QUANTUM INNOVATION 2023

The International Symposium on Quantum Science, Technology and Innovation

Proceedings

Date 15-17 November 2023

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QUANTUM INNOVATION 2023

The International Symposium on Quantum Science, Technology and Innovation

Welcome to Quantum Innovation 2023

It is our pleasure to invite all of you including scientists, engineers, business delegates, young researchers and students to Quantum Innovation 2023, the International Symposium on Quantum Science, Technology and Innovation, to be held on 15-17 November 2023 in -person.

Quantum Innovation 2023 is the third international symposium hosted by Japanese government and research institutes, that aims to bring together multi-disciplined researchers to present and exchange breaking-through ideas in quantum science and technology.

The topics of Quantum Innovation 2023 cover the latest achievements, trends and needs in quantum science and technology including quantum computing, quantum sensing, quantum cryptography and quantum communication.

We look forward to seeing you in Quantum Innovation 2023 and hope you enjoy excellent presentations from distinguished guests, share exciting discoveries and promote fruitful collaborations.

Organizing Committee

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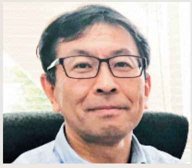
Mutsuko Hatano
Tokyo Institute of Technology

Track Chair
Quantum Computing
Mio Murao
The University of Tokyo



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National Institutes for Quantum Science and Technology (QST)

Masahiro Kitagawa
Osaka University

Atsushi Noguchi
The University of Tokyo

Yutaka Tabuchi
RIKEN

Symposium Outline

Aims

Addressing the state-of-the-art quantum technology

Exploring cooperation on research, application, education and social awareness on quantum technology

We will bring together researchers working on quantum technology and offer a platform for discussions among them. Inviting prominent speakers from abroad and Japan, Quantum Innovation 2023 covers latest development of quantum computing, quantum sensing, quantum cryptography and quantum communication.
We also aim to give young researchers, future quantum working force candidates and aware citizens an overview of fast evolving quantum technology by listening to inspiring talks.

Scope of the Symposium

Highlights of the development of quantum technology

- Quantum Computing
- Quantum Sensing
- Quantum Cryptography & Communication

Development of Infrastructure for the progress of quantum technology

- Promotion of practical applications of quantum technology
- Development of human resources for quantum technology
- Promotion of international collaborations

Date

15-17 November 2023

Venue

Tokyo Convention Hall
Tokyo Square Garden 5F
3-1-1 Kyobashi, Chuo-ku, Tokyo

Tokyo Convention Hall is conveniently located within walking distance of Tokyo Station, the main hub station of Tokyo. Tokyo Convention Hall TEL : 03-5542-1995 FAX : 03-5542-1994. Click here for the website : https://www.tokyo.conventionhall.-jp/eng/index.html

Schedule

15 November 2023	Plenary Sessions
16-17 November 2023	Quantum Computing Track Quantum Sensing Track Quantum Cryptography & Communication Track Poster Session(16 November)

Speakers

All the speakers are to be invited.

Participants

The expected participants include researchers, engineers, business delegates, policy makers, administrators, students, and the media people, who share interests in quantum technology and innovation.

Symposium Sponsors

Cabinet Office
Ministry of Internal Affairs and Communications (MIC)
Ministry of Education, Culture, Sports, Science and Technology (MEXT)
Ministry of Economy, Trade and Industry (METI)
RIKEN
Japan Science and Technology Agency (JST)
National Institutes for Quantum Science and Technology (QST)
National Institute of Advanced Industrial Science and Technology (AIST)
National Institute of Information and Communications Technology (NICT)
Okinawa Institute of Science and Technology Graduate University (OIST)
Osaka University
The University of Tokyo
Tohoku University
Tokyo Institute of Technology
Quantum STrategic industry Alliance for Revolution (Q-STAR)

Symposium Supporters

National Institute for Material Science (NIMS)

About QIH

Quantum technology is bringing a great impact on a wide range of industry. In order to accelerate the progress and make best use of quantum technology, industry, academia and government are expected to collaborate on promoting basic research, technology demonstration, industrialization, intellectual property management and human resource development. For promoting these activities, Japan established Quantum Technology Innovation Hubs in February 2021.

QIH Quantum Innovation Hubs

- Quantum computation pioneering hub (RIKEN)
- Quantum sensing hub (Tokyo Tech)
- Foundational quantum technology and quantum life R&D hub (QST)
- Quantum material hub (NIMS)
- Quantum solution hub (Tohoku University)
- hub of Quantum-based chemistry for industry development (THERS)
- Quantum technology international collaboration hub (OIST)
- Quantum security hub (NICT)
- Quantum computer applications hub (UTokyo & Business alliance)
- Quantum software hub (Osaka University)
- hub of Global research and development for business by quantum-AI technology (AIST)

RIKEN serves as Headquarters of the Hubs to incorporate efforts to advance quantum technology research in Japan.

Program at a Glance

Tracks

PL

Plenary Sessions

Contents / Topics

Welcome from Organizing Committee and Hosts, Plenary Talks, Keynote

Tracks

CP

Quantum Computing Track

Contents / Topics

Quantum Computing architecture, Quantum computers with Atoms and Ions, Photonic Quantum Computers, Fault Tolerant Quantum Computing, Quantum Algorithms for Chemistry, NISQ Algorithms, Young PIs Session, Superconducing Quantum Computing, Quantum Annealing, Verifiable Quantum Computing, Semiconductor Quantum Computers, Quantum Simulations

Tracks

SE

Quantum Sensing Track

Contents / Topics

Q-sensors for Life Science, NV Center and Applications for Life Sciences, Solid-State Quantum Sensors, 5th IFQMS Short Presentation Session for Young Scientists, Solid-State Quantum Sensors, Q-sensors for Life Science, NV Center and Applications for Life Sciences, Atom Interferometer, Atom/Ion Clocks *29th Nov Sessions are a joint-program with The 5th IFQMS (The 5th International Forum on Quantum Metrology and Sensing).

Tracks

CC

Quantum Cryptography & Communication Track

Contents / Topics

Quantum Internet, Young Researcher Panel Session, Quantum Cryptography

All the times in the program are **Japan Standard Time**(GMT+9)

15 Nov (Wed.)

10:00-10:20	Opening	PL-01
10:40-11:40	Government Policy on Quantum Science and Technology	PL-02
13:10-14:30	Keynotes	PL-03
14:30-15:45	Quantum Innovation Strategy in Industry	PL-04
16:20-17:00	Panel 1: Social Implementation of Quantum Technologies	PL-05
17:00-17:40	Panel 2: Human Resource Development in Quantum Science and Technology	PL-06
18:00-20:00	Reception	

* Q-LEAP 6th IFQMS Joint Session

16 Nov (Thu.)

9:00-10:30	QC with Ions, Atoms and Photons	CP-01	9:00-10:30	Solid-state Quantum Sensors Part 1	SE-01*	9:00-10:30	Quantum Key Distribution Network	CC-01
10:50-12:20	Semiconductor QC	CP-02	10:50-12:20	Solid-state Quantum Sensors Part 2	SE-02*	10:50-12:20	Satellite Quantum Communication	CC-02
13:50-14:50	Superconducting QC	CP-03	13:50-15:20	Optical Quantum Sensing	SE-03*	13:50-15:20	Panel Session: Standardization and Social Deployment	CC-03
14:50-15:20	Industrialization of QC	CP-08						

15:40-17:30	Poster Session	PO

Plenary Sessions

All the times in the program are **Japan Standard Time**(GMT+9)

15 Nov (Wed.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
10:00-10:20	PL-01. Opening			
	Chairperson	Yasunobu Nakamura	RIKEN	
10:00	Welcome	Mutsuko Hatano	General Chair, Quantum Innovation 2023 Organizing Committee	
10:10	Welcome	Hiroki Matsuo	Vice-Minister, Secretary General, Science, Technology and Innovation Policy, Cabinet Office, Government of Japan	
10:15	Congratulatory Speech	Yoshimasa Hayashi	Parliamentary Association for Quantum Technology Promotion	
10:20	Coffee Break			
10:40-11:40	PL-02. Government Policy on Quantum Science and Technology			
	Chairperson	Yasunobu Nakamura	RIKEN	
10:40	Strategy of quantum future industry development	Daisuke Kawakami	Deputy Secretary General for Secretariat of Science, Technology and Innovation Policy, Cabinet Office	**PL-02-01**
11:00	The U.S. National Quantum Initiative	Tanner Crowder	Policy Analyst, National Quantum Coordination Office, Office of Science and Technology Policy Executive Office of the President	**PL-02-02**
11:20	Quantum technology in the European Union	Peter Fatelnig	Minister Counsellor, Delegation of the EU to Japan	**PL-02-03**
11:40	Lunch			
13:10-14:30	PL-03. Keynotes			
	Chairperson	Yasuhiko Arakawa	UTokyo	
13:10	Challenges in superconducting quantum computing	Yasunobu Nakamura	RIKEN	**PL-03-01**
13:50	Advancing the quantum economy through sensors and standards	Barbara Goldstein	NIST	**PL-03-02**
14:30-15:45	PL-04. Quantum Innovation Strategy in Industry			
	Chairperson	Shunsuke Okada	Q-STAR	
14:30	Introduction of the Australian Quantum Association (AQA)	George Robinson	AQA	**PL-04-01**
14:45	The Quantum Economic Development Consortium (QED-C): Growing the quantum industry	Celia Merzbacher	QED-C	**PL-04-02**
15:00	UK Quantum, the UK's quantum industry trade body	Tim Prior	UKQuantum	**PL-04-03**
15:15	Introduction of Q-STAR -Create industries & businesses with quantum technology	Taro Shimada	Q-STAR	**PL-04-04**
15:30	Supporting collaboration between academia and industry for quantum innovation	Akihisa Tomita	Quantum ICT Forum/Hokkaido U	**PL-04-05**
15:45	Coffee Break			
16:20-17:00	PL-05. Panel 1: Social Implementation of Quantum Technologies			
	Chairperson	Masahiro Horibe	AIST	
		Celia Merzbacher	QED-C	
		Hidetaka Takano	Q-STAR	
		George Robinson	AQA	
		Tim Prior	UKQuantum	
		Yu Chen	Google	
17:00-17:40	PL-06. Panel 2: Human Resource Development in Quantum Science and Technology			
	Chairperson	Kae Nemoto	OIST	
		Peter Turner	Sydney Quantum Academy	
		Eleni Diamanti	Sorbonne U	
		Shinya Ogata	Q-STAR	
		Celia Merzbacher	QED-C	
18:00	Reception			

Quantum Computing Track

All the times in the program are **Japan Standard Time**(GMT+9)

16 Nov (Thu.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
9:00-10:30	CP-01. QC with Ions, Atoms and Photons			
	Chairperson	Shuntaro Takeda	UTokyo	
9:00	Nanofiber cavity quantum electrodynamics systems for distributed quantum computing	Takao Aoki	Waseda U	CP-01-01
9:30	Photonic quantum machine learning	Philip Walther	U Vienna	CP-01-02
10:00	Quantum science with tweezer arrays	Manuel Endres	Caltech	CP-01-03
10:30-10:50	Coffee Break			
10:50-12:20	CP-02. Semiconductor QC			
	Chairperson	Yusuke Kozuka	NIMS	
10:50	Electron and hole spin qubits in silicon	Leon Camenzind	RIKEN	CP-02-01
11:20	Semiconductor integration technology for realization of silicon quantum computers	Noriyuki Lee	Hitachi	CP-02-02
	Chairperson	Takahiro Mori	AIST	
11:50	Recent progress on graphene quantum dot devices	Takuya Iwasaki	NIMS	CP-02-03
12:20-13:50	Lunch			
13:50-14:50	CP-03. Superconducting QC			
	Chairperson	Yutaka Tabuchi	RIKEN	
13:50	Beyond-classical quantum computing with superconducting circuits	Yu Chen	Google	CP-03-03
14:20	Niobium-nitride-based superconducting qubits	Summi Kim	NICT	CP-03-04
14:50-15:20	CP-08. Industrialization of QC			
	Chairperson	Shu Tanaka	Keio U	
14:50	Usecases by quantum technologies for social contribution	Yuichi Nakamura	NEC	CP-08-01

17 Nov (Fri.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
9:30-10:30	CP-04. Quantum Annealing			
	Chairperson	Shu Tanaka	Keio U	
9:30	Quantum CAE: automation in science with quantum computing and machine learning	Tadashi Kadowaki	AIST / DENSO	CP-04-02
10:00	Quantum inspired computing: technology & strategy and applications	Taisuke Iwai	Q-STAR	CP-04-03
10:30-10:50	Coffee Break			
10:50-12:20	CP-06. Toward FTQC			
	Chairperson	Shigeru Yamashita	Ritsumeikan U	
10:50	Low-cost quantum error correction using looped pipelines	Zhenyu Cai	U Oxford	CP-06-01
11:20	How many qubits do you need, really?	Mathias Soeken	Microsoft Research	CP-06-02
11:50	Partially fault-tolerant quantum computing architecture with error-corrected Clifford gates and space-time efficient analog rotations	Yutaro Akahoshi	Fujitsu	CP-06-03
12:20-13:20	Lunch			
13:20-15:20	CP-05. NISQ Algorithms			
	Chairperson	Keisuke Fujii	Osaka U / RIKEN	
13:20	Perspectives on the current state of quantum computing systems capability	Hanhee Paik	IBM Quantum	CP-05-01
13:50	Beyond classical machine learning: new insights on quantum machine learning	Sofiene Jerbi	Freie U	CP-05-02
14:20	Generalized quantum subspace expansion for quantum error mitigation	Suguru Endo	NTT	CP-05-03
14:50	Quantum chemistry on NISQ devices beyond variational quantum algorithms	Keita Kanno	QunaSys	CP-05-04
15:20-15:40	Break			
15:40-17:10	CP-07. Quantum Algorithms and Foundation			
	Chairperson	Mio Murao	UTokyo	
15:40	Do quantum computers have applications in machine learning and combinatorial optimization?	Jens Eisert	Freie U	CP-07-01
16:10	Verifiable quantum advantage without structure	Takashi Yamakawa	NTT	CP-07-02
16:40	Theoretical foundations of quantum advantage in quantum algorithms	François Le Gall	Nagoya U	CP-07-03

Quantum Sensing Track

All the times in the program are **Japan Standard Time**(GMT+9)
*** Q-LEAP 6th IFQMS Joint Session**

16 Nov (Thu.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
9:00-10:30	SE-01*. Solid-state Quantum Sensors Part 1			
	Chairperson	Norikazu Mizuoch	Kyoto U	
9:00	Quantum sensing: the promise, the challenge, and the path ahead	Danielle Braje	MIT	SE-01-01
9:30	Diamond-based magnetometer with dc sensitivity below 10 pT Hz^-1/2 for magnetoencephalography	Naota Sekiguchi	Tokyo Tech	SE-01-02
10:00	Double/Triple resonance of electron spin in diamond: Quantum sensing and manipulation	Junko Ishi-Hayase	Keio U	SE-01-03
10:30-10:50	Coffee Break			
10:50-12:20	SE-02*. Solid-state Quantum Sensors Part 2			
	Chairperson	Takayuki Iwasaki	Tokyo Tech	
10:50	Basic properties and quantum control of diamond qubits	Adam Gali	Wigner RCP / BME	SE-02-01
11:20	Plasma CVD engineering of diamond nitrogen-vacancy centers for quantum sensing	Hiromitsu Kato	AIST	SE-02-02
11:50	Magnetic field imaging using quantum sensors for condensed matter physics	Kensuke Kobayashi	UTokyo	SE-02-03
12:20-13:50	Lunch			
13:50-15:20	SE-03*. Optical Quantum Sensing			
	Chairperson	Shigeki Takeuchi	Kyoto U	
13:50	Mid-IR quantum sensing with entangled photons	Sven Ramelow	Humboldt U	SE-03-01
14:20	Quantum enhancement towards sensitive molecular vibrational imaging	Yasuyuki Ozeki	UTokyo	SE-03-02
14:50	Reaching the quantum limit with a gravitational-wave telescope	Kentaro Somiya	Tokyo Tech	SE-03-03

17 Nov (Fri.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
9:00-10:30	SE-04*. Quantum Life Sciences Meets Quantum Computing Part 1			
	Chairperson	Noriaki Yahata	QST	
9:00	The state of quantum computing applications in health and medicine	Frederik Flöther	QuantumBasel	SE-04-01
9:30	Quantum computing in chemistry, molecular biology, and materials science	Markus Reiher	ETH Zürich	SE-04-02
10:00	Exploring the quantum acceleration of machine learning in neural data analysis	Kei Majima	QST	SE-04-03
10:10	Expansion of the scope of quantum annealing	Yuya Seki	Keio U	SE-04-04
10:20	Application of quantum annealing to quantum sensing	Yuichiro Matsuzaki	Chuo U	SE-04-05
10:30-10:50	Coffee Break			
10:50-12:20	SE-05. Quantum Life Sciences Meets Quantum Computing Part 2			
	Chairperson	Keisuke Fujii	Osaka U	
10:50	Quantum cognition? The subatomic frontier of brain research	Matthew Fisher	UCSB	SE-05-01
11:20	Hyperpolarized spin sensing of metabolic processes in a brain	Makoto Negoro	Osaka U / QST	
11:50	Some steps towards enabling practical quantum computing of biomolecules	Wataru Mizukami	Osaka U	SE-05-03
12:20-13:50	Lunch			
13:50-15:20	SE-06. Atom Interferometer			
	Chairperson	Tetsuo Kishimoto	UEC	
13:50	Can a rock be a wave? From 100 years of de-Broglie's wave-particle duality to quantum-gravity	Ron Folman	Ben-Gurion U	SE-06-01
14:35	Precise magnetometer with a Bose-Einstein condensate	Kosuke Shibata	Gakushuin U	SE-06-02
15:20-15:40	Break			
15:40-17:10	SE-07. Atom/Ion Clocks			
	Chairperson	Rekishu Yamazaki	ICU	
15:40	Trapped-ion optical atomic clocks: from fundamental physics to quantum sensing	David Leibrandt	UCLA	
16:25	Laser spectroscopy of triply charged Th-229 toward a nuclear clock	Atsushi Yamaguchi	RIKEN	SE-07-02

Quantum Cryptography & Communication Track

All the times in the program are **Japan Standard Time**(GMT+9)

16 Nov (Thu.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
9:00-10:30	CC-01. Quantum Key Distribution Network			
	Chairperson	Akihisa Tomita	Hokkaido U	
9:00	Research and demonstration activities of Toshiba on QKD	Keisuke Mera	Toshiba	CC-01-01
9:30	Quantum key distribution research and development in NEC	Kenichiro Yoshino	NEC	CC-01-02
10:00	Research on quantum-secured networking: QKD for networks and networks for QKD	Chankyun Lee	KISTI	CC-01-03
10:30-10:50	Coffee Break			
10:50-12:20	CC-02. Satellite Quantum Communication			
	Chairperson	Go Kato	NICT	
10:50	EuroQCI: A quantum communication infrastructure for Europe's digital decade	Peter Fatelnig	Delegation of the European Union to Japan	CC-02-01
11:20	Classic space optical communication technology will realize satellite QKD	Tomohiro Araki	JAXA	CC-02-02
11:50	Space laser communication and our technologies	Kyohei Iwamoto	SONY	CC-02-03
12:20-13:50	Lunch			
13:50-15:20	CC-03. Panel Session: Standardization and Social Deployment			
	Chairperson	Masahide Sasaki	NICT	
		Katsuyuki Hanai	Q-STAR	
		Oleg Nikiforov	DT	
		Gregoire Ribordy	IDQ	
		Akihiro Mizutani	U Toyama	
		Eleni Diamanti	CNRS	

17 Nov (Fri.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
9:00-10:30	CC-04. Quantum Cryptography: Present and Prospects			
	Chairperson	Takuya Hirano	Gakushuin U	
9:00	Quantum delegation with an off-the-shelf device	Anne Broadbent	uOttawa	CC-04-01
9:30	Numerical method for security analysis of quantum key distribution based on complementarity	Toshihiko Sasaki	UTokyo	CC-04-02
10:00	Quantum key distribution network and quantum internet toward next generation communication infrastructure	Mikio Fujiwara	NICT	CC-04-03
10:30-10:50	Coffee Break			
10:50-12:20	CC-05. Quantum Internet Part 1			
	Chairperson	Masahiro Takeoka	Keio U	
10:50	Building the quantum internet	Saikat Guha	U Arizona	CC-05-01
11:20	Generation and manipulation of telecom photons towards quantum internet	Yoshiaki Tsujimoto	NICT	CC-05-02
11:50	Prospects for quantum network using trapped-ion quantum nodes	Alto Osada	Osaka U / UTokyo	CC-05-03
12:20-13:50	Lunch			
13:50-15:20	CC-06. Quantum Internet Part 2			
	Chairperson	Nicolo Lo Piparo	OIST	
13:50	Privacy for the paranoid ones - the ultimate limits of secrecy	Artur Ekert	U Oxford	CC-06-01
14:20	Inter-node quantum operations and assessment of devices for such operations	Akihito Soeda	NII	CC-06-02
14:50	Characterization and optimization of quantumrepeater networks	David Elkouss	OIST	CC-06-03

Poster Session
PO-CP : Posters on Quantum Computing

All the times in the program are **Japan Standard Time**(GMT+9)

16 Nov (Thu.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
15:40-17:30	Characterising the hierarchy of multi-time quantum processes with classical memory	Philip Taranto	UTokyo	**PO-CP-01**
	Universal, deterministic, and exact protocol to reverse qubit-unitary and qubit-encoding isometry operations	Satoshi Yoshida	UTokyo	**PO-CP-02**
	Entanglement-efficient bipartite-distributed quantum computing with entanglement-assisted packing processes	Timothy Forrer	UTokyo	**PO-CP-03**
	Quantum algorithms for transforming Hamiltonian dynamics: simulating wide-ranging Hamiltonian dynamics	Tatsuki Odake	UTokyo	**PO-CP-04**
	Efficient decoding of stabilizer code by single-qubit local operations and classical communication	Koki Shiraishi	UTokyo	**PO-CP-05**
	Quantum error correction with dissipatively stabilized squeezed-cat qubits	Fernando Quijandria	OIST	**PO-CP-06**
	Revealing nonlocality in boson sampling	Jun-Yi Wu	Tamkang U	**PO-CP-07**
	Resonant image charge detection for e-@He qubit	Mikhail Belianchikov	OIST	**PO-CP-08**
	Spin-dependent harmonic traps for electrons on liquid helium	Mohamed Hatifi	OIST	**PO-CP-09**
	Increasing quantum volume through distributed quantum computing	Shao-Hua Hu	Tamkang U	**PO-CP-10**
	Quantum ridgelet transform: winning lottery ticket of neural networks with quantum computation	Hayata Yamasaki	UTokyo	**PO-CP-11**
	Towards quasioptical microwave field enhancement for electrons on liquid helium	Natalia Morais	OIST	**PO-CP-12**
	Space-bounded quantum state testing via space-efficient quantum singular value transformation	Yupan Liu	Nagoya U	**PO-CP-13**
	Quantum multiplexing applied to the quantum Reed-Solomon code	Nicolo Lo Piparo	OIST	**PO-CP-14**
	Time-domain three-mode universal linear optical operations with a dual-loop-based circuit	Takato Yoshida	UTokyo	**PO-CP-15**
	Demonstration of continuous-variable quantum approximate optimization for quadratic functions with a photonic quantum processor	Keitaro Anai	UTokyo	**PO-CP-16**
	A hybrid algorithm using annealing machines for large problems with many constraints	Masashi Yamashita	Keio U	**PO-CP-17**
	Fluorescence spectra of a driven nonlinear oscillator with weak Kerr nonlinearity	Aree Taguchi	U Tsukuba	**PO-CP-18**
	Optimal mapping to nearest-neighbor architectures by appling simulated annealing-based Gaussian elimination iterator	Zanhe Qi	Ritsumeikan U	**PO-CP-19**
	Leveraging different Boolean function decompositions to optimize LUT-based quantum circuit synthesis	David Clarino	Ritsumeikan U	**PO-CP-20**
	Classical circuit simulation s of superconducting quantum computer using conventional SPICE	Tetsufumi Tanamoto	Teikyo U	**PO-CP-21**
	QuEL-1: a scalable quantum control system for superconducting qubits	Ryutaro Ohira	QuEL	**PO-CP-22**
	Circuit division based on reinforcement learning to optimize Steiner-Gauss elimination for NNA-compliant quantum circuit synthesis	Huan Yu	Ritsumeikan U	**PO-CP-23**
	Control over a shared phonon between trapped ions in a two-dimensional array for quantum simulation	Nathan Lysne	NIST	**PO-CP-24**
	High generation rates of Fock states for ultra-fast optical quantum computers	Kazuma Takahashi	UTokyo	**PO-CP-25**
	Graphical approach for characterization of non-Gaussian quantum process	Hironari Nagayoshi	UTokyo	**PO-CP-26**
	Quantum Metropolis-Hastings algorithm with the target distribution calculated by quantum Monte Carlo integration	Koichi Miyamoto	Osaka U	**PO-CP-27**
	Interface enabling classical and quantum hybrid algorithms to simulate various realistic chemical systems	Tomoya Shiota	Osaka U	**PO-CP-28**
	Energy-consumption advantage of quantum computation	Florian Meier	VCQ	**PO-CP-29**
	Variational quantum algorithm for partial singular value decomposition	Shohei Miyakoshi	Osaka U	**PO-CP-30**
	Efficient concatenated bosonic code for additive Gaussian noise	Kosuke Fukui	UTokyo	**PO-CP-31**
	The second law of information thermodynamics in feedback control with a general quantum measurement process	Shintaro Minagawa	Nagoya U	**PO-CP-32**
	Distributed search on graphs using discrete time quantum walk	Mathieu Roget	Aix-Marseille U	**PO-CP-33**
	Correlated oscillations in Kerr parametric oscillators with tunable effective coupling	Tomohiro Yamaji	NEC	**PO-CP-34**
	A novel method for power spectrum evaluation	Katsuta Sakai	TMDU	**PO-CP-35**
	Achieving scalable quantum error correction with union-find on systolic srrays by using multi-context processing elements	Jan Wichmann	RIKEN	**PO-CP-36**
	Progressing towards the transmission of spin qubit in mid-range for quantum computing application	Rajkumar Chinnasamy	Osaka U	**PO-CP-37**

16 Nov (Thu.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
15:40-17:30	Four-body interaction of Josephson parametric oscillators for quantum computation	Ryoji Miyazaki	NEC	**PO-CP-38**
	Z_2 point-gap topology of a non-unitary quantum walk with time-reversal symmetry	Zhiyu Jiang	Hokkaido U	**PO-CP-39**
	Feasibility of superconducting quantum computation using two-qubit gates with static ZZ interaction	Kazuhisa Ogawa	Osaka U	**PO-CP-40**
	Experimental realization of displacement detection beyond classical limit using single-photon states	Fumiya Hanamura	UTokyo	**PO-CP-41**
	Enhancing quantum computations with the synergy of auxiliary field quantum Monte-Carlo and computational basis tomography	Viktor Khinevich	Osaka U	**PO-CP-42**
	Incorporating missing electron correlations into quantum chemical calculations with quantum computers utilizing classical coupled cluster theory	Luca Erhart	Osaka U	**PO-CP-43**
	The rubidium cold-atom quantum computer, a Moonshot Project	Sylvain de Lesleuc	IMS	**PO-CP-44**
	The Moonshot R&D Program of cold-atom quantum computer	Akane Makino	IMS	**PO-CP-45**
	Characterization of chirped Bragg grating for cold-atom quantum computing applications	Arnab Maity	IMS	**PO-CP-46**
	Towards large-scale quantum processors in silicon	Leon Camenzind	RIKEN	**PO-CP-47**
	Low-rank approximations and selection of results in quantum circuit simulation in tensor networks	Akihiro Yatabe	RIKEN	**PO-CP-48**
	Towards coherent excitation to Rydberg states using home-made lasers	Karthikeyan Ganesan	IMS	**PO-CP-49**
	Development of an ion-shuttling system for the QCCD architecture	Tatsuya Oshio	Osaka U	**PO-CP-50**
	Proposal of multidimensional quantum walks to explore Dirac and Schroedinger systems	Manami Yamagishi	UTokyo / RIKEN	**PO-CP-51**

Poster Session
PO-SE : Posters on Quantum Sensing

All the times in the program are **Japan Standard Time**(GMT+9)

16 Nov (Thu.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
15:40-17:30	Probing exciton dynamics with spectral selectivity through the use of entangled photons: application to the study of photosynthetic light-harvesting systems	Yuta Fujihashi	UEC	**PO-SE-01**
	Measurement of reflection phase difference between s-polarization and p-polarization	Hinata Takidera	UTokyo	**PO-SE-02**
	Nitrogen-vacancy centres in silicon-doped detonation nanodiamonds	Frederick Tze Kit So	Kyoto U	**PO-SE-03**
	Creation of NV centers in diamond over a wide region by single-shot femtosecond laser pulse	Masanori Fujiwara	Kyoto U	**PO-SE-04**
	Group IV color centers in detonation nanodiamonds for temperature sensing	Nene Hariki	Kyoto U	**PO-SE-05**
	Investigation on sensitivity parameter of diamond quantum sensors controlled by continuously excited Ramsey protocol	Zehan Li	Tokyo Tech	**PO-SE-06**
	Quantum state tomography with NV-NV pair for quantum sensing application	Kosuke Kimura	Gunma U	**PO-SE-07**
	Study of NVC probe fabricated by focused ion beam	Teruo Kohashi	Hitachi	**PO-SE-08**
	Biphoton spectral measurement with delay-line-anode single-photon detectors	Ozora Iso	UEC	**PO-SE-09**
	Magnetoencephalography with wearable magnetometers and active noise canceler for real-time tracking and denoising	Xinyu Cao	UTokyo	**PO-SE-10**
	Loss reduction of SiN waveguide in green light for diamond NV excitation	Yoki Nishi	Tokyo Tech	**PO-SE-11**
	Development of a wearable active magnetic shield for magnetoencepha-lography under head motion	Soichiro Shido	UTokyo	**PO-SE-12**
	Evaluation of a superconducting nanowire single photon detector for mid-infrared	Satoru Mima	NICT	**PO-SE-13**
	CW-ODMR-based frequency-tunable magnetometry utilizing RF double-dressed states with nitrogen-vacancy centers in diamond	Ryusei Okaniwa	Keio U	**PO-SE-14**
	Widefield imaging of the magnetization process in soft magnetic-thin film using diamond quantum sensors	Ryota Kitagawa	Tokyo Tech	**PO-SE-15**
	Spectral modulation by temporal manipulation of a biphoton wave packet	Yuki Okura	UEC	**PO-SE-16**
	Toward improvement of waveguide-based squeezing at 795nm	Shiori Koiso	Gakushuin U	**PO-SE-17**
	Imaging AC magnetization response of soft magnetic thin film using diamond quantum sensors	Aoi Nakatsuka	Tokyo Tech	**PO-SE-18**
	Development of a hybrid atomic gravimeter for field gravity measurements	Kaito Takamura	UEC	**PO-SE-19**
	Reconstruction of cardiac current source by magnetocardiography with cylindrical sensor array	Wenyu Shang	UTokyo	**PO-SE-20**
	Increasing T2* of ensemble NV centers by reduction of stress distribution in CVD diamond film	Takeyuki Tsuji	Tokyo Tech	**PO-SE-21**
	Continuously excited - Ramsey simulation for high sensitive magnetometry	Yuta Araki	Tokyo Tech	**PO-SE-22**
	Measurement of somatosensory evoked potentials against whisker stimulation for high-resolution magnetoencephalography of small animals	Motofumi Fushimi	UTokyo	**PO-SE-23**
	Control of impurity incorporation into CVD diamond toward long coherence time of the NV center by optimizing pressure	Riku Kawase	Kyoto U	**PO-SE-24**
	Coupling nitrogen vacancy centres for sensitivity improvement	David Herbschleb	Kyoto U	**PO-SE-25**
	Robust quantum sensing via the standard deviation	David Herbschleb	Kyoto U	**PO-SE-26**
	Stress imaging of ensemble NV diamond layer	Yukako Kato	AIST	**PO-SE-27**
	Dipole-dipole interaction between NV- center and various nitrogen related defects	Chikara Shinei	NIMS	**PO-SE-28**
	Creation of NV- center in type-Ib diamonds by high temperature post-annealing for quantum sensing	Shuya Ishii	QST	**PO-SE-29**
	Electron-spin double resonance in diamond under a strong RF field	Takumi Mikawa	Keio U	**PO-SE-30**
	Simultaneous magnetic field and temperature measurements by simultaneously-resonated optically detected magnetic resonance using silicon vacancy quantum sensor: reduction of measurement time by time dividing method	Tomoaki Tanaka	QST	**PO-SE-31**
	Development of sensitive diamond quantum sensor for detecting the brain magnetic field of a living rat	Atsumi Yoshimura	Tokyo Tech	**PO-SE-32**
	Analysis of electron spin double resonance spectra in diamond using Lindblad master equation	Rui Suzuki	Keio U	**PO-SE-33**
	Charge state manipulation of nitrogen vacancy centers by using diamond MOS structure	Moriyoshi Haruyama	AIST	**PO-SE-34**
	Development of diamond NV magnetometry with optical fiber array	Akihiro Kuwahata	Tohoku U	**PO-SE-35**
	Experimental criteria for the classification of multi-photon correlations	Geobae Park	Kyoto U	**PO-SE-36**
	Ultrasensitive solid-state nuclear gyroscope based on diamond	Anshuman Nayak	OIST	**PO-SE-37**
	A diamond chiral waveguide structure for nanoscale magnetometry	Kosuke Takada	TUT	**PO-SE-38**

16 Nov (Thu.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
15:40-17:30	Massive quantum superpositions using superconducting magneto-mechanics	Shilu Tian	OIST	**PO-SE-39**
	Feedback cooling of magnetically-levitated cm-size resonators	Shilu Tian	OIST	**PO-SE-40**
	Quantum infrared spectroscopy with ATR method	Torataro Kurita	Kyoto U	**PO-SE-41**
	Tyrosine 319 may play a key role in the radical pair mechanism through bifurcation in the light initiated redox reaction	Hiroaki Otsuka	Waseda U	**PO-SE-42**
	Functional analyses of chicken cryptochrome 4, a candidate molecule of magnetoreception	Naoki Kimata	Waseda U	**PO-SE-43**
	Holographic brain theory: super-radiance, memory capacity and control theory	Akihiro Nishiyama	Kobe U	**PO-SE-44**
	First-principles calculations of DNA irradiated with a proton and a carbon ion beam	Takuya Sekikawa	JAEA	**PO-SE-45**
	Electronic states of a fluorinated DNA base, nucleoside and nucleotide revealed by synchrotron X-ray photoemission spectroscopy	Sota Onuma	Ibaraki U	**PO-SE-46**
	Charge state control of tin-vacancy centers in diamond using surface termination	Keita Takeda	Tokyo Tech	**PO-SE-47**
	Exploring charge-state dynamics of tin-vacancy in diamond by time-resolved measurements	Keita Ikeda	Tokyo Tech	**PO-SE-48**
	Long spin relaxation time of a lead-vacancy center in diamond	Kazuki Oba	Tokyo Tech	**PO-SE-49**
	Theoretical and experimental approach to investigate change of heat-flux in a cell exposed to radiation stress	Keiko Hanazawa	Ibaraki U	**PO-SE-50**
	Why do enzyme assemblies activate enzymatic reactions?	Tomoto Ura	QST	**PO-SE-51**
	A diamond quantum sensor for electrical metrology	Hidekazu Muramatsu	Tokyo Tech	**PO-SE-52**
	Effects of optical excitation on the Ramsey magnetometry of ensemble NV centers in diamond	Yusei Aoki	Tokyo Tech	**PO-SE-53**
	Highly sensitive compact quantum sensor with NV center in angle-shaped diamond	Yuta Kainuma	Tokyo Tech	**PO-SE-54**
	Current monitoring for electric vehicle batteries using heteroepitaxial CVD diamond quantum sensors	Kenichi Kajiyama	Tokyo Tech	**PO-SE-55**
	Tuneable Gaussian entanglement in levitated nanoparticle arrays	Anil Kumar	OIST	**PO-SE-56**
	Rotational cavity magnomechanics	Kani Mohamed	OIST	**PO-SE-57**

Poster Session
PO-CC : Posters on Quantum Cryptography & Communication

All the times in the program are **Japan Standard Time**(GMT+9)

16 Nov (Thu.)	Session / Presentation	Chairperson / Presenter	Affiliation	Abstract PDF
15:40-17:30	Performance comparison of the two reconstruction methods for stabilizer-based quantum secret sharing	Shogo Chiwaki	Tokyo Tech	**PO-CC-01**
	Polarization-entangled photon pair generation with a pulse excited tandem type-II QPM PPLN waveguide	Daiki Hara	Osaka U	**PO-CC-02**
	Effects of spontaneous emission and the pump pulse waveform in photonic interconnect of distant ion-cavity systems	Kazufumi Tanji	Keio U	**PO-CC-03**
	A scheme of reducing the effects of the two-photon temporal distinguish-ability on measurement-device-independent quantum key distribution	Haobo Ge	Hokkaido U	**PO-CC-04**
	Loss tolerant distribution of GHZ-state in a star optical network	Hikaru Shimizu	Keio U	**PO-CC-05**
	Polarization-entangled biphoton frequency comb for DWDM technology	Toshiki Kobayashi	Osaka U	**PO-CC-06**
	Improved efficiency of photon echo generation from quantum dots using chirped pulses	Yutaro Kinoshita	Keio U	**PO-CC-07**
	Error and disturbance as irreversibility	Haruki Emori	Hokkaido U	**PO-CC-08**
	Evaluation of multiplexed quantum key distribution system using network simulator	Masashi Ito	Toshiba	**PO-CC-09**
	Interoperable key relay and management between heterogeneous QKD networks	Mayuko Koezuka	Toshiba	**PO-CC-10**
	Macroscopic state and entropy	Teruaki Nagasawa	Nagoya U	**PO-CC-11**
	Observation of frequency-multiplexed Hong-Ou-Mandel interference	Mayuka Ichihara	YNU	**PO-CC-12**
	Performance of rotation-symmetric bosonic codes in a quantum repeater	Peizhe Li	SOKENDAI	**PO-CC-13**
	Entanglement distribution between quantum memories based on single-photon interference requiring mild stability	Daisuke Yoshida	YNU	**PO-CC-14**
	Noise is resource contextual in quantum communication	Ananda Maity	OIST	**PO-CC-15**
	Framework for comparing classical and quantum computers with unified rules online applications	Takahiko Satoh	Keio U	**PO-CC-16**
	Quantum algorithms for routing on quantum repeater networks	Hyensoo Choi	Keio U	**PO-CC-17**
	Study on cavity-enhanced spontaneous parametric down conversion sources for long-distance quantum communication	Tomoki Tsuno	YNU	**PO-CC-18**
	Design of hardware monitor for quantum repeater software architecture	Amin Taherkhani	Keio U	**PO-CC-19**
	Quantum resource theory of Bell nonlocality in Hilbert space	Wojciech Roga	Keio U	**PO-CC-20**
	Private quantum signal processing	Yuto Nishikubo	Mie U	**PO-CC-21**
	Long distance continuous-variable quantum key distribution with discrete-modulated coherent state and two-mode squeezed vacuum	Makoto Ishihara	Keio U	**PO-CC-22**
	Coherent microwave-to-optical quantum transduction using diamond optomechanical crystals with a color center	Byunggi Kim	UTokyo	**PO-CC-23**
	RuleSet-based recursive quantum internetworking	Kentaro Teramoto	Mercari	**PO-CC-24**

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Quantum Sensing Track

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Quantum Cryptography & Communication Track

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PL-02-01

Strategy of quantum future industry development

Daisuke KAWAKAMI

Cabinet Office

Biography

Dr. Daisuke KAWAKAMI graduated from Kyoto University and completed master's program in chemistry, Graduate School of Science, Kyoto University in 1993. He joined Toray Industries, Inc., and was assigned to Fibers & Textiles Research Laboratory in 1993. He received Ph.D. in engineering from Graduate School of Organic Engineering, Faculty of Engineering, Tokyo Institute of Technology in 2008. He has been the vice president of Toray Industries (America), Inc. since 2016. After serving as Director for Life Innovation Business Strategy Planning Department from 2016 to 2023, he was appointed as Deputy Director General for Science, Technology and Innovation Policy, Cabinet Office, in 2023.

Abstract

In April 2022, Japanese Government compiled "Vision of Quantum Future Society," which has established the vision and goals to be achieved by quantum technology. The goals by 2030 are "10 million quantum technology users," "Through quantum technology, production to 50 trillion Yen," and "Fostering quantum unicorn companies to create future markets." The new "Strategy of Quantum Future Industry Development," established this past April, summarizes the priority actions to realize the goals by making quantum technology practically-applied and industrialized. This presentation overviews an overall policy of Japan on quantum technology research and development.

PL-02-02

The U.S. National Quantum Initiative

Tanner Crowder

Office of Science and Technology Policy

Abstract

The United States launched the National Quantum Initiative in 2018 to accelerate quantum information science research and development across the nation. The National Quantum Initiative prioritizes getting the science right, enhancing competitiveness, and enabling people. This talk will discuss some of the developments in the National Quantum Initiative; for more information about the initiative, see www.quantum.gov.

PL-02-03

Quantum technology in the European Union

Peter Fatelnig

Delegation of the European Union to Japan

Biography

Peter Fatelnig is the Minister-Counsellor for Digital Economy Policy at the Delegation of the European Union to Japan, in Tokyo. Digital economy policy is a top-priority in EU-Japan relations. His work is instrumental in implementing the Digital Partnership Agreement and drives the conversation on key European policies such as the Digital Services Act, on AI or Quantum, on data flows and cyber. He is committed to a positive European vision for a society and an economy increasingly benefiting from digital technologies.
Prior to his current role, from 2018 to 2023, Peter managed the digital economy portfolio at the Delegation of the European Union to the United States, including the Trade & Technology Council. Before joining the European External Action Service, Peter was a senior manager at the European Commission where he started in 1998.
Peter began his international career by working on assignments for the strategy-consulting firm American Management Systems, and for the European Space Agency, in the Netherlands. Peter holds a Master degree in Communication Engineering from the University of Technology in Graz, Austria, and is a senior member of the IEEE and alumni of the '93 class of the International Space University. He is married and has raised two daughters.

Abstract

In this presentation about Quantum Technology in the European Union, I explore the growing potential of quantum technologies and the EU's

vision to remain a global leader. The presentation discusses different application areas, such as enhancing MRI capabilities for early cancer detection or conducting virtual drug trials. It delves into quantum communication initiatives, aiming for unbreakable codes, and highlights gravimeter applications to probe underground resources. Building on the transformative power of quantum technologies, we can envision real-time simulations in finance, engineering, and climate change. Furthermore, the conversation shows the potential of quantum technologies in space exploration and defence applications. The EU's early commitment to pioneering advancements in Quantum Technology underscores its ambition to be at the forefront of the global quantum revolution.

PL-03-01

Challenges in superconducting quantum computing

Yasunobu Nakamura

RIKEN Center for Quantum Computing

Biography

Yasu Nakamura started his research career at NEC Fundamental Research Laboratories in 1992, where he demonstrated the first coherent manipulation of a superconducting qubit in 1999 and met quantum information science. He also spent a year as a Visiting Researcher at TU Delft from 2001 to 2002. Since 2012, he has been a Professor at The University of Tokyo. He has also been leading his research team at RIKEN since 2014. He is currently the Director of the RIKEN Center for Quantum Computing and the Project Leader of the MEXT Q-LEAP Flagship project on Superconducting Quantum Computing.

Abstract

Research and development of superconducting quantum computing have made significant progress since the first demonstration of a superconducting qubit in 1999. Thanks to the nearly six orders of magnitude improvement of the coherence time and more sophisticated circuit designs and operations, the fidelities of gate control and readout are now approaching and surpassing the threshold for fault-tolerant quantum computation. Many groups worldwide are competing intensively toward larger-scale superconducting quantum computing with better coherence and fidelity that allow for quantum error correction and fault tolerance. At the RIKEN Center for Quantum Computing, we pursue a scalable architecture using all-microwave control and readout on a two-dimensional array of frequency-fixed

transmon qubits. Our scheme uses a substrate pierced with a dense array of through-silicon vias and vertical access of coaxial cables from the backside of the substrate. We present the current status of our research and discuss the challenges ahead.

PL-03-02

Advancing the quantum economy through sensors and standards

Barbara Lynne Goldstein

National Institute of Standards and Technology

Biography

Ms. Barbara Goldstein serves as Associate Director of the Physical Measurement Laboratory of NIST. PML, consisting of about 1300 staff and associates and two joint institutes, realizes and disseminates precision measurements to support commerce, defense and research.

Ms. Goldstein leads the “NIST on a Chip” program which is developing a suite of quantum sensors to deliver traceable, embeddable measurements directly to point-of-use. She is also a leader in international quantum standardization. She convenes/leads multiple efforts, including a working group of the IEC Standards Evaluation Group on quantum technologies (SEG 14), the international IMEKO TC25 on quantum measurement and quantum information, and a new effort she initiated to foster collaboration across metrology institutes to advance the quantum economy. She served as an Embassy Science Fellow in 2021, hosted by the U.S. Embassies in the Netherlands, Denmark and Finland, where she helped foster a “trusted partners” network for quantum collaboration.

Abstract

The strength and pace of growth of the global quantum economy will depend on the strength of its foundation, not just in terms of technology maturity but the infrastructure needed to measure, characterize and interconnect both systems and components. Are there physical

standards and measurement practices available to fact-check products under development or deployed in the field? Do we have a common language to bridge the gap between research and commerce? This talk will discuss how the measurement and standards infrastructure is being developed to accelerate the development and adoption of quantum technologies.

PL-04-01

Introduction of the Australian Quantum Association (AQA)

George Robinson

AQA

Biography

Chiel Financial Officer, Quantum Brilliance

Abstract

PL-04-02

The Quantum Economic Development Consortium (QED-C): Growing the quantum industry

Celia Merzbacher

QED-C

Biography

Dr. Celia Merzbacher is the Executive Director of the Quantum Economic Development Consortium (QED-C), a global consortium of nearly 250 stakeholders from industry, academia and government that aims to grow the quantum industry and associated supply chain. Dr. Merzbacher has two decades of experience leading technology initiatives and partnerships. Previously, she was Vice President for Innovative Partnerships at the Semiconductor Research Corporation, a consortium of the semiconductor industry. In 2003-2008, she was Assistant Director for Technology R&D in the White House Office of Science and Technology Policy where she led the multi-agency National Nanotechnology Initiative. She also served as Executive Director of the President's Council of Advisors on Science and Technology (PCAST). Dr. Merzbacher is a Fellow of the AAAS and serves on the Innovation Policy Forum of the National Academy of Sciences, Engineering and Medicine (NASEM). She advises the Krach Institute for Tech Diplomacy at Purdue University, as well as advisory boards of several university centers and institutes. She is past chair of the NASEM National Materials and Manufacturing Board and was on the Board of Directors of the American National Standards Institute. Dr. Merzbacher began her career as a research scientist at the U.S. Naval Research Laboratory, where her research in optical materials led to numerous scientific publications and six patents.

Abstract

The Quantum Economic Development Consortium (QED-C) is an industry-driven consortium of stakeholders, managed by SRI International, that aims to enable and grow the quantum industry and supply chain. The consortium was called for in the U.S. National Quantum Initiative Act of 2018 and is supported by the National Institute of Standards and Technology (NIST) and approximately 250 corporate, academic and other members. Today, QED-C is open to members from select countries around the world and is building a trusted community of innovators from like-minded countries. Through the work of member volunteers, QED-C seeks to identify and address gaps in enabling technologies, standards and benchmarks, workforce and policies to accelerate the development of quantum technologies for economic and societal benefit. With its global membership and in partnership with other quantum industry associations, QED-C is helping quantum companies to expand their business and collaborations across borders and to strengthen the quantum ecosystem in accordance with international norms.

PL-04-03

UK Quantum, the UK's quantum industry trade body

Tim Prior

UKQuantum

Biography

UKQuantum Steering Committee,
Quantum Programme Manager at the National Physical Laboratory

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Abstract

- UK Quantum, the UK's quantum industry trade body
- The UK quantum strategy, how it has developed and where it is going
- The UK National Physical laboratory activities to support the UK's quantum ecosystem.

PL-04-04

Introduction of Q-STAR -Create industries & businesses with quantum technology-

Taro Shimada

Quantum STrategic industry Alliance for Revolution

Biography

Taro Shimada began his career in 1990, working on aircraft design at ShinMaywa Industries Ltd.
In 1999 he joined Structural Dynamics Research Corporation, a part of Siemens, which led to a series of progressively senior posts in Japan and at Siemens HQ in Germany.
After serving as Managing Executive Officer of Siemens K.K, he joined Toshiba in October 2018 as Corporate Digital Business Chief Strategy Officer, and in April 2019 became Chief Digital Officer, responsible for Toshiba's digital transformation and for strategic business creation and promotion. He was appointed CEO & Representative Director of Toshiba Data Corporation in February 2020, and President and CEO of Toshiba Digital Solutions Corporation in April 2020. In March 2022, Mr. Shimada was appointed to take the reins at Toshiba, as President & CEO.

Mr. Shimada's diverse experience in hardware development includes commercial aircraft; process consultation for industry; and product life cycle management. An expert in factory automation and digitization, he has advised many of Japan's leading manufacturers. He is also an advisor to the Robot Revolution & Industrial IoT Initiative and the IoT Acceleration Lab, and has contributed to Industrie 4.0 in Germany and Connected Industries in Japan.

Mr. Shimada has been a guest professor at Otemon Gakuin University in Osaka, Japan, since April 2020.
In September 2021, he was appointed Chair of the Executive committee for the establishment of Q-STAR (Quantum STrategic industry Alliance for

Revolution), a consortium to promote business creation through quantum technology, and was appointed Chair of the board in May 2022.

Mr. Shimada relaxes by playing the drums, and enjoys all genres of music.

Abstract

The presentation will look at current trends in the practical application of quantum technology, including in logistics, manufacturing, finance, and medicine. It will also emphasize the accelerating industrialization of the Ising model, which many of Q-STAR's member companies are developing. To date, Q-STAR has discussed over 50 quantum-technology use cases and selected 16 of them to be followed up on as the next step and made their industry roadmap.

In addition, Q-STAR member companies, representatives of academia, and national institutes outside the council, are discussing an open software platform that is not dependent on the type of quantum computer. The plan here is to visualize a hierarchy extending from customer issues to the various calculation methods, and to build a hypothesis for practical use as a platform.

Beyond this, the presentation will also look at the current status of international cooperation in establishing a global quantum market.

PL-04-05

Supporting collaboration between academia and industry for quantum innovation

Akihisa Tomita

Quantum ICT Forum/Hokkaido University

Biography

Akihisa Tomita earned his Bachelor's and Master's degrees in Physics, and his Ph.D. in Electronics from the University of Tokyo in 1982, 1984, and 1998, respectively. From 1984 to 2000, he conducted research on photonics, and from 1998 to 2010, he was involved in the development of quantum information technology at NEC Corporation. From 2000 to 2010, he led the group for quantum information experiments in the Quantum Computation and Information Project, ERATO and SORST, JST. In 2010, he became a professor at the Faculty of Information Science and Technology at Hokkaido University. He co-founded the Quantum ICT Forum and has been serving as Representative Director since 2019. His current research focuses on photonics for quantum information processing and quantum communication.

Abstract

The Quantum ICT Forum aims to develop sustainable quantum technologies that will advance both industry and society. Combining academic research with practical industry experience will accelerate progress toward globally competitive quantum technologies. The collaboration seeks to achieve this goal by fostering a partnership between academia and industry.

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Quantum Sensing Track

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Quantum Cryptography & Communication Track

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CP-01-01

Nanofiber cavity quantum electrodynamics systems for distributed quantum computing

Takao Aoki

Waseda University

Abstract

Distributed quantum computing, where many quantum processing units containing small to moderate number of qubits are connected to form a large-scale quantum network, is a promising approach to realize a quantum system with a large number of qubits required for fault-tolerant universal quantum computing.
Cavity quantum electrodynamics (QED) systems, where atoms and photons are confined and interacts within optical cavities, can be utilized to construct a distributed quantum computer, if one could place many atoms in a cavity while maintaining strong coupling between individual atoms and the cavity, individually address the atoms, operate quantum gates on selected atoms, and connect multiple cavity QED systems with low losses. These tasks have been difficult to achieve with conventional cavity QED systems based on free-space cavities. To overcome these difficulties with the conventional systems, we have been developing novel cavity QED systems based on optical nanofibers and neutral atoms.
In this talk, I will present our experimental research on nanofiber cavity QED systems and prospects toward distributed quantum computing based on these systems.

CP-01-02

Photonic quantum machine learning

Philip Walther

University of Vienna

Abstract

After a brief overview of quantum photonic technology, I will present the recent demonstration of a deterministic time-reversal protocol for qubit evolutions by exploiting so-called quantum-switches that superimpose the order of quantum operations. Then I will show experimental results of reinforcement learning using a tunable photonic nanoprocessor, where the learning of the machine is enhanced with respect to classical architectures. In addition, I will discuss our development of a so-called quantum memristor for single photons. Such devices, which are capable of mimicking the behavior of neurons and synapses, are promising for quantum neural networks.

CP-01-03

Quantum science with tweezer arrays

Manuel Endres

Caltech

Abstract

I will give an update on experiments in our group on quantum computing/simulation with Rydberg arrays based on two valence electron atoms. The rich level structure of such atoms enables novel cooling, control, and read-out schemes. First, I will show our latest results on creating Bell states with ~0.9985 fidelity and associated error budget. Second, I will give an overview on benchmarking a 60-atom quantum simulation in terms of the fidelity for reaching maximum entanglement entropy states. I will also show new results for quantifying the amount of mixed state entanglement in this system. If time permits, I will show results on novel cooling, control and entanglement of motional states in tweezers.

CP-02-01

Electron and hole spin qubits in silicon

Leon C. Camenzind

QFSRG, CEMS RIKEN

Abstract

Silicon-based spin qubits offer promise for large-scale quantum processing, thanks to their compatibility with industrial nanofabrication, small size, fast processing, and long coherence times.

The Quantum Function System Research Group (QFSRG) at RIKEN achieved impressive results with electron spin qubits in isotopically purified silicon-28 quantum wells. We surpassed the fault-tolerant threshold of 99% fidelity for critical operations, implemented quantum error correction, and introduced a novel shuttling-based quantum link.

In a collaboration between the University of Basel and IBM Research, we demonstrated that fin field-effect transistors (finFET) in natural silicon can host hole spin qubits. These qubits operate above 4 Kelvin, a temperature at which there is an improved potential for scalability using integrated quantum circuit solutions. Furthermore, we demonstrated fast electrical control, high fidelity single-qubit gate operations, and achieved two-qubit gates with anisotropic exchange interaction.

The results of these two projects mark significant steps towards scalable electron and hole spin qubits in silicon. Recognizing the need for millions of qubits for fault-tolerant quantum computing, the semiconductor industry is increasingly investing in spin qubits. By leveraging existing semiconductor fabrication techniques for mass production, the scalability of spin-based quantum computing is becoming more feasible, capitalizing on the inherent advantages of spin qubits.

CP-02-02

Semiconductor integration technology for realization of silicon quantum computers

Noriyuki Lee

Hitachi, Ltd.

Abstract

The scalability and long coherence time of silicon quantum dot-based qubits make them promising candidates for large-scale quantum computing. We are developing two-dimensional Si spin-qubit arrays and operating circuits utilizing silicon integrated circuit technologies. In the “Initialization”, “Operation”, and “Readout” schemes required for quantum computing, the technology developed in consideration of large-scale integration and operability by taking advantage of the characteristics of silicon is demonstrated. We will discuss our efforts to realize large-scale quantum computers including hardware and software.

CP-02-03

Recent progress on graphene quantum dot devices

Takuya Iwasaki

National Institute for Materials Science

Abstract

Graphene is a promising host material to implement the solid-state spin qubits due to its extremely small spin-orbit and hyperfine interactions. Moreover, the valley degree of freedom in graphene offers the possibility to encode quantum information with novel principles. Although graphene does not have a band gap, graphene quantum dot devices can be realized with confinement potential defined by patterning graphene into a nanostructure or by applying a perpendicular electric field to bilayer graphene. Thanks to the development of transfer technology for two-dimensional materials, gate-defined bilayer graphene quantum dot devices have been recently established for investigating the spin and valley quantum states. Furthermore, van der Waals heterostructures also have the potential to modulate various physical properties of graphene through the proximity effect and moiré superlattice. In this talk, we will present the method to realize high-quality graphene devices, and single-electron transport properties in double quantum dot devices based on the bilayer graphene/hexagonal boron nitride moiré superlattice.

CP-03-03

Beyond-classical quantum computing with superconducting circuits

Yu Chen

Google Quantum AI

Abstract

Quantum computers have the potential to solve problems that are intractable for classical computers. However, achieving such beyond-classical performance has been an outstanding challenge, requiring the development of quantum algorithms and capable hardware systems. I will give an overview on the research in the Google Quantum AI team in this area. I will discuss the technical advancements in our quantum hardware, which enabled the recent beyond-classical random circuit sampling result and its underlying physical mechanisms. I will conclude the talk by discussing the challenges and promises associated with measuring physical local observable in the beyond-classical regime.

CP-03-04

Niobium-nitride-based superconducting qubit

Sunmi Kim

National Institute of Information and Communications Technology (NICT)

Abstract

We present an investigation focused on advancing superconducting qubits by using niobium-nitride (NbN)-based qubit. In conventional superconducting qubits utilizing aluminum-based Josephson junctions (JJs), the decoherence from microscopic two-level systems in amorphous aluminum oxide is concerned. As alternative materials for the JJs of the qubits, we introduce fully epitaxial nitride JJs consisting of NbN/AlN/NbN tri-layer. The all-nitride qubits offer several advantages, such as the potential for epitaxial tunnel barriers, resulting in reduced two-level fluctuators, and a larger superconducting gap of approximately 5.2 meV for NbN, compared to ~0.3 meV for aluminum, which suppresses the excitation of quasiparticles.

To investigate qubit properties, we have fabricated a capacitively-shunted flux qubit coupled to a half-wavelength coplanar waveguide resonator. By employing a Si substrate with TiN buffer layer instead of the conventional MgO substrate for the epitaxial growth of the NbN film, our nitride qubit has demonstrated a significant improvement in coherence times, such as T1 = 16.3 μs and T2 = 21.5 μs [1], which are more than an order of magnitude longer than those reported in the literature using MgO substrates [2]. These results represent a significant step towards constructing a new platform for superconducting quantum hardware.

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[2] Y. Nakamura et al., Appl. Phys. Lett. 99, 212502 (2011).

CP-04-02

Quantum CAE: automation in science with quantum computing and machine learning

Tadashi Kadowaki

AIST / DENSO

Abstract

Scientific discoveries progress through experimentation, data processing, and the formation of new hypotheses. Recently, advancements in computer capabilities and algorithmic enhancements have enabled the partial automation of this process, a trend particularly noticeable in Computer-Aided Engineering (CAE) within the industrial sector. In CAE, simulations are utilized to extract product characteristics (observable values) from blueprints (hypotheses), subsequently refining the blueprints based on these characteristics. From a machine learning perspective, this equates to input and output data. As more data becomes available, it becomes feasible to construct a surrogate model that represents this relationship. Solving the inverse problem of this model provides the desired blueprints (hypotheses). Optimization techniques play a crucial role in solving the inverse problem, indicating that product design with CAE is a cyclical process involving simulations, machine learning, and optimization. Studies have demonstrated that these computational tasks are well-aligned with the strengths of quantum computers, and it is anticipated that they will substantially reduce the lead time for producing product blueprints. Quantum CAE, defined as performing these tasks on a quantum computer, not only accelerates the process but also aids in automating science, reflecting the cycle of scientific discovery and promoting a more efficient and innovative approach.

CP-04-03

Quantum inspired computing: technology & strategy and applications

Taisuke Iwai

Strategic Alliance Unit, Fujitsu Limited

Abstract

Q-STAR (Quantum STrategic industry Alliance for Revolution) is general incorporated association to create quantum-related industries and businesses. Quantum computing is one of scope in Q-STAR. Quantum gate computing is definitely a candidate of future computing, but, from the industrial point of view, it will take more than several years to realize a mature quantum gate computer implemented into the society. Alternatively, quantum inspired computing is a mature computing and recently has been garnering attention.
In this talk, I will give a brief introduction of Q-STAR and quantum inspired computing which is used in the subcommittee on combinatorial optimization problem to create quantum-related use-cases. I will also give use-cases by utilizing quantum inspired computing. Following that I will discuss about future computing candidates next decade.

CP-05-01

Perspectives on the current state of quantum computing systems capability

Hanhee Paik

IBM Quantum

Abstract

I would like to share IBM's perspective on the current state of quantum computing capabilities and the future direction of quantum computing. As individual metrics, we can now observe two qubit gate fidelities are approaching 99.9% and quantum systems can process circuits at the speed of 15,000 CLOPS(1). With improved quantum computing performance metrics, IBM can provide nearly 20 quantum computing systems being on service 24/7 with more than 95% uptime. In this environment, we can start pursuing the utility of quantum computing to tackle non-trivial problems that can be challenging for classical computing. I will summarize the recent advancement of quantum computing utility with quantum circuits of ~ 100 qubits by depth ~ 50 with ~ 1000 gates and how IBM envisions quantum computing should evolve-to a quantum-centric supercomputing.

(1) A. Wack et al. https://arxiv.org/abs/2110.14108

CP-05-02

Beyond classical machine learning: new insights on quantum machine learning

Sofiene Jerbi

Freie Universität Berlin

Abstract

Quantum machine learning (QML) is a rapidly evolving field, driven by its prospects to bring quantum enhancements in many practical applications. Yet, several open questions are in the way of achieving this goal: Do there exist learning tasks, even artificially constructed, where QML can achieve a provable quantum advantage? If so, can we still retain this quantum advantage in quantumly trained but classically evaluated QML models? Among proposed models in the literature, are there preferred models we should use in QML? In this talk, I will present some of the recent insights we have gathered in an attempt to answer these questions.

CP-05-03

Generalized quantum subspace expansion for quantum error mitigation

Suguru Endo

NTT computer and data science laboratories

Abstract

One of the major challenges for erroneous quantum computers is undoubtedly the control over the effect of noise. Considering the rapid growth of available quantum resources that are not fully fault tolerant, it is crucial to develop practical hardware-friendly quantum error mitigation (QEM) techniques to suppress unwanted errors. Here, we propose a novel generalized quantum subspace expansion method which can handle stochastic, coherent, and algorithmic errors in quantum computers. By fully exploiting the substantially extended subspace, we can efficiently mitigate the noise present in the spectra of a given Hamiltonian, without relying on any information of noise. The performance of our method is discussed under two highly practical setups: the quantum subspaces are mainly spanned by powers of the noisy state and a set of error-boosted states, respectively. We also propose the resource-efficient implementation of generalized quantum subspace expansion by using the dual-state purification method, and show that it can even allow for the simulation of the twice the system size with the moderate sampling overhead.

CP-05-04

Quantum chemistry on NISQ devices beyond variational quantum algorithms

Keita Kanno

QunaSys

Abstract

Quantum chemistry has been one of the most promising applications of quantum computing, motivated by the natural correspondence between the quantum states on quantum computers and the electronic states in chemical systems. The quantum phase estimation algorithm enables one to exploit this correspondence to calculate ground- and excited-state energies of complex molecules accurately and efficiently, but its demanding gate complexity requires fault-tolerance for a successful execution. Variational quantum algorithms such as the variational quantum eigensolver (VQE) has been proposed to exploit noisy, non-fault-tolerant quantum computers by using them repeatedly in combination with classical computers, but they have problems such as the large number of quantum circuit executions for optimization and for suppressing the sampling error, in addition to its insufficient noise resilience. Developing a noise-resilient algorithm with a practical runtime is a fundamental challenge to take advantage of noisy quantum computers in quantum chemistry.

In this talk, as a potential solution to this challenge, I will introduce the Quantum-Selected Configuration Interaction (QSCI) algorithm. QSCI uses more of classical computing than a simple VQE, thereby resulting in a more accurate and reliable result. I will also touch on the subsequent studies and future directions that further develops QSCI.

CP-06-01

Low-cost quantum error correction using looped pipelines

Zhenyu Cai

University of Oxford

Abstract

Noise in quantum computers is the single biggest obstacle in their practical realisation, which needs to be tackled using quantum error correction (QEC). However, even the leading QEC code – surface codes – faces many practical challenges like large spatial overhead for storing quantum information and large space-time overhead for logical gates. In order to achieve large-scale fault-tolerant quantum computation, we explore a concept called 'looped pipelines' which permits one to obtain many of the advantages of a 3D lattice while operating a strictly 2D device. The concept leverages qubit shuttling, a well-established feature in platforms like semiconductor spin qubits and trapped-ion qubits. The looped pipeline architecture has similar hardware requirements to other shuttling approaches, but can process a stack of surface codes instead of just one, allowing for higher qubit density and much more efficient logical gates. We find that this can achieve a cost saving of up to a factor of ~ 80 in the space-time overhead for magic state distillation (and a factor of ~ 200 with modest additional hardware). Using numerical modelling and experimentally-motivated noise models we verify that the looped pipeline approach provides these benefits without significant reduction in the code's threshold. In addition, we can also use looped pipeline to remove almost all the space-time costs in implementing virtual distillation, which is one of the leading quantum error mitigation schemes.

CP-06-02

How many qubits do you need, really?

Mathias Soeken

Microsoft

Abstract

While quantum computers promise to solve some of the scientifically and commercially valuable problems intractable for classical machines, delivering on this promise will require a large-scale quantum machine integrated with the cloud. Determining how to best navigate the architecture design choices of a large-scale quantum computer that efficiently caters to the performance and quality requirements of practical applications is an open challenge. To this end, we have developed Azure Quantum Resource Estimation, a tool which uses detailed models of the quantum stack to provide resource estimates (such as qubit counts and runtimes) for large-scale algorithms. Understanding the number of qubits required for a quantum program and the differences between qubit technologies allows innovators to prepare and refine their quantum programs to run on future scaled quantum machines and ultimately accelerate their quantum impact. In the talk, we will illustrate the framework that we apply to perform resource estimation and demonstrate how the tool helps to analyze resource requirements for scalable quantum algorithms. You'll leave ready to find out just how many qubits you'll need, really.

CP-06-03

Partially fault-tolerant quantum computing architecture with error-corrected Clifford gates and space-time efficient analog rotations

Yutaro Akahoshi

Fujitsu Limited

Abstract

Quantum computers have the potential to revolutionize some computational tasks by significantly enhancing their calculation speed compared to classical computers.
Although quantum computing devices have been rapidly developed in recent years, there is still a large gap between today's noisy intermediate-scale quantum (NISQ) computing and fully fault-tolerant quantum computing (FTQC) based on quantum error correction (QEC) codes due to the very large requirements of physical qubits for the latter.
In this study, we propose a quantum computing architecture that bridges the gap between NISQ and FTQC.
This architecture realizes universal computation by noisy analog rotation gates and error-corrected Clifford gates.
Direct analog rotation is performed with small qubit requirements and residual errors are minimized by a carefully designed state injection protocol.
Our estimation based on numerical simulations shows that, for early-FTQC devices consisting of 10^4 physical qubits with physical error probability p = 10^{-4}, we can perform roughly 1.72 * 10^7 Clifford operations and 3.75 * 10^4 analog rotations on 64 logical qubits.
Such computations cannot be achieved with existing NISQ and FTQC architectures on the same device, as well as classical computers.
This talk is based on a recent paper by the authors (arXiv:2303.13181).

CP-07-01

Do quantum computers have applications in machine learning and combinatorial optimization?

Jens Eisert

Freie Universität Berlin

Abstract

There has been substantial excitement recently in identifying tasks for which quantum devices could possibly outperform classical devices. Recent experimental implementations on random circuit sampling have provided strong evidence that near-term quantum devices can outperform classical computers on paradigmatic tasks [1]. These developments invite further studies to see what applications of quantum devices could be found.

Notions of quantum-assisted machine learning are seen as candidates for this. We will have a careful look at such notions. We will discuss the comparative power of classical and quantum learners for generative modelling within the PAC framework, for which we prove a separation [2, 3]. Going further, will discuss how much structure is actually expected to be required for quantum advantages in machine learning [4]. We prove that the injection of a single T-gate into Clifford circuits renders the task of learning evaluators from samples infeasible in polynomial time. This is in stark contrast to the case of Clifford circuits for which we provide an efficient learning algorithm [5].

Finally, we will have a look at the sense in which quantum computers may assist in solving problems of combinatorial optimization. These problems are usually NP-hard in worst case complexity, so it is far from

clear what type of quantum advantage one can even hope for, despite commonly made claims of expectations of such advantages in the literature. We discuss a proven super-exponential quantum advantage for combinatorial optimization [6].

At the end of the talk, we will put these findings into perspective and discuss the potential for near-term quantum computing, including limitations of quantum error mitigation in NISQ devices [7], noise being helpful in variational quantum algorithms [8], classical surrogates simulating variational quantum algorithms in execution but not in training [9, 10] and the exploitation of symmetry [10, 11].

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[7] arXiv:2210.11505 (2022).
[8] arXiv:2210.06723 (2022).
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[10] arXiv:2309.11647 (2023).
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CP-07-02

Verifiable quantum advantage without structure

Takashi Yamakawa

NTT Social Informatics Laboratories

Abstract

We show the following hold, unconditionally unless otherwise stated, relative to a random oracle with probability 1:
- There are NP search problems solvable by BQP machines but not BPP machines.
- There exist functions that are one-way, and even collision resistant, against classical adversaries but are easily inverted quantumly. Similar separations hold for digital signatures and CPA-secure public key encryption (the latter requiring the assumption of a classically CPA-secure encryption scheme). Interestingly, the separation does not necessarily extend to the case of other cryptographic objects such as PRGs.
- There are unconditional publicly verifiable proofs of quantumness with the minimal rounds of interaction: for uniform adversaries, the proofs are non-interactive, whereas for non-uniform adversaries the proofs are two message public coin.
- Our results do not appear to contradict the Aaronson-Ambanis conjecture. Assuming this conjecture, there exist publicly verifiable certifiable randomness, again with the minimal rounds of interaction.

By replacing the random oracle with a concrete cryptographic hash function such as SHA2, we obtain plausible Minicrypt instantiations of the above results. Previous analogous results all required substantial structure, either in terms of highly structured oracles and/or algebraic assumptions in Cryptomania and beyond.

CP-07-03

Theoretical foundations of quantum advantage in quantum algorithms

François Le Gall

Nagoya University

Abstract

In this talk I will describe recent developments on establishing theoretical foundations of quantum advantage in quantum algorithms. I will start with some well-known quantum algorithms and discuss their potential applications. I will then present recent results that establish the theoretical foundations of quantum advantage for these algorithms, as well as recent works that successfully "dequantize" them in some special cases. I will conclude by mentioning challenges and open problems.

CP-08-01

Usecases by quantum technologies for social contribution

Yuichi Nakamura

NEC Corp.

Abstract

One of targets of Q-star is to develop new industries by using quantum technologies. We think image of social contribution to develop new quantum industries are the most important issue.
Then, each Q-star subgroup is looking for use cases for social contribution. The subgroup of applications of quantum superposition is a discussion group of applications of computer with quantum superposition. We think quantum superposition has advantages in huge search area, simulation of elementary particles, and randomness. Currently, our subgroup is discussing use cases in total solution of social contribution or solution. In my talk, I presented our proposed solution level use cases by using quantum superposition.

Abstracts

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Quantum Computing Track

Contents / Topics

Quantum Computing architecture, Quantum computers with Atoms and Ions, Photonic Quantum Computers, Fault Tolerant Quantum Computing, Quantum Algorithms for Chemistry, NISQ Algorithms, Young PIs Session, Superconducing Quantum Computing, Quantum Annealing, Verifiable Quantum Computing, Semiconductor Quantum Computers, Quantum Simulations

Tracks

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Quantum Sensing Track

Contents / Topics

Q-sensors for Life Science, NV Center and Applications for Life Sciences, Solid-State Quantum Sensors, 5th IFQMS Short Presentation Session for Young Scientists, Solid-State Quantum Sensors, Q-sensors for Life Science, NV Center and Applications for Life Sciences, Atom Interferometer, Atom/Ion Clocks *29th Nov Sessions are a joint-program with The 5th IFQMS (The 5th International Forum on Quantum Metrology and Sensing).

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Quantum Cryptography & Communication Track

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Quantum Internet, Young Researcher Panel Session, Quantum Cryptography

SE-01-01

Quantum sensing: the promise, the challenge, and the path ahead

Danielle Ann Braje

Massachusetts Institute of Technology Lincoln Laboratory

Abstract

With the promise of improved accuracy, stability, sensitivity, and smaller size, quantum sensors have the potential for significant advantages over traditional technologies. Achieving these ends requires overcoming non-trivial challenges including maintaining the delicate quantum state, operating in realistic noise environments, and developing practical, extensible technologies.

I will give an overview of our quantum technologies, highlighting quantum sensing with solid state systems. Spin defects in solids, such as the nitrogen-vacancy color center in diamond, can be initialized into pure quantum states, can be coherently controlled, and can have relatively long-lived quantum coherence at room temperature. The semiconductor-like platform has advantages through manufacturability and the intrinsic vector nature of the sensors. Bringing devices to fruition requires outperforming established technologies. Despite comparable theoretical sensitivity limits to atomic and superconducting systems, the performance of solid-state quantum sensors to date has lagged behind these more mature alternatives.

We combine tailored diamond growth and quantum control together with classical engineering to create fieldable magnetometers, which outperform competitive technologies.

SE-01-02

Diamond-based magnetometer with dc sensitivity below 10 pT Hz^-1/2 for magnetoencephalography

Naota Sekiguchi

Tokyo Institute of Technology

Abstract

Diamond-based magnetometer using negatively charged nitrogen-vacancy (NV) centers is one of favorable quantum sensors for biomedical applications such as magnetoencephalography (MEG) due to its robustness and good field sensitivity under an ambient condition. However, MEG requires a minimum detectable field on the order of picotesla, which has not been realized with a diamond-based magnetometer.

We develop a sensitive diamond-based magnetometer with a dc sensitivity below 10 pT/√Hz toward MEG of a living rat. We found that the sensor is stable with the remarkable sensitivity for at least 200 minutes. The minimum detectable magnetic field was found to be 0.3 pT for a few thousand seconds of measurement. Therefore, our sensor is capable of detecting a repetitive biomagnetic field, for example, a stimulus-evoked field, with a strength of the order of 1 pT by accumulating the signals.

This work was supported by the MEXT Quantum Leap Flagship Program (MEXT Q-LEAP) Grant No. JP- MXS0118067395 and JPMXS0118068379.

SE-01-03

Double/Triple resonance of electron spin in diamond: Quantum sensing and manipulation

Junko Ishi-Hayase

Keio University

Abstract

Nitrogen-vacancy (NV) centers in diamond have been attractive candidates for implementing quantum sensors, since electron spin states of NV centers can be coherently manipulated using microwave (MW) field and optically initialized/readout with long coherence time at room temperature. In this study, we demonstrate AC magnetic field and/or temperature sensing based on electron spin double- or triple-resonance of NV centers in diamond observed under the continuous application of laser, MW and radio-frequency (RF) fields[1-5]. In addition, we show the analysis of electron spin state observed under the strong MW/RF fields using Floquet theory[6] and Lindblad master equation.
This work was done in collaboration with Dr. Matsuzaki (Chuo Univ.), Prof. Tokuda (Kanazawa Univ.), Dr. Ikeda (RIKEN), Dr. Watanabe (AIST), Prof. Mizuochi (Kyoto Univ.), Prof. Kobayashi, Dr. Sasaki (Univ. Tokyo), and Hayase Laboratory members (Keio Univ.). This work was partly supported by MEXT Q-LEAP (No. JPMXS0118067395), JSPS KAKENHI (No. JP20H05661, JP21K13852, and JP22H01558), JST PRESTO (Grant Nos. JPMJPR1919 and JPMJPR2112), JST Moonshot R&D (Grant No. JPMJMS226C), Kanazawa University CHOZEN Project 2022, and Keio University CSRN.
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SE-02-01

Basic properties and quantum control of diamond qubits

Ádám Gali

HUN-REN Wigner Research Centre for Physics / Budapest University of Technology and Economics

Abstract

Room temperature solid state defect qubits are relatively rare. Spin-lattice relaxation poses an ultimate limit to the coherence times of the qubits in the given material. Understanding the underlying microscopic mechanisms is essential to discover qubits that can operate under ambient conditions. We show for the exemplary diamond nitrogen-vacancy (NV) center by means of first principles simulations that – in contrast to textbook cases – the electron-spin coupling is governed by Raman scattering due to second-order spin-phonon interactions at elevated temperatures. The applicability of this finding to other defect spin systems will be discussed. Further addressing NV centers, a more than four-fold improvement in sensitivity compared to that possible with non-resonant illumination has been recently demonstrated at cryogenic temperatures. In these experiments, nuclear spin relaxation under resonant excitation to polarize the 14N host was leveraged that can be important in low temperature magnetometer applications. We explain the single- and double-quantum jumps in these experiments by transverse hyperfine and quadrupolar couplings in the excited state. Furthermore, we present recent results on inversion-symmetric defect qubits in diamond that could be important for quantum communication and low-temperature quantum sensing applications.

SE-02-02

Plasma CVD engineering of diamond nitrogen-vacancy centers for quantum sensing

Hiromitsu Kato

AIST

Abstract

Nitrogen vacancy (NV) centers in diamond have attracted attention as quantum sensor due to their excellent spin properties such as long coherence time and fast operation. There are several methods for forming NV centers, including introduction during crystal growth, electron beam irradiation, ion implantation, and their combinations. This presentation will focus on plasma CVD engineering and will introduce recent progress in the development of sensor materials and junction devices. In terms of sensor materials, uniformity across the entire crystal and suppression of crystal distortion are important perspectives, along with thicker films. CVD thick film growth, its NV spin property, and resulting sensitivity and current measurement demonstrations will be described. For device applications, the MOS structure enabled control of NV charge states by applying an external bias voltage. Furthermore, by employing PIN junction device structure, electrical spin readout and NV emission could be achieved. This is a major step toward an all-electric NV control. Details and future prospective will be discussed including technical aspects peculiar to plasma CVD engineering of diamond NV centers. Acknowledgements: JPMXS0118067395, JPMJMS2062, JPMI00316.

SE-02-03

Magnetic field imaging using quantum sensors for condensed matter physics

Kensuke Kobayashi

The University of Tokyo

Abstract

Exploring the magnetic properties of various materials is one of the central topics in condensed matter physics. Diverse local magnetic field (magnetization) measurement methods have been developed.
Recently, there has been considerable interest in using nitrogen-vacancy centers (NV centers) in diamonds as quantum magnetic sensors. As they have unique electron spin-dependent optical excitation and relaxation processes, the spin state of a single NV center can be optically read out by combining microwaves. This technique is called optically detected magnetic resonance (ODMR). As the ODMR spectrum of an NV center in a magnetic field shows a Zeeman splitting, the magnetic field felt by the NV center can be measured by analyzing the spectrum. In 2020, it was revealed that similar magnetic field measurements can be made using boron vacancy defects in hexagonal boron nitride (hBN).
We aim to use these diamond and hBN quantum sensors to measure the magnetic properties of various materials locally. This talk will introduce our recent achievements, such as real-space observation of superconducting magnetic vortex, precise magnetic field measurement aided by machine learning, and hBN quantum sensor nanoarray. These will be fundamental techniques for future quantum sensor-based precision physical property measurements.

SE-03-01

Mid-IR quantum sensing with entangled photons

Sven Ramelow

Humboldt-University Berlin

Abstract

A severe limitation for real-world adaptation of mid-IR sensing is that broadband mid-IR sources and detectors are often prohibitively expensive, technically demanding and suffer from poor sensitivity and resolution. This has lead to different approaches of side-stepping these by moving the detection wavelength to the visible regime, where one can enjoy the maturity of CCD and CMOS technology driven by the life sciences, mobile phone and automotive industry. A convenient means for this, also making sources in the mid-IR obsolete are nonlinear interferometers based on entangled photons. They enable compact and cost-effective sensing in the mid-IR, for which I will present experimental results on microscopy, spectroscopy and OCT and highlight their potential on real-world, industry-ready applications.

SE-03-02

Quantum enhancement towards sensitive molecular vibrational imaging

Yasuyuki Ozeki

RCAST, The University of Tokyo

Abstract

Stimulated Raman scattering (SRS) microscopy is regarded as a sensitive molecular-vibrational imaging method, opening up various biomedical applications including label-free imaging, metabolic imaging, and supermultiplex imaging. The quantum enhancement (QE) of SRS is attracting attention for achieving sub-shot-noise sensitivity, while previous QE-SRS suffered from low optical power, which limits the sensitivity. Here we present QE-SRS microscopy in high-power regimes (>30 mW) that are comparable to classical SRS microscopes. We demonstrated QE-SRS imaging with 2.89 dB noise reduction compared with classical balanced detection SRS microscopy, paving the way for breaking the sensitivity of classical SRS microscopes.

SE-03-03

Reaching the quantum limit with a gravitational-wave telescope

Kentaro Somiya

Tokyo Institute of Technology

Abstract

Gravitational waves are ripples in the spacetime. A massive astronomical even like a black hole merger can generate gravitational waves that are observable by an interferometric detector on Earth. Gravitational-wave detectors can measure a tiny displacement of a 10kg-scale test mass and its sensitivity is about to reach and exceed the standard quantum limit. Our quantum limit comes from quantum fluctuation of light. Phase fluctuation of light makes shot noise and amplitude fluctuation of light makes radiation pressure noise. A number of proposals have been made to reduce the quantum noise and the current telescopes implement the optical squeeze injection technique. A recent study has revealed that the quantum noise level in LIGO detector with the squeezing technique has already exceeded the standard quantum limit. In my talk, I will review the fundamental noise sources of a gravitational-wave telescope and then move on to the discussion about the quantum limit and the zero-point fluctuation of the test mass.

SE-04-01

The state of quantum computing applications in health and medicine

Frederik F. Floether

QuantumBasel

Abstract

Medicine, including fields in healthcare and life sciences, has seen a flurry of quantum-related activities and experiments in the last few years (although biology and quantum theory have arguably been entangled ever since Schrödinger's cat). The initial focus was on biochemical and computational biology problems; recently, however, clinical and medical quantum solutions have drawn increasing interest.

In this presentation, clinical and medical proof-of-concept quantum computing applications are summarized. These consist of over 40 experimental and theoretical studies. The use case areas span genomics, clinical research and discovery, diagnostics, and treatments and interventions. Quantum machine learning (QML) in particular has rapidly evolved and shown to be competitive with classical benchmarks in some studies. Near-term QML algorithms have been trained with diverse clinical and real-world data sets. This includes studies in generating new molecular entities as drug candidates, diagnosing based on medical image classification, predicting patient persistence, forecasting treatment effectiveness, and tailoring radiotherapy. The presentation covers how such advances help pave the way towards the long-term goals of cell-centric therapeutics and precision medicine. An outlook on medicine in the quantum era, including technical and ethical challenges, is provided.

SE-04-02

Quantum computing in chemistry, molecular biology, and materials science

Markus Reiher

ETH Zurich

Abstract

Many problems in molecular science and condensed-phase systems, which are both governed by the dynamics of electrons and atomic nuclei, demand an explicit quantum mechanical description. In such quantum problems, the representation of wave functions grows exponentially with system size, which poses a severe restriction on traditional approaches. However, such quantum problems should naturally benefit from digital quantum simulation on a number of logical qubits, as this would scale only linearly with system size. In recent years, we have considered quantum computing applications in molecular biology, catalysis, and physical chemistry in general, with a focus on how and where to establish a quantum advantage in these areas (see list of references below). In my talk, I will elaborate on the potential benefits of quantum computing in these application areas, especially when compared to state-of-the-art traditional approaches.

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SE-04-03

Exploring the quantum acceleration of machine learning in neural data analysis

Kei Majima

National Institutes for Quantum Science and Technology

Abstract

Recent advances in machine learning algorithms have enabled the extraction of inherent information in neural activities, the so-called neural decoding technique, providing us with in-depth knowledge of mechanisms of information processing in the brain. However, their application to high-dimensional data is limited due to their sizeable computational complexity. To tackle this problem, we have developed scalable machine-learning algorithms using computational techniques developed in quantum computation. In this short presentation, we will present recent results obtained with these quantum-inspired machine learning algorithms and discuss future perspectives.

SE-04-04

Expansion of the scope of quantum annealing

Yuya Seki

Graduate School of Science and Technology, Keio University

Abstract

Developing calculators based on quantum mechanics is one of the attractive topics in quantum physics. Quantum annealing (QA), which can prepare a desired quantum state by using quantum real-time dynamics, is an important method on the calculators. A main application of QA is combinatorial optimization problems such as job scheduling and capacitated vehicle routing problem. To solve such problems by using QA, we need to represent the problems with Ising model. However, not all problems can be represented by Ising model. A typical example is black-box optimization problems. In the black-box optimization problems, cost functions are not given analytically. Hence, we need to estimate the cost function from properties of a target black-box optimization problem before optimizing it. Since the black-box optimization problems frequently appears in applications of optimization, expanding the range of application of QA to the black-box optimization problems is an important work. In this presentation, we start from a review of QA, and describe some applications of QA. Then, we see that QA can be applied to black-box optimization problems by using machine learning techniques. These techniques could pave the way to expand the scope of applications of quantum technologies.

SE-04-05

Application of quantum annealing to quantum sensing

Yuichiro Matsuzaki

Chuo University

Abstract

In biology, it is important to detect weak signals associated with biological processes such as neural activity and chemical reactions. Quantum sensing is a promising way to detect such signals, and so an improvement of the sensitivity of quantum sensing plays a crucial role to understand the mechanism of life. Importantly, we can in principle use entanglement to enhance the sensitivity of quantum sensors. However, it is not straightforward to generate metrologically useful entanglement in realistic systems. Here, we propose a way to generate an entanglement between quantum sensors by using the principle of quantum annealing. We drive the systems by external fields, and gradually change the amplitude and detuning. As long as there is an Ising-type interaction between quantum sensors, we can prepare the so-called GHZ states, which is one of the most useful states in quantum metrology. We discuss possible implementations of our scheme by using nitrogen vacancy centers in diamond.

SE-05-01

Quantum cognition? The subatomic frontier of brain research

Matthew P. A. Fisher

University of California, Santa Barbara

Abstract

The endeavor to construct a laboratory quantum computer has evolved into a multi-billion-dollar undertaking, marked by remarkable progress. However, an intriguing question arises: could we ourselves be quantum computers?

While maintaining quantum coherence on macroscopic time scales is exceedingly unlikely in the warm wet brain, there is one exception: Nuclear spins.

Our strategy is one of reverse engineering, seeking to pinpoint the biochemical substrate and mechanisms that might underpin the hypothetical quantum processing involving nuclear spins. Seemingly, a specific neural qubit and a unique collection of ions, molecules and organelles can be identified, illuminating an apparently single path towards possible quantum processing in the brain. In this presentation, I will provide an overview of our ongoing efforts to delve into this captivating realm of exploration.

SE-05-03

Some steps towards enabling practical quantum computing of biomolecules

Wataru Mizukami

Center for Quantum Information and Quantum Biology, Osaka University, Japan

Abstract

Quantum computers hold the promise of simulating biomolecules that are currently beyond the reach of even the most advanced quantum chemistry theories. In the last five years, there's been a notable increase in studies using quantum computers for these calculations. While the field has seen considerable advancements, we're still some way from using quantum computers for practical calculations. In this talk, I'll shed light on our latest efforts to close this gap. It's important to note that quantum computers have specific strengths, and to unlock their full potential for quantum chemistry, better integration with classical computers is essential. We're working on this integration and have pioneered techniques such as quantum-selected configuration interaction (QSCI) and computational basis sampling. I'll talk about hybrid algorithms we've developed that combine the strengths of quantum and classical computing.

SE-06-01

Can a rock be a wave? From 100 years of de-Broglie's wave-particle duality to quantum-gravity

Ron Folman

Atom Chip Group / Ben-Gurion University of the Negev * https://tzin.bgu.ac.il/atomchip/*

Abstract

It is almost exactly 100 years since De-Broglie made public his outrageous hypothesis regarding Wave-Particle Duality (WPD), where the latter plays a key role in interferometry. In parallel, the Stern-Gerlach (SG) effect, found a century ago, has become a paradigm of quantum mechanics. I will describe the realization of a half- [1-3] and full- [4-5] loop SG interferometer for single atoms [6], and show how WPD, or complementarity, manifests itself. I will then use the acquired understanding to show how this setup may be used to realize an interferometer for macroscopic objects doped with a single spin [5], namely, to show that even rocks may reveal themselves as waves. I emphasize decoherence channels which are unique to macroscopic objects such as those relating to phonons [7,8] and rotation [9]. These must be addressed in such a challenging experiment. The realization of such an experiment could open the door to a new era of fundamental probes, including the realization of previously inaccessible tests of the foundations of quantum theory and the interface of quantum mechanics and gravity, including the probing of exotic theories such as the Diosi-Penrose gravitationally induced collapse. Time permitting, and as an anecdote noting also De-Broglie's less popular assertion, namely, that the standard description of QM is lacking, I will also present our recent work on Bohmian mechanics, which is an extension of De-Broglie's ideas concerning the pilot wave [10]. Finally, I will also discuss technological applications of some of the above works.

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[9] Y. Japha and R. Folman, Role of rotations in Stern-Gerlach interferometry with massive objects, Phys. Rev. Lett. 130, 113602 (2023).
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SE-06-02

Precise magnetometer with a Bose-Einstein condensate

Kosuke Shibata

Gakushuin University

Abstract

State-of-the-art magnetometers offer magnetic field sensitivities down to sub fT per root Hertz. A Bose-Einstein condensate (BEC) of neutral atoms has realized an excellent magnetic field sensitivity of pT per root Hertz with um spatial resolution. We aim to construct a quantum-enhanced precise magnetometer with a BEC of rubidium-87 atoms. In this talk, I will present our development of sensitive BEC magnetometer, construction of squeezed light for improving the magnetometry, and measurement and cancellation of nonlinear ac Stark shift with the use of multi-state interferometer for measurement-based spin squeezing. This work was supported by the MEXT Quantum Leap Flagship Program (MEXT Q-LEAP) Grant Number JPMXS0118070326.

SE-07-02

Laser spectroscopy of triply charged Th-229 toward a nuclear clock

Atsushi Yamaguchi

RIKEN

Abstract

The first-excited nuclear state of Thorium-229 (229mTh) can be excited from the ground state by a vacuum ultraviolet laser. One of its applications is a nuclear clock: an atomic clock based on the nuclear transition between the ground state and 229mTh.
An ion trap is an optimal system for the nuclear clock because the quantum states of the 229Th ion in a trap can be precisely controlled by laser cooling. We developed an ion trap system of triply charged 229Th (229Th3+). The 229Th recoil ions emitted from 233U were cooled by collisions with a helium buffer gas and extracted as a low-energy ion beam by an RF carpet. Since 2% of the recoiled 229Th ions from 233U is 229mTh, laser spectroscopy of trapped 229mTh3+ ions can be performed. Such measurements provide detailed knowledge of this unique nuclear state. In this presentation, we will present details on our experiments of trapping and laser spectroscopy of 229Th3+.

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Quantum Computing Track

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Quantum Sensing Track

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Quantum Cryptography & Communication Track

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Quantum Internet, Young Researcher Panel Session, Quantum Cryptography

CC-01-01

Research and demonstration activities of Toshiba on QKD

Keisuke Mera

Corporate Research and Development Center, Toshiba Corporation

Abstract

Quantum key distribution (QKD) provides a means for exchanging cryptographic keys securely. No matter how fast future computers may become, it is vital that we have technologies that make it possible for cryptographic keys to be delivered without being eavesdropped on along the way.

This talk presents the Quantum Key Distribution (QKD) service platform based on Toshiba QKD technologies. We also introduce future research and demonstrations of quantum communication technologies.

CC-01-02

Quantum key distribution research and development in NEC

Ken-ichiro Yoshino

NEC Corporation

Abstract

Quantum key distribution (QKD) can provide cryptographic keys that are not leaked to the third-party using the principles of quantum mechanics and is expected to be applied to many important mission-critical systems. NEC is engaged in various research and development toward the commercialization of QKD. This presentation shows overview of NEC's QKD related activities including BB84 and continuous variable (CV) QKD systems. NEC and the partners also conduct field trials of QKD in some important application areas.

CC-01-03

Research on quantum-secured networking: QKD for networks and networks for QKD

Chankyun Lee

KISTI

Abstract

Quantum-secured networking forms a layered architecture comprising quantum, key management, and service layers. Quantum layer distributes quantum keys by means of quantum key distribution (QKD) protocol. Key management layer relays quantum keys to establish an end-to-end key. Service layer utilizes the key to provide end-to-end quantum-secured service.

The nature of quantum mechanics provides us with new opportunities to improve networking system. As a research on the quantum layer in the quantum-secured networking, the first part of this talk will cover a research on eavesdropping detection in classical fiber networks, by means of BB84 QKD protocol. An eavesdropper in the BB84 QKD protocol cannot avoid affecting quantum bit error rate, which provides us an opportunity to detect the eavesdropper statistically with sufficiently high accuracy.

For practical quantum-secured service, efficient utilization of a quantum key resource is required, which is a limited and costly resource in the current quantum technology. In the second part of this talk, I will deliver a research on quantum key resource aware key relay algorithms for key management layer in the quantum-secured networking. The key relay algorithm can control the balance between max-min fairness and efficiency in the key relay.

CC-02-01

EuroQCI: A quantum communication infrastructure for Europe's digital decade

Peter FATELNIG

Delegation of the European Union to Japan

Abstract

The EuroQCI will be a secure quantum communication infrastructure spanning the entire European Union, including its overseas territories. The European Commission works with all 27 EU Member States and the European Space Agency to design, develop and deploy the EuroQCI. This includes a terrestrial segment relying on fibre communications networks linking strategic sites at national and cross-border level and a space segment based on satellites. This quantum communications infrastructure will be an integral part of IRIS^2, the new EU space-based secure communication system. The EuroQCI will safeguard sensitive data and critical infrastructures by integrating quantum-based systems into existing communication infrastructures, providing an additional security layer based on quantum physics. It will reinforce the protection of Europe's governmental institutions, their data centres, hospitals, energy grids, and more, becoming one of the main pillars of the EU's Cybersecurity Strategy for the coming decades.

CC-02-02

Classic space optical communication technology will realize satellite QKD

Tomohiro Araki

JAXA

Abstract

CLASSIC space optical communication technology must be needed to realize satellite QKD.
Outline, recent trends of space optical communication and it's tandardization will be presented.

CC-02-03

Space laser communication and our technologies

Kyohei Iwamoto

Sony Space Communications Corporation

Abstract

Sony Computer Science Laboratories (Sony CSL) has been develop laser communication terminal jointly with NICT, University of Tokyo, NESTRA and SKY Perfect JSAT Corporation under sponsored research from Ministry of Internal Affairs and Communications and successfully launched on August 2nd, 2023 (JST) from wallops space launch site in VA, USA.
This laser communication terminal is the second space terminal of Sony CSL which is followed by SOLISS space laser communication terminal launch in 2019.
Sony CSL continues developing small laser communication terminals utilizing commercial technologies from Sony to be ready for current market requirements including productivity and reliability. In 2022, Sony Corporation of America, one of subsidiary company of Sony Group Corporation established Sony Space Communication Corporation in California, USA to launch space laser communication business. In this presentation, technologies inside our laser communication terminals, some of space projects and expected business will be discussed.

Quantum delegation with an off-the-shelf device

Anne Broadbent

University of Ottawa

Abstract

Given that reliable cloud quantum computers are becoming closer to reality, the concept of delegation of quantum computations and its verifiability is of central interest. Many models have been proposed, each with specific strengths and weaknesses. Here, we put forth a new model where the client trusts only its classical processing, makes no computational assumptions, and interacts with a quantum server in a single round. In addition, during a set-up phase, the client specifies the size n of the computation and receives an untrusted, off-the-shelf (OTS) quantum device that is used to report the outcome of a single constant-sized measurement from a predetermined logarithmic-sized input. In the OTS model, we thus picture that a single quantum server does the bulk of the computations, while the OTS device is used as an untrusted and generic verification device, all in a single round.

We show how to delegate polynomial-time quantum computations in the OTS model. Scaling up the technique also yields an interactive proof system for all of QMA, which, furthermore, we show can be accomplished in statistical zero-knowledge. This yields the first relativistic (one-round), two-prover zero-knowledge proof system for QMA.

As a proof approach, we provide a new self-test for n-EPR pairs using only constant-sized Pauli measurements, and show how it provides a new avenue for the use of simulatable codes for local Hamiltonian verification. Along the way, we also provide an enhanced version of a well-known stability result due to Gowers and Hatami and show how it completes a common argument used in self-testing.

Based on joint work with Arthur Mehta and Yuming Zhao
arxiv:2304.03448.

CC-04-02

Numerical method for security analysis of quantum key distribution based on complementarity

Toshihiko Sasaki

The University of Tokyo

Abstract

The main goal of the security analysis in the quantum key distribution is to provide the security proof for general attacks in the finite-key regime. In recent years, it is also important to consider imperfections of the devices. It increases the number of parameters in the device models and makes security analysis complicated. One possible way to deal with this situation is to use numerical methods to provide the security analysis. The question is how to make it adaptable to a wide range of situations and how to achieve high key rate even in the finite-key regime. We will present recent progress in a numerical method for the security proof based on complementarity.

CC-04-03

Quantum key distribution network and quantum internet toward next generation communication infrastructure

Mikio Fujiwara

National Institute of Information and Communications Technology

Abstract

We are conducting research and development on quantum key distribution (QKD) networks as well as quantum internet. Even with optical fibers or satellite links, communication paths are subject to significant losses, therefore, the global quantum communication requires the use of protocols that are tolerant of quantum bits losses and errors, as well as the implementation of functions unique to quantum technology. Regarding quantum Internet, we define the quantum Internet as a communication network with remote transmission of quantum states and high-precision synchronization. Our definition of the quantum Internet is a future communication infrastructure that can coexist with trusted nodes based QKD networks would provide more secure communication. Specifically, we aim to synchronize distant atom clocks for high-precision synchronization and frequency stabilization of light sources to achieve higher performance such as twin field (TF) QKD, and to combine the keys obtained from Quantum Internet with secure network coding techniques such as secret sharing schemes on QKD networks based on trusted nodes. By combining such technologies, we would like to realize more secure key and data transmission. This lecture will explain the details.

CC-05-01

Building the quantum internet

Saikat Guha

University of Arizona

Abstract

Many organized efforts across the world are racing to realize the "Quantum Internet" – the internet of the future that is upgraded to provide an additional service: that of reliably transmitting qubits between distant users. Just like the internet's classical data communications service, the quantum communications service must reliably support many user groups, and support diverse and dynamic applications – each with its unique requirements on the quality of service for transmission of qubits, e.g., rate, latency, fidelity etc. Supporting long-distance quantum communications at high rates and fidelities will require scalable quantum repeaters and quantum-capable satellites for continental-scale quantum connectivity. In this talk, I will describe the underlying theory of quantum networking and quantum repeaters, allude to a few important applications, and give a glimpse of a large effort underway as part of an NSF-funded 10-year engineering research center called the Center for Quantum Networks (CQN). CQN is a highly interdisciplinary effort with research ranging material-science theory to design high-coherence time quantum memories, quantum memory design and fabrication, building efficient interfaces between matter and photon qubits, cryogenic compatible packaging capabilities, quantum error correction theory to design codes for quantum communication and entanglement distillation, repeater architecture design and analysis, the entire network protocol stack up to the application layer, and finally network control, tomography and management protocols. I will also describe how CQN engages disciplines such as law and policy, social and behavioral sciences and economics through a research thrust focusing on societal impacts of the quantum internet.

CC-05-02

Generation and manipulation of telecom photons towards quantum internet

Yoshiaki Tsujimoto

National Institute of Information and Communications Technology

Abstract

By connecting distant quantum devices through entanglement, the entangled quantum devices act as a single huge quantum device. This feature would be useful for realizing long-distance quantum key distribution and quantum sensor/computer network. Such entanglement networks are called quantum internet. As building blocks of quantum internet, development of elemental technologies such as entangled photon pair sources, quantum memories and quantum frequency converters are of importance. Quantum ICT Laboratory in NICT has developed entangle photon pair sources in telecom wavelength band and quantum frequency converters. In the presentation, I talk about two research topics. First, I talk about entangled photon pair sources at telecom wavelength. By using an electro-optic frequency comb and a nonlinear crystal with waveguide structure, we have developed entangled photon pair sources operating in GHz order clock rate. Second, I talk about a quantum frequency converter which can be used to convert the wavelength of single photons emitted from a quantum memory to telecom wavelength. We focus on the photons emitted from a Ca+ ion trap, and successfully demonstrated the quantum frequency conversion.

CC-05-03

Prospects for quantum network using trapped-ion quantum nodes

Alto Osada

QIQB, Osaka University / KIS, The University of Tokyo

Abstract

Building a quantum computer using trapped ions inevitably involves photonic interconnection of quantum nodes, which is equivalent to constructing a trapped-ion quantum network. From quantum networking and communication perspectives, trapped-ion quantum node is a promising platform to implement various functionalities such as quantum repeaters, quantum memory, and so on. We will present our prospects for the implementation of quantum networking nodes using trapped ions and discuss the realization of reproducible, plug-and-play trapped-ion quantum nodes by fully utilizing the nanophotonics.

CC-06-01

Privacy for the paranoid ones - the ultimate limits of secrecy

Artur Ekert

OIST / Oxford / CQT Singapore

Abstract

Among those who make a living from the science of secrecy, worry and paranoia are just signs of professionalism. Can we protect our secrets against those who wield superior technological powers? Can we trust those who provide us with tools for protection? Can we even trust ourselves, our own freedom of choice? Recent developments in quantum cryptography show that some of these questions can be addressed and discussed in precise and operational terms, suggesting that privacy is indeed possible under surprisingly weak assumptions. I will provide an overview of how quantum entanglement, after playing a significant role in the development of the foundations of quantum mechanics, became a new physical resource for all those who seek the ultimate limits of secrecy.

CC-06-02

Inter-node quantum operations and assessment of devices for such operations

Akihito Soeda

National Institute of Informatics

Abstract

Global operations between network nodes are crucial to achieve any benefit of quantum computation. We have to design the individual network components appropriately so that they function as a single large quantum system when connected together. How to assess a single device for its expected quantumness when used to form a large network? And how to do so with as little experimental resources as possible? We explore the case of remote CNOT gate utilizing one Bell state and discuss how we can reduce the assessment complexity with respect to full quantum process tomography.

CC-06-03

Characterization and optimization of quantum repeater networks

David Elkouss

OIST

Abstract

Very recently we have seen the first proof of principle demonstrations of entanglement-based quantum networks. However, many challenges remain to scale these demonstrations. Here, I will discuss several ideas for optimizing the performance of near-term networks. First, I will introduce tools for efficiently evaluating the performance of quantum networks and show how these tools can be leveraged for implementing quantum key distribution over a very noisy chain of quantum repeaters. Then, I will discuss some ideas for efficient entanglement characterization as a byproduct of entanglement distillation.

QUANTUM INNOVATION 2023

List of Awardees for

Quantum Innovation 2023 Poster Presentation Awards for Young Researchers

5 December 2023

Congratulations to the following individuals (15 persons) for their outstanding contributions.

PO-CP-25 Kazuma Takahashi The University of Tokyo
High generation rates of Fock states for ultra-fast optical quantum computers

PO-CP-29 Florian Meier The Vienna Center for Quantum Science and Technology
Energy-consumption advantage of quantum computation

PO-CP-32 Shintaro Minagawa Nagoya University
The second law of information thermodynamics in feedback control with a general quantum measurement process

PO-CP-50 Tatsuya Oshio Osaka University
Development of an ion-shuttling system for the QCCD architecture

PO-CP-51 Manami Yamagishi The University of Tokyo / RIKEN
Proposal of multidimensional quantum walks to explore Dirac and Schroedinger systems

PO-SE-07 Kosuke Kimura Gunma University
Quantum state tomography with NV-NV pair for quantum sensing application

PO-SE-09 Ozora Iso The University of Electro-Communications
Biphoton spectral measurement with delay-line-anode single-photon detectors

PO-SE-15 Ryota Kitagawa Tokyo Institute of Technology
Widefield imaging of the magnetization process in soft magnetic-thin film using diamond quantum sensors

PO-SE-24 Riku Kawase Kyoto University
Control of impurity incorporation into CVD diamond toward long coherence time of the NV center by optimizing pressure

PO-SE-32 Atsumi Yoshimura Tokyo Institute of Technology
Development of sensitive diamond quantum sensor for detecting the brain magnetic field of a living rat

PO-SE-36 Geobae Park Kyoto University
Experimental criteria for the classification of multi-photon correlations

PO-SE-42 Hiroaki Otsuka Wasede University
Tyrosine 319 may play a key role in the Radical Pair Mechanism through bifurcation in the light initiated redox reaction

PO-CC-03 Kazufumi Tanji Keio University
Effects of spontaneous emission and the pump pulse waveform in photonic interconnect of distant ion-cavity systems

PO-CC-12 Mayuka Ichihara Yokohama National University
Observation of frequency-multiplexed Hong-Ou-Mandel interference

PO-CC-21 Yuto Nishikubo Mie University
Private quantum signal processing

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