating layer emerged as challenges. On the undoped substrate, ohmic contacts must be selectively formed on the quantum well layer. This is thought to be caused by an inappropriate angle. Furthermore, the leakage is presumed to have been caused by a large overlapping area between the electrodes.

In response, we optimized the deposition angle and reconsidered the device design, thereby obtaining guidelines for device improvements. These development lead achieving p-type and n-type single-carrier confinement and coherent spin manipulation for on-demand photon emission, an future essential element for networking quantum computing technology.

PWe-06

Optical Characterization of a Diamond Optomechanical Crystal Coupled to a SiN Waveguide

Masaki Yoshioka[1], Kiyotaka Sato[1], Hodaka Kurokawa[2,3], Yuhei Sekiguchi[2,3], Mikiya Kamata[1,2], Shoji Hachuda[1,2], Masaki Kunii[1,2], Takemasa Tamanuki[1,2,3], Satomi Ishida[4], Hidetsugu Matsukiyo[5], Natthajuks Pholsen[5], Masao Nishioka[5], Sangmin Ji[5], Hideo Otsuki[4], Kosuke Kimura[6], Kouta Takenaka[6], Shinobu Onoda[3,6], Toshihiko Baba[1,2,3], Satoshi Iwamoto[3,4,5], Hideo Kosaka[1,2,3]

[1]Department of Physics, Graduate School of Engineering Science, Yokohama National University
[2]Department of Electrical and Computer Engineering, Yokohama National University
[3]Quantum Information Research Center (QIC), Yokohama National University
[4]Research Center for Advanced Science and Technology (RCAST), The University of Tokyo
[5]Institute of Industrial Science (IIS), The University of Tokyo
[6]National Institutes for Quantum Science and Technology (QST)

The realization of Fault-Tolerant Superconducting Quantum Computer requires more than one million qubits, but the associated increase in microwave interconnects is a major challenge to be solved in terms of scalability and heat influx. Quantum Transducers, which convert microwave signals into optical photons, offer a viable solution to this problem. Such transducers are being developed using Diamond Optomechanical Crystals (Diamond OMCs) with embedded Nitrogen-Vacancy (NV) Centers, where efficient coupling to a photonic waveguide is critical for performance.

We report a high-precision method to place a diamond crystal on a SiN waveguide using a tungsten probe. Optical characterization via a coupled fiber confirms the successful integration, as the photoluminescence spectrum shows both the NV center's zero-phonon line and a distinct cavity resonance peak. This achievement demonstrates reproducible optical access to the NV centers within the diamond OMC via the waveguide, marking a significant advance toward the construction of efficient and scalable quantum transducers.

PWe-07

Quantum signal processing on a Hilbert-space fragmented system

Naoya Egawa[1], Kaoru Mizuta[2, 3, 4], and Joji Nasu[1]

[1]Department of Physics, Tohoku University
[2]Department of Applied Physics, Graduate School of Engineering, The University of Tokyo
[3]Photon Science Center, Graduate School of Engineering, The University of Tokyo
[4]RIKEN Center for Quantum Computing (RQC)

Quantum Signal Processing (QSP) has proven to be a powerful paradigm in quantum algorithms, enabling polynomial transformations of block-encoded operators [1]. While the standard formulation typically requires highly non-local unitary gates, it has been shown that, by treating points in the momentum space of a quantum many-body system as the signal, one can realize QSP within local many-body dynamics [2]. In particular, for local integrable many-body systems, proposals have demonstrated that QSP can be embedded into the dynamics of transverse-field models, providing physically motivated realizations.

However, realistic quantum platforms typically exhibit nonintegrable systems, where the system is complex and the dynamics show thermalization driven by entanglement spreading. In this work, we propose and develop QSP in a local non-integrable system, showing that QSP protocols can survive within the kinetically constrained subspaces, thereby exhibiting Hilbert-space fragmentation. Leveraging the kinetically constrained 1D pair-hopping model [3], we identify Krylov subspaces that host SU(2) dynamics on a momentum space even in nonintegrable regimes. Within these subspaces, one can implement QSP sequences with enriched operational scope of QSP compared to the local integrable systems.

[1] G. H. Low and I. L. Chuang, Optimal Hamiltonian Simulation by Quantum Signal Processing, Phys. Rev. Lett. 118, 010501 (2017).
[2] V. M. Bastidas et al., Quantum signal processing with the one-dimensional quantum Ising model, Phys. Rev. B 109, 014306 (2024).
[3] S. Moudgalya et al., Thermalization and its Absence within Krylov Subspaces of a Constrained Hamiltonian, arXiv:1910.14048 (2019).

High-Performance Simulation Platform for Bosonic Quantum System Integrating HPC and Machine Learning

Ryo Maekura[1,2], Shotaro Shirai[1,2], Genta Ando[1,2], Yusuke Tominaga[1,2], Atushi Noguchi[1,2,3]

[1]Komaba Institute for Science (KIS), The University of Tokyo,
Meguro-ku, 153-8902, Tokyo, Japan
[2]RIKEN Center for Quantum Computing, Wako, 351-0198, Saitama, Japan
[3]Inamori Research Institute for Science (InaRIS), Organization, Kyoto-shi,
600-8411, Kyoto, Japan

Quantum Error Correction (QEC) is indispensable for realizing fault-tolerant quantum computers. Among various approaches, bosonic QEC is emerging as a promising candidate due to its hardware-efficient encoding of logical information into harmonic oscillators. However, classically simulating these infinite-dimensional Hilbert spaces is computationally prohibitive, posing a significant bottleneck for designing and verifying bosonic codes.
To overcome this challenge, we are developing a high-performance simulation library specifically architected for GPU-accelerated High-Performance Computing (HPC) environments. Our library is designed to enable large-scale and high-fidelity simulations of complex bosonic quantum systems.
In this poster session, we will first detail the software architecture and key features of our library. We will then demonstrate its practical utility through a simulation of quantum control, where reinforcement learning is employed to optimize gate operations on a bosonic qubit. Furthermore, we will showcase a pioneering framework that integrates our simulation library with a real-world experimental setup. This creates a powerful feedback loop between numerical modeling and physical implementation, aiming to accelerate the development cycle of practical bosonic QEC systems.

PWe-09

Adiabatic optical fiber coupling for diamond quantum nanophotonic devices

Keitaro Aoyama[1], M. Kamata[1,2], S. Hachuda[1,2], M. Kunii[1,2], T. Tamanuki[1,2,3], S. Ishida[4], H. Matsukiyo[5], N. Pholsen[5], M. Nishioka[5], S. Ji[5], H. Otsuki[4], K. Kimura[6], K. Takenaka[6], S. Onoda[3,6], T. Baba[1,2,3], S. Iwamoto[3,4,5], H. Kosaka[1,2,3]

[1]Grad. Sch. Sci. Eng. Yokohama Natl. Univ.,
79-5, Tokiwadai, Hodogaya, Yokohama, Kanagawa, 240-8501, Japan
[2]IAS Yokohama Natl. Univ.,
79-5, Tokiwadai, Hodogaya, Yokohama, Kanagawa, 240-8501, Japan
[3]QIC Yokohama Natl. Univ.,
79-5, Tokiwadai, Hodogaya, Yokohama, Kanagawa, 240-8501, Japan
[4]RCAST Tokyo Univ., 4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan
[5]IIS Tokyo Univ., 4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan
[6]QST, 1233, Watanuki-machi, Takasaki, Gunma, 370-1292, Japan

Efficient and stable interfaces between quantum devices and optical fibers are a key requirement for realizing large-scale quantum networks and distributed quantum computing. Adiabatic coupling between a diamond waveguide and a tapered fiber provides a promising route to broadband, efficient, and robust optical coupling [*]. In this work, we present the design, fabrication, and characterization of such interface.

First, we performed FDTD simulations to optimize the diamond nanobeam geometry. These simulations predict a maximum coupling efficiency of 98% with an optimized design. Next, tapered optical fibers with angles <3° and tips <150 nm were fabricated using an optimized hydrofluoric acid etching process. Finally, we experimentally evaluated the coupling efficiency by measuring photoluminescence from nitrogen-vacancy centers in a diamond nanobeam through the fiber, yielding an efficiency of 14%.

These results establish a clear design path for a practical interface. The gap between simulation and experiment highlights the need to improve physical contact and nanobeam fabrication. Future work will target these optimizations to realize a more efficient and robust packaged device, a critical component for quantum networks.

[*] Zeng et al. Appl. Phys. Lett. 123, 161106 (2023)

PWe-10

Spin readout using Pauli spin blockade in an InAs gate-defined quadruple quantum dot

Yuki Yokoyama[1], Nozomu Hayashi[2], Jason T. Dong[3], Mihir Pendharkar[4], Takafumi Fujita[2,5], Rio Fukai[2,5], Chris J. Palmstrøm[3,4], Akira Oiwa[2,5], and Haruki Kiyama[1,2]

[1]Graduate School and Faculty of Information Science and Electrical Engineering, Kyushu University
[2]SANKEN, The University of Osaka
[3]Materials Department, University of California Santa Barbara, Santa Barbara, CA 93106, USA
[4]Department of Electrical and Computer Engineering, University of California, Santa Barbara, USA, CA 93106
[5]Center for Quantum Information and Quantum Biology, The University of Osaka

InAs-based quantum structures provide a promising platform for quantum information technologies due to their high-quality junctions with superconductors and strong spin-orbit interaction. Single-electron charge sensing is an indispensable technique for the realization of quantum computing, as it is a key component of single-shot spin readout. Until now, single-electron charge sensing has been demonstrated in InAs nanowire quantum dots and self-assembled InAs quantum dots. However, it has not yet been reported in planar gate-defined InAs quantum dots, which are expected to offer excellent scalability.

In this work, we demonstrate charge sensing and pauli spin blockade measurements in gate-defined InAs quantum dots using an adjacent charge sensor. We fabricated quantum dots using standard semiconductor nanofabrication techniques. First, we confirmed that the basic characteristics of the device and electron occupation of each quantum dot could reach zero electron. By tuning barrier gates, we formed a double quantum dot in the few-electron regime. Furthermore, using the neighboring charge sensor, we demonstrated single-electron charge sensing. Finally, we performed spin readout using Pauli spin blockade.

These results show that gate-defined InAs quantum dots possess fundamental performances comparable to existing quantum dot platforms. The next step is to realize single electron spin manipulation, and to evaluate qubit performances such as manipulation speed and coherence time.

PWe-11

Linear ion trap with an integrated fiber Fabry-Perot cavity: Shielded Design and Adaptive Mirror Fabrication

Shuma Oya[1], Soon Teh[1], Zhenghan Yuan[1], Ezra Kassa[1], Shaobo Gao[1], Vishnu Kavungal[1], Daichi Okuno[1], Hiroki Takahashi[1]

[1]Experimental Quantum Information Physics (EQuIP) Unit,
Okinawa Institute of Science and Technology,
1919-1 Tancha, Onna-son, Okinawa, 904-0412, Japan

Interconnecting remote trapped-ion qubits through photons necessitates efficient photon collection. One promising approach to achieve this is coupling with optical microcavities. However, using short cavities places dielectric mirrors in close proximity to the ions, leading to issues such as charging, trap distortion, and heating. We present the design of an ion trap system that features improved symmetry, enhanced electrical and optical access (through PCB feedthroughs and a re-entrant window), and effective conductive shielding for the fiber Fabry–Perot cavity (FFPC). This design aims to integrate an FFPC while mitigating the effects of dielectric charging.

Concurrently, we developed a high-yield CO_2 laser micromachining method for creating fiber mirrors. This method incorporates patterned irradiation with in-situ feedback to correct beam profile distortions, allowing us to achieve precise concave profiles and enhance fabrication efficiency. We can actively tune the ablation process by adjusting the duration of pauses between shots, allowing us to manipulate feature widths, switch between Gaussian and spherical profiles, and produce mirrors with low ellipticity ($r_e < 0.2$) and radii of curvature ranging from 250 to 700 µm. The high-reflectivity-coated FFPCs we are developing can achieve a finesse of approximately 1.5×10^5 at 854 nm and greater than 10^5 for cavity lengths up to 430 µm, which facilitates strong, low-loss ion–cavity coupling in compact devices.

PWe-12

Properties of computational entanglement measures

Ilia Ryzov, Faedi Loulidi, David Elkouss

OIST

Quantum entanglement is a useful resource for implementing communication tasks. However, for the resource to be useful in practice, it needs to be accessible by parties with bounded computational resources.

Computational entanglement measures quantify the usefulness of entanglement in the presence of limited computational resources.

In this paper, we analyze systematically some basic properties of two recently introduced computational entanglement measures, the computational distillable entanglement and entanglement cost.

To do so, we introduce lower bound and upper bound extensions of basic properties to address the case when entanglement measures are not defined by a scalar value but when only lower or upper function bounds are available.

In particular, we investigate the lower bound convexity and upper bound concavity properties of such measures, and the upper and lower bound additivity with respect to the tensor product. We also observe that these measures are not invariant with local unitaries, although invariance is recovered for efficient unitaries. As a consequence, we obtain that these measures are only LOCC monotones under efficient families of LOCC channels.

PWe-13

Log-Likelihood Ratio for Improving Accuracy in Silicon Spin Qubit Readout

R. Mizokuchi[1], R. Wada1, R. Matsuoka[1], S. Ota[1], I. Yanagi[2], T. Mine[2], R. Tsuchiya[2], D. Hisamoto[2], H. Mizuno[2], and T. Kodera[1]

[1]Institute of Science Tokyo, Japan.
[2]Hitachi, Ltd, Japan.

Fast qubit readout within the coherence time is a key challenge in quantum error correction. Digital signal processing can accelerate readout by improving accuracy. Among these techniques, the log-likelihood ratio (LLR) method is a promising candidate, offering high detection accuracy with low computational cost. Here, we experimentally apply LLR to silicon spin qubit readouts and evaluate its performance. In these readouts, the qubit state is encoded in the presence or absence of a pulse-like feature in the time-domain signal. We compute likelihoods for both hypotheses, take the logarithm of their ratio, and apply a threshold to the maximum value to detect the feature. We find that, even with a wide bandwidth yielding an SNR below one, LLR reliably detects coherent oscillations, whereas conventional thresholding fails. Simulations confirm the effectiveness of LLR, showing an accuracy improvement from ~76% to ~86%, consistent with experiments. This method enables observation of dynamics that simple thresholding misses and combined with fast signal processing, supports real-time qubit state feedback.

PWe-14

Ferromagnetic Josephson junctions with NbN/GdN/NbN trilayer for high-coherence superconducting qubits

Daiki Kurihara, Yugo Mori, Koki Honda, Hiroki Kutsuma, and Taro Yamashita

Department of Applied Physics, Graduate School of Engineering, Tohoku University, 6-6-05 Aramaki-aza Aoba, Aoba-ku, Sendai, Miyagi 980-8579, Japan

A flux qubit, which shows the higher anharmonicity than that of the transmon qubits, is a promising candidate for a fundamental element of large-scale superconducting quantum computers. However, their operation requires a half-flux-quantum bias which is a bottleneck for the large-scale integration. To address this issue, it has been proposed that the need for the flux bias could be eliminated by introducing ferromagnetic Josephson junctions (superconductor/ferromagnet/superconductor junctions, π-junctions). Recently, a proof-of-principle demonstration of the flux-bias-free operation of the flux qubit was reported. Although the energy relaxation time of 1.5 μs was achieved, it has been suggested that quasiparticle excitations in the metal used as the ferromagnetic layer may suppress the coherence properties of the qubit.

To improve the coherence of the qubits with the π-junction, we are focusing on ferromagnetic insulators with a band gap. In this study, NbN/GdN/NbN junctions were fabricated on a MgO (100) substrate, where GdN is a ferromagnetic insulator. We have confirmed that these junctions exhibit the underdamped characteristics and a large subgap resistance of the junctions, similar to those of the conventional Josephson junctions used for qubits. In the presentation, we will report the systematic investigation of the π-state by tuning the deposition conditions and thickness of the GdN layer, and discuss how these parameters affect the junction characteristics.