QUANTUM INNOVATION 2025 OSAKA

Program and Abstracts I

Abstracts for Oral Presentations

Date

July 29th – August 2nd, 2025

Venue

Congrès Square Grand Green Osaka

INTERNATIONAL YEAR OF Quantum Science and Technology

QIH Quantum Innovation Hubs

Sponsors of Quantum Innovation 2025

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 Institute for Materials Science(NIMS), 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), Quantum STrategic industry Alliance for Revolution(Q-STAR), The University of Tokyo, Tohoku University, Tokai National Higher Education and Research System(THERS), Institute of Science Tokyo, Kyoto University, The University of Osaka

https://www.qi2025.jp

QUANTUM INNOVATION 2025

The International Symposium on Quantum Science, Technology and Innovation

Welcome Message

Welcome to Quantum Innovation 2025

The International Symposium on Quantum Science, Technology and Innovation 2025 (Quantum Innovation 2025) is organized by research institutes and universities of the Quantum Technology Innovation Hubs (QIH https://qih.riken.jp/en/) and is supported by the Government of Japan, the Japan Science and Technology Agency (JST), and corporate sponsors.

Quantum Innovation covers a wide range of topics, including the latest achievements, trends, and demands in quantum science and technology, such as quantum computing, quantum sensing, and quantum cryptography and communication. Since 2021, it has been held annually as a three-day symposium in Tokyo.

In 2025, the symposium will be held for five days in Osaka, adding a two-day Moonshot session towards fault-tolerant quantum computing and a one-day SIP session towards the future quantum society. This event also presents a great opportunity to visit Osaka and the 2025 World Expo (https://www.expo2025.or.jp/en/).

The symposium is one of the IYQ (International Year of Quantum Science and Technology) Global Events and is a great opportunity to discuss the latest advances and prospects in quantum science and technology.

Professor Masahiro Kitagawa
General Chair,
Quantum Innovation 2025 Organizing Committee

Organizing Committee

Global Organising Committee

Chairs

Artur Ekert
University of Oxford / Centre for Quantum Computation, NUS, Singapore / Okinawa Institute of Science and Technology(OIST)

Michelle Simmons
The University of New South Wales

Isaac Chuang
Massachusetts Institute of Technology(MIT)

Yasunobu Nakamura
RIKEN / The University of Tokyo

Masahiro Kitagawa
The University of Osaka /
JST Moonshot Goal 6 PD

Organizing Committee

General Chair

Masahiro Kitagawa
The University of Osaka /
JST Moonshot Goal 6 PD

Organizing Committee

Quantum Computing

Track Chair

Keisuke Fujii
The University of Osaka

Vice Track Chair

François Le Gall
Nagoya University

Committee members

Kazuhiro Igeta
Japan Science and Technology Agency (JST)

Kunihiro Inomata
National Institute of Advanced Industrial Science and Technology (AIST)

Yusuke Kozuka
National Institute for Materials Science(NIMS)

Yasunari Suzuki
RIKEN

Shuntaro Takeda
The University of Tokyo

Shu Tanaka
Keio University

Yutaka Tabuchi
RIKEN

Takafumi Tomita
Institute for Molecular Science(IMS)

Atsushi Noguchi
RIKEN

Masaru Hitomi
Tohoku University

Wataru Mizukami
The University of Osaka

Mio Murao
The University of Tokyo

Takahiro Mori
National Institute of Advanced Industrial Science and Technology (AIST)

Shigeru Yamashita
Ritsumeikan University

Naoki Yamamoto
Keio University

Organizing Committee

Quantum Sensing

Track Chair

Makoto Negoro
The University of Osaka

Vice Track Chair

Tadashi Sakai
Institute of Science Tokyo

Committee members

Takayuki Iwasaki
Institute of Science Tokyo

Hiromitsu Kato
National Institute of Advanced Industrial Science and Technology (AIST)

Ami Kihara
National Institute of Information and Communications Technology(NICT)

Tomoya Sato
Institute of Science Tokyo

Shigeki Takeuchi
Kyoto University

Yoshie Harada
The University of Osaka

Fuminori Hyodo
Gifu University

Norikazu Mizuochi
Kyoto University

Nobuhiro Yanai
The University of Tokyo

Yuichi Yamazaki
National Institutes for Quantum Science and Technology(QST)

Akinari Yokoya
National Institutes for Quantum Science and Technology(QST)

Organizing Committee

Quantum Cryptography & Communication

Track Chair

Go Kato
National Institute of Information and Communications Technology(NICT)

Vice Track Chair

Takashi Yamamoto
The University of Osaka

Committee members

Koji Azuma
Nippon Telegraph and Telephone Corporation(NTT)

Koichiro Iwamoto
Quantum STrategic industry Alliance for Revolution(Q-STAR)

Tetsuo Kawakami
NEC Corporation

Hiroshi Shimada
Quantum STrategic industry Alliance for Revolution(Q-STAR)

Masahiro Takeoka
Keio University

Yoshimichi Tanizawa
Toshiba Corporation

Kae Nemoto
Okinawa Institute of Science and Technology Graduate University (OIST)

Takuya Hirano
Gakushuin University

Akihiro Mizutani
University of Toyama

Tetsuomi Sogawa
Nippon Telegraph and Telephone Corporation(NTT)

Yoshiro Hirayama
National Institutes for Quantum Science and Technology(QST)

Organizing Committee

Poster Session Committee

Chair

Shigeru Yamashita
Ritsumeikan University

Committee members

Kazuhiro Igeta
Japan Science and Technology Agency (JST)

Ami Kihara
National Institute of Information and Communications Technology(NICT)

Yuichi Yamazaki
National Institutes for Quantum Science and Technology(QST)

Tetsuo Kawakami
NEC Corporation

Akihiro Mizutani
University of Toyama

Organizing Committee

Local Organizing Committee(LOC)

Chair

Takashi Yamamoto
The University of Osaka

Committee members

Miyuki Imada
The University of Osaka

Yusuke Kobayashi
The University of Osaka

Yusuke Kodaira
The University of Osaka

Emi Kamada
The University of Osaka

Co-organizers

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 Institute for Materials Science(NIMS)

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)

Quantum STrategic industry Alliance for Revolution (Q-STAR)

The University of Tokyo

Tohoku University

Tokai National High Education and Research System(THERS)

Institute of Science Tokyo

Kyoto University

The University of Osaka

Symposium Outline

Aims

Quantum Innovation 2025 aims to accelerate research, development, and societal implementation of quantum technologies by fostering dialogue and collaboration among researchers, industry, and policy makers worldwide.

Scope of the Symposium

The symposium covers a broad range of topics in quantum computing, quantum sensing, quantum communication and cryptography, with dedicated sessions on Moonshot goals for fault-tolerant quantum computing and SIP strategies toward a future quantum society.

Date: July 29th (Tue.) – August 2nd (Sat.), 2025

Venue: Congres Square Grand Green Osaka
4F, South Bldg. Grand Green Osaka,
5-54, Daishinmachi, Kita-ku, Osaka, Japan

Speakers: All 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

Diamond

FUJITSU

Platinum

BLUEFORS

Deloitte.
デロイト トーマツ

Symposium Sponsors

Gold

HAMAMATSU
PHOTON IS OUR BUSINESS

QuEL, Inc.

SHIMADZU
Excellence in Science

LQUOM
Quantum Communication

QUNASYS
We are Quantum Native.

QUANTINUUM

Q-STAR

Symposium Sponsors

Silver

ULVAC

ULVAC CRYOGENICS INC.

COAX CO., LTD.

JHPC-quantum

SEIKEN

Bronze

JLC JAPAN LASER

SOGO ELECTRONICS,INC.

Booth exhibitors and other sponsors

AMP Consulting GK
Autex Inc.
Kawashima Manufacturing Co., Ltd.
Japan Communication Equipment Co., Ltd.
Japan Laser Corporation
KEYCOM Corporation
NIKI GLASS CO.,LTD
NTT Communications Corporation
OHTAMA CO., LTD.
OPTOQUEST CO., LTD.
Royal Danish Embassy
Seiken Co., Ltd.
Yaqumo Inc.

The order of listing is as follows.

Diamond, Platinum, Gold, Silver and Bronze are listed in no particular order
Booth exhibitors and other sponsors are listed in alphabetical order.

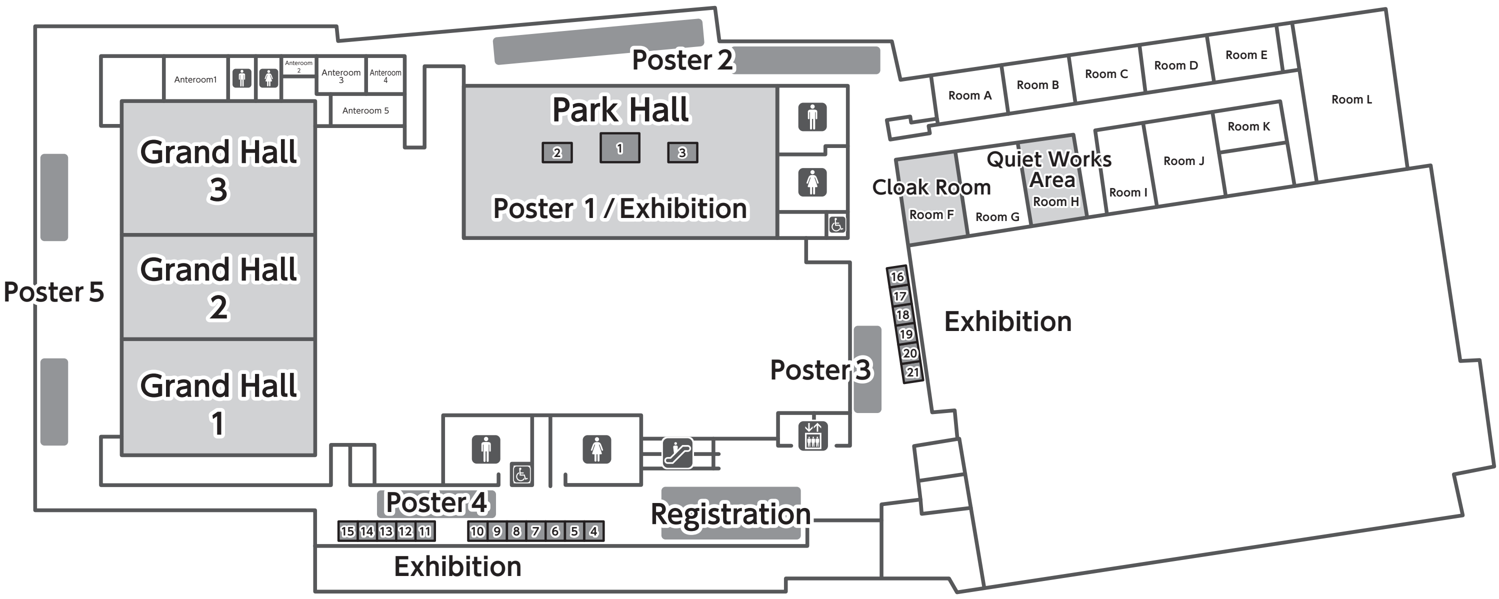
About QIH

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

Please also refer to the QIH website.
https://qih.riken.jp/

Venue



Exhibition

1 FUJITSU LIMITED
2 Bluefors
3 Deloitte Tohmatsu LLC
4 HAMAMATSU PHOTONICS K.K.
5 QuEL, Inc.
6 Shimadzu Corporation
7 LQUOM, Inc.
8 QunaSys Inc.
9 Quantinuum
10 Quantum STrategic industry Alliance for Revolution
11 OPTOQUEST CO., LTD.
12 KEYCOM Corporation
13 Autex Inc.
14 Japan Laser Corporation
15 Seiken Co., Ltd.
16 Japan Communication Equipment Co., Ltd.
17 NTT Communications Corporation
18 OHTAMA CO., LTD.
19 Yaqumo Inc.
20 NIKI GLASS CO.,LTD
21 Royal Danish Embassy

Wifi Connection Information

SSID: congre-square-ggo

Program at a Glance

Track	Contents / Topics
PL Plenary Sessions	Opening/Global Quantum Ecosystem/Policy/Industry/IYQ Keynotes
CP Quantum Computing	Quantum Algorithms and Foundation/Practical Quantum Computing/QC with Ions, Atoms and Photons: part1-2/ Superconducting QC/Semiconductor QC/Quantum Annealing/
SE Quantum Sensing	Optical Quantum Sensing/Hyperpolarization Method/Quantum Life /Hyperpolarized Application/Solid-State/Nano Quantum Sensing (1)(2)/Atomic/Ion Quantum Sensing
CC Quantum Cryptography & Communication	Quantum Communication/Progress and Prospects on Quantum Cryptography/Standardization and Certification of QKD and PQC/Free-Space Quantum Key Distribution/Social Implementation of Quantum Communication
JT Joint Session	Quantum Sensing, Biology and Computing/ Quantum Communication and Computation
SP SIP3 special session	Quantum Security and Network/Quantum Computing/ Innovation Creation Platform/Quantum Sensing
MS MS6 Session	Fault-tolerant Quantum Computing/Quantum Computing (Superconductinig)/Quantum Computing (Neutral Atom)/ Quantum Computing (Trapped ion)/Quantum Computing (Semiconductor)/Quantum Computing (Photon)/Quantum Communication and Network

Tue 29 July

Time	Oral Session Hall 3 Grand Hall 3	Oral Session Hall 2 Grand Hall 2	Oral Session Hall 1 Grand Hall 1	Poster 1 Exhibition Park Hall 2 / Park Hall 1	Poster 2-5 Exhibition Hoyer/Lobby/Corridor
9:00-12:00				**Poster Mounting** **Exhibition**	**Poster Mounting (Group1)** **Exhibition**
10:00	**Opening Remarks**				
10:10-10:40	**PL-01** **Opening**				
10:40-12:00	**PL-02** **Global Quantum Ecosystem**				
12:00-13:40	**Lunch Break & Networking**			**Exhibition** **Poster Viewing**	**Exhibition** **Poster Viewing (Group1)**
13:40-15:10	**PL-03** **Policy**	**CP-01** **Quantum Algorithms and Foundation**	**SE-01** **Optical Quantum Sensing**		
15:10-15:30	**Break**				
15:30-17:00	**PL-04** **Industry**	**CP-02** **Practical Quantum Computing**	**CC-01** **Quantum Communication**		
17:10-				**Exhibition Reception**	**Exhibition Reception**
17:10-17:50				**Poster Session (Odd No.)**	
17:10-18:30					**Poster Session (Group1)**
17:50-18:30				**Poster Session (Even No.)**	

CP: Quantum Computing
SE: Quantum Sensing
CC: Quantum Cryptography & Communication

Wed 30 July

Time	Oral Session Hall 3 (Grand Hall 3)	Oral Session Hall 2 (Grand Hall 2)	Oral Session Hall 1 (Grand Hall 1)	Poster 1 Exhibition (Park Hall 2 / Park Hall 1)	Poster 2-5 Exhibition (Hoyer/Lobby/ Corridor)
8				**Exhibition** **Poster Viewing**	**Exhibition** **Poster Viewing (Group1)**
9	8:40-10:10 **CP-03 QC with Ions, Atoms and Photons: part1**	8:40-10:10 **SE-02 Hyperpolarization Method**	8:40-10:10 **CC-02 Progress and Prospects on Quantum Cryptography**		
10	10:10-10:30 **Break**				
11	10:30-12:00 **CP-04 QC with Ions, Atoms and Photons: part2**	10:30-12:00 **SE-03 Quantum Life / Hyperpolarized Application**	10:30-12:00 **CC-03 Standardization and Certification of QKD and PQC**		
12	12:00-13:40 **Lunch Break & Networking**				**Poster Removal (Group1)**
13					**Poster Mounting (Group2)**
14	13:40-15:10 **CP-05 Superconducting QC**	13:40-15:10 **SE-04 Solid-State/Nano Quantum Sensing (1)**	13:40-15:10 **CC-04 Free-Space Quantum Key Distribution**		**Exhibition** **Poster Viewing (Group2)**
15	15:10-15:30 **Break**				
16	15:30-17:00 **CP-06 Semiconductor QC**	15:30-17:00 **SE-05 Solid-State/Nano Quantum Sensing (2)**	15:30-17:00 **CP-07 Quantum Annealing**	**Exhibition Reception**	**Exhibition Reception**
17				17:10-17:50 **Poster Session (Even No.)**	17:10-18:30 **Poster Session (Group2)**
18				17:50-18:30 **Poster Session (Odd No.)**	
19					

CP: Quantum Computing
SE: Quantum Sensing
CC: Quantum Cryptography & Communication

Thu 31 July

Time	Oral Session Hall 3 (Grand Hall 3)	Oral Session Hall 2 (Grand Hall 2)	Oral Session Hall 1 (Grand Hall 1)	Poster 1 Exhibition (Park Hall 2 / Park Hall 1)	Poster 2-5 Exhibition (Hoyer/Lobby/ Corridor)
8:40-10:10	JT-01(CP+SE) Quantum Sensing, Bilogy and Computing		CC-05 Social Implementation of Quantum Communication	Exhibition Poster Viewing	Exhibition Poster Viewing (Group2)
10:10-10:30	Break				
10:30-12:00	JT-02(CC+CP) Quantum Communication and Computation		SE-06 Atomic/Ion Quantum Sensing		
12:00-13:40	Lunch Break & Networking				Poster Removal (Group2)
13:40-15:10	PL-05 IYQ Keynotes *Available via live online streaming and on-demand viewing			Exhibition Removal	Exhibition Removal
15:10-15:20	Break				
15:20-15:30	Quantum Art Exhibition				
15:30-17:00	PL-06 IYQ Keynotes *Available via live online streaming and on-demand viewing				
17:00-				Poster Removal	
18:00-20:00	Banquet at the Garden Oriental Osaka				

CP: Quantum Computing
SE: Quantum Sensing
CC: Quantum Cryptography & Communication

Fri 1 August

SIP3 special session — Grand Hall 3

8:40-8:55	**Opening**
8:55-10:05	**SP-01 Quantum Security and Network**
10:05-10:20	**Break**
10:20-11:30	**SP-02 Quantum Computing**
11:30-13:00	**Lunch Break & Networking**
13:00-14:10	**SP-03 Innovation Creation Platform**
14:10-14:25	**Break**
14:25-15:25	**SP-04 Quantum Sensing**
15:25-15:30	**Closing**

MS6 Session — Grand Hall 2＋Grand Hall 1

8:40-8:55	**Opening**
8:55-10:25	**MS-01* Fault-tolerant Quantum Computing**
10:25-10:45	**Break**
10:45-11:45	**MS-01* Fault-tolerant Quantum Computing**
11:45-13:15	**Lunch Break & Networking**
13:15-14:10	**MS-02* Quantum Computing (Superconductinig)**
14:10-14:30	**Break**
14:30-16:15	**MS-03* Quantum Computing (Neutral Atom)**
16:15-16:35	**Break**
16:35-17:30	**MS-04* Quantum Computing (Trapped ion)**

Sat 2 August

MS6 Session — Grand Hall 2＋Grand Hall 1

8:40-10:25	**MS-05* Quantum Computing (Semiconductor)**
10:25-10:45	**Break**
10:45-11:40	**MS-06* Quantum Computing (Photon)**
11:40-13:10	**Lunch Break & Networking**
13:10-14:40	**MS-07* Quantum Communication and Network**
14:40-15:00	**Break**
15:00-16:00	**MS-07* Quantum Communication and Network**
16:00-16:10	**Closing**

*Available via live online streaming

Program

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

July 29

Grand Hall 1+2+3

	Session / Presentation	Chairperson# / Presenter	Affiliation
10:00-10:10	**OP. Opening Remarks**	**Masahiro Kitagawa**	**General Chair, Quantum Innovation 2025 Organizing Committee**
	PL-01. Opening	**Masashi Kawasaki #**	**RIKEN**
10:10-10:15	Welcome Message	Tetsuro Fukunaga	Cabinet Office, Government of Japan
10:15-10:20	Welcome Message (video message)	Yoshimasa Hayashi	Chairperson, Parliamentary Association for Quantum Technology Promotion
10:20-10:25	Welcome Message (video message)	Seiji Kihara	Chairperson, Quantum Industry Creation Project Team
10:25-10:35	PL-01-5. The Quantum Europe Strategy: A Global Outlook and Opportunities for EU–Japan Cooperation	Oscar Diez	European Commission
	PL-02. Global Quantum Ecosystem	**Kazuya Masu #**	**G-QuAT, AIST**
10:40-12:00	Panel Discussion	Taro Shimada	Q-STAR, Toshiba
		Ditte Bjerregaard	Ministry of Foreign Affairs of Denmark
		Ling Keok Tong	Singapore’s National Quantum Office (NQO)
		Jonathan Legh-Smith	UK Quantum
12:00-13:40	**Lunch Break & Networking**		

Grand Hall 3

	Session / Presentation	Chairperson# / Presenter	Affiliation
	PL-03. Policy	**Masashi Kawasaki #**	**RIKEN**
13:40-13:55	PL-03-1. TBA	Daisuke Kawakami	Cabinet Office, Government of Japan
13:55-14:10	PL-03-2. Denmark: A Quantum & Deep-Tech Harbour	Ditte Bjerregaard	Ministry of Foreign Affairs of Denmark
14:10-14:25	PL-03-3. Building the Quantum Workforce: Europe’s Strategy for Skills, Education, and Inclusive Talent Pipelines	Oscar Diez	European Commission
14:25-14:40	PL-03-4. Singapore’s National Quantum Strategy: Building Global Partnerships and Future-Ready Capabilities	Ling Keok Tong	Singapore’s National Quantum Office (NQO)
14:40-14:55	PL-03-5. Superpositioned for Collaboration: The UK's National Quantum Technologies Programme	Marie-Louise Taylor	British Embassy Tokyo
		Najwa Sidqi	STFC, NQCC

	Session / Presentation	Chairperson# / Presenter	Affiliation
15:10-15:30	**BREAK**		
	PL-04. Industry	**Shunsuke Okada #**	**Q-STAR**
15:30-16:00	Panel Discussion	Taro Shimada	Q-STAR, Toshiba
		Lisa Lambert	Quantum Industry Canada (QIC)
		Thierry Botter	European Quantum Industry Consortium (QuIC)
		Celia Merzbacher	QED-C
16:00-16:10	PL-04-1. Scalable Qubit Controller	Yosuke Ito	QuEL
16:10-16:20	PL-04-2. Advancing Toward FTQC: Practical Quantum Algorithm Initiatives	Yu-ichiro Matsushita	Quemix
16:20-16:30	PL-04-3. Building the Quantum Internet: LQUOM's Approach to Scalable Quantum Repeaters	Yuya Mochizuki	LQUOM
16:30-16:40	PL-04-4. Expanding Real-World Applications of Quantum Optimization: From Classical Solvers to Quantum Hardware Integration	Yu Yamashiro	Jij
16:40-16:50	PL-04-5. TBA	Tennin Yan	QunaSys
16:50-17:00	PL-04-6. QuEra Computing: Advancing Quantum with Neutral Atoms	Ayumu Imai	QuEra

Grand Hall 2

	Session / Presentation	Chairperson# / Presenter	Affiliation
	CP-01. Quantum Algorithms and Foundation	**François Le Gall #**	**Nagoya University**
13:40-14:10	CP-01-1. Classical Simulation of Non-Gaussian Quantum Circuits	Robert König	Munich Center for Quantum Science and Technology
14:10-14:40	CP-01-2. Reducing the Number of Qubits in Quantum Factoring	Clémence Chevignard	University of Rennes
14:40-15:10	CP-01-3. Generalized Quantum Stein's Lemma and Second Law of Quantum Resource Theories	Hayata Yamasaki	The University of Tokyo
15:10-15:30	**BREAK**		
	CP-02. Practical Quantum Computing	**Keisuke Fujii #**	**The University of Osaka**
15:30-16:00	CP-02-1. Sample-based quantum diagonalization for quantum chemistry calculations with classical and quantum computers	Mario Motta	IBM T.J. Watson Research Center
16:00-16:30	CP-02-2. Recent progress in early fault-tolerant quantum algorithms for eigenvalue problems	Lin Lin	University of California Berkeley
16:30-17:00	CP-02-3. Double-bracket quantum algorithms for ground-state preparation via cooling	Yudai Suzuki	École Polytechnique Fédérale de Lausanne (EPFL)

Grand Hall 1

	Session / Presentation	Chairperson# / Presenter	Affiliation
	SE-01. Optical Quantum Sensing**	**Soyoung Baek #**	**Tohoku University**
13:40-14:10	SE-01-1. Imaging and sensing with “undetected photons”: From a scientific curiosity to new measurement tools	Frank Kühnemann	Freiburg University
14:10-14:40	SE-01-2. Quantum-inspired classical optical metrology	Yoon-Ho Kim	Pohang University of Science and Technology
14:40-15:10	SE-01-3. Quantum sensing using entangled photons	Shigeki Takeuchi	Kyoto University
15:10-15:30	**BREAK**		
	CC-01. Quantum Communication	**Kae Nemoto #**	**OIST**
15:30-16:00	CC-01-1. Quantum Repeaters: Fermions or Bosons?	Peter van Loock	University of Mainz
16:00-16:30	CC-01-2. TBA	Tomoyuki Morimae	Kyoto University
16:30-17:00	CC-01-3. Our Recent Progress in Photonic Quantum Technologies Toward the Quantum Internet	Rikizo Ikuta	The University of Osaka

**8th IFQMS Joint Session

July 30

Grand Hall 3

	Session / Presentation	Chairperson# / Presenter	Affiliation
	CP-03. QC with Ions, Atoms and Photons: part1	**Shuntaro Takeda #**	**The University of Tokyo**
8:40-9:10	CP-03-1. Quantum Advantage with Continuous Variable Optical Systems	Ulrik Lund Andersen	Technical University of Denmark
9:10-9:40	CP-03-2. Optical Parametric Amplifiers based on PPLN waveguides for Continuous-variable Optical Quantum Computing	Takeshi Umeki	NTT
9:40-10:10	CP-03-3. Quantinuum's Trapped-Ion Quantum Computers	Brian Neyenhuis	Quantinuum
10:10-10:30	**BREAK**		
	CP-04. QC with Ions, Atoms and Photons: part2	**Takafumi Tomita #**	**Institute for Molecular Science**
10:30-11:00	CP-04-1. Universal Gate Set for Bosonic Logical Qubits in Mechanical Oscillators of Trapped Ions	Ting Rei Tan	The University of Sydney
11:00-11:30	CP-04-2. Benchmarking and Fault-Tolerant Operation of a Neutral Atom Quantum Processor	Thomas Noel	Infleqtion
11:30-12:00	CP-04-3. Development of Ytterbium Atom Tweezer Array For Quantum Computing	Yoshiro Takahashi	Kyoto University
12:00-13:40	**Lunch Break & Networking**		
	CP-05. Superconducting QC	**Yutaka Tabuchi #**	**RQC**
		Kunihiro Inomata #	**AIST**
13:40-14:10	CP-05-1. Challenges in Achieving Practical Quantum Computing	Shintaro Sato	Fujitsu, RIKEN
14:10-14:40	CP-05-2. Quantum computing from chips to applications at IQM	Juha Hassel	IQM Quantum Computers
14:40-15:10	CP-05-3. Imaging defects in live superconducting quantum circuits: revealing sources of decoherence	Sebastian de Graaf	National Physical Laboratory
15:10-15:30	**BREAK**		
	CP-06. Semiconductor QC	**Takahiro Mori #**	**AIST**
		Yusuke Kozuka #	**NIMS**
15:30-16:00	CP-06-1. Silicon Spin Qubits: Advances and Insights from SiGe and FDSOI Technologies	Elena Blokhina	Equal1 Laboratories
16:00-16:30	CP-06-2. Engineering Substrates to Accelerate the Quantum Leap	Cesar Road Neve	SOITEC
16:30-17:00	CP-06-3. Toward Stable Operation of Si Spin Qubits: Origin of Long-period Charge Fluctuation in Fin-type Quantum Dots	Hiroshi Oka	AIST

Grand Hall 2

	Session / Presentation	Chairperson# / Presenter	Affiliation
	SE-02. Hyperpolarization method**	**Nobuhiro Yanai #**	**The University of Tokyo**
8:40-9:10	SE-02-1. Quantum sensing with molecular systems	Ashok Ajoy	University of California Berkeley
9:10-9:40	SE-02-2. Nuclear Zeeman and Singlet State Relaxation from Experiment and Computation	Alexej Jerschow	New York University
9:40-10:10	SE-02-3. Crystal Engineering of Polarization Solids at Room Temperature	Munehiro Inukai	Tokushima University
10:10-10:30	**BREAK**		
	SE-03. Quantum Life / Hyperpolarized Application	**Shigeki Kiyonaka #**	**Nagoya University**
10:30-11:00	SE-03-1. Development of Hyperpolarized Carbon-13 Molecular Imaging for Novel Human Clinical-Research Studies	Daniel B. Vigneron	University of California San Francisco
11:00-11:30	SE-03-2. Shaping the Future of Clinical Metabolic Imaging with Hyperpolarized ^{13}C MRI	Arnaud Comment	GE HealthCare
11:30-12:00	SE-03-3. New Horizons in Hyperpolarized MRI using Quantum Technologies	Ilai Schwartz	NVision Imaging Technologies GmbH
12:00-13:40	**Lunch Break & Networking**		
	SE-04. Solid-State/Nano Quantum Sensing (1)**	**Norikazu Mizuochi #**	**Kyoto University**
13:40-14:10	SE-04-1. Nanoscale Quantum Sensing	Jörg Wrachtrup	University of Stuttgart
14:10-14:40	SE-04-2. About the electronic structure and charge state dynamics of nitrogen-vacancy centers in diamond	Ronald Ulbricht	Max-Planck Institute for Polymer Research
14:40-15:10	SE-04-3. Precision current comparator for AC and DC current ratio measurements using a nitrogen-vacancy center in a diamond	Yasutaka Amagai	AIST,G-QuAT
15:10-15:30	**BREAK**		
	SE-05. Solid-State/Nano Quantum Sensing (2)**	**Yuichi Yamazaki #**	**QST**
15:30-16:00	SE-05-1. Spin Defects in Low-Dimensional Materials for Quantum Sensing	Vladimir Dyakonov	Julius Maximilian University of Würzburg
16:00-16:30	SE-05-2. Harnessing Quantum Defects in Fluorescent Nanodiamonds for Semiconductor Applications	Huan-Cheng Chang	Academia Sinica
16:30-17:00	SE-05-3. Fluorescent nanodiamonds for thermal biology	Yoshie Harada	The University of Osaka

**8th IFQMS Joint Session

Grand Hall 1

	Session / Presentation	Chairperson# / Presenter	Affiliation
	CC-02. Progress and Prospects on Quantum Cryptography	**Go Kato #**	**NICT**
8:40-9:10	CC-02-1. Progress in Security Analysis of Practical Quantum Key Distribution	Norbert Luetkenhaus	University of Waterloo
9:10-9:40	CC-02-2. Entanglement in Science and Technology for Quantum Key Distribution	Akihisa Tomita	NICT
9:40-10:10	CC-02-3. A Security Framework for Quantum Key Distribution Implementations	Kiyoshi Tamaki	University of Toyama
10:10-10:30	**BREAK**		
	CC-03. Standardization and Certification of QKD and PQC	**Masahide Sasaki #**	**NICT**
10:30-10:50	CC-03-1. Standardisation and Assurance of Quantum Security Technologies	Martin Ward	Toshiba Europe
10:50-11:10	CC-03-2. Recent Developments in Post-Quantum Cryptography	Tsuyoshi Takagi	The University of Tokyo
11:10-12:00	Panel Discussion	Martin Ward	Toshiba Europe
		Norbert Luetkenhaus	University of Waterloo
		Tsuyoshi Takagi	The University of Tokyo
		Masato Koashi	The University of Tokyo
12:00-13:40	**Lunch Break & Networking**		
	CC-04. Free-Space Quantum Key Distribution	**Yoko Miyamoto #**	**The University of Electro-Communications**
13:40-14:10	CC-04-1. Quantum communication in Space – An important step towards a global quantum internet	Thomas Jennewein	University of Waterloo
14:10-14:40	CC-04-2. Free-space optical communication technology for quantum key distribution via satellite	Hideki Takenaka	Tokyo Metropolitan University
14:40-15:10	CC-04-3. Study on QKD Using Optical Wireless Technology: Challenges and Future Prospects for Practical Use of Quantum Cryptography	Masayuki Miyashita	SoftBank
15:10-15:30	**BREAK**		
	CP-07. Quantum Annealing	**Shu Tanaka #**	**Keio University**
15:30-16:00	CP-07-1. TBA	Yuya Seki	Keio University
16:00-16:30	CP-07-2. Thermalization and criticality on an analog-digital quantum simulator	Trond I. Andersen	Google Quantum AI
16:30-17:00	CP-07-3. Annealing Quantum Computation for Scientific Applications	Mark Johnson	D-Wave

July 31

Grand Hall 2+3

	Session / Presentation	Chairperson# / Presenter	Affiliation
	JT-01 (CP+SE). Quantum Sensing, Biology and Computing	**Makoto Negoro #**	**The University of Osaka**
8:40-9:10	JT-01-1. Future of Quantum Biology through Quantum Computing: Expectations and Practical Challenges	Wataru Mizukami	The University of Osaka
9:10-9:40	JT-01-2. Experimental Evidence for Quantum Tunnelling of Protons in DNA Mutation	Johnjoe McFadden	University of Surrey
9:40-10:10	JT-01-3. Quantum Technologies for Magnetic Resonance Spectroscopy, Imaging and Sensing in the Life Sciences	Martin B. Plenio	Ulm University
10:10-10:30	**BREAK**		
	JT-02 (CC+CP). Quantum Communication and Computation	**Yasunari Suzuki #**	**RIKEN**
10:30-11:00	JT-02-1. Simulating photons traveling through linear optical elements for more accurate models of quantum interconnects	Akihito Soeda	NII
11:00-11:30	JT-02-2. Fast and Scalable Fault-Tolerant Quantum Computing with Neutral Atoms and Cavity-QED Interconnects	Shinichi Sunami	NanoQT
11:30-12:00	JT-02-3. Toward Scalable Multicore Fault-Tolerant Quantum Computers using Quantum Multiplexing	Shin Nishio	Keio University, University College London

Grand Hall 1

	Session / Presentation	Chairperson# / Presenter	Affiliation
	CC-05. Social Implementation of Quantum Communication	**Mayuko Koezuka #**	**Toshiba**
8:40-9:10	CC-05-1. Migration to Post-Quantum Cryptography: Recent Trend and Challenges in the Financial Sector	Masashi Une	Bank of Japan
9:10-9:40	CC-05-2. Towards a Global Quantum Cryptography Infrastructure	Taofiq Paraiso	Toshiba Europe
9:40-10:10	CC-05-3. Quantum Key Distribution Research and Development in NEC	Hiroki Kawahara	NEC
10:10-10:30	**BREAK**		
	SE-06. Atomic/Ion Quantum Sensing	**Utako Tanaka #**	**The University of Osaka**
10:30-11:00	SE-06-1. Multi-ion clocks for compact clocks and sensors	Tanja E. Mehlstaubler	Physikalisch-Technische Bundesanstalt Leibniz Universität Hannover
11:00-11:30	SE-06-2. Quantum-amplified global-phase spectroscopy on an optical clock transition	Leon Zaporski	Massachusetts Institute of Technology
11:30-12:00	SE-06-3. Contributions of NICT's Optical Lattice Clock to Local and International Timescales	Hidekazu Hachisu	NICT

Grand Hall 1+2+3

	Session / Presentation	Chairperson# / Presenter	Affiliation
12:00-13:40	**Lunch Break & Networking**		
	PL-05. IYQ Keynotes	**Masahiro Kitagawa #**	**The University of Osaka**
13:40-14:10	PL-05-1. On the Nature of Quantum Algorithms	Isaac Chuang	Massachusetts Institute of Technology
14:10-14:40	PL-05-2. Superconducting quantum computing at the International Year of Quantum Science and Technology and the future	Yasunobu Nakamura	RIKEN, The University of Tokyo
14:40-15:10	PL-05-3. Engineering high quality qubits in silicon with atomic precision	Michelle Y. Simmons	The University of New South Wales
15:10-15:20	**BREAK**		
	Quantum Art Exhibition	**Makoto Negoro #**	**The University of Osaka**
15:20-15:30	Quantum Art Exhibition	Akihiro Kubota	Tama Art University
	PL-06. IYQ Keynotes	**Mio Murao #**	**The University of Tokyo**
15:30-16:00	PL-06-1. "Machine Learning Physics" --- an emergent new arena of research unifying AI and quantum physics	Koji Hashimoto	Kyoto University
16:00-16:30	PL-06-2. Make Optical Lattice Clocks Compact and Useful for Real-world Applications	Hidetoshi Katori	The University of Tokyo, RIKEN
16:30-17:00	PL-06-3. The Age of Computation is yet to Come	Artur Ekert	University of Oxford

August 1

Grand Hall 3

	Session / Presentation	Chairperson# / Presenter	Affiliation
	OP. Opening	**Yoshiro Hirayama #**	**QST**
8:40-8:55	OP. Opening Remarks	Tetsuomi Sogawa	NTT
	SP-01. Quantum Security and Network	**Goichiro Hanaoka #**	**AIST**
8:55-9:25	SP-01-1. Securing Global Networks in the Quantum Era	Chune Yang Lum	SpeQtral
9:25-9:45	SP-01-2. Quantum secure cloud technology for establishing highly confidential data centers	Mikio Fujiwara	NICT
9:45-10:05	SP-01-3. Applications for Quantum Secure Cloud	Shinya Murai	Toshiba Digital Solutions
10:05-10:20	**BREAK**		
	SP-02. Quantum Computing	**Masahiro Horibe #**	**AIST**
10:20-10:50	SP-02-1. Towards Quantum-Accelerated Supercomputing - A Europe-Japan Perspective	Juha Vartiainen	IQM Quantum Computers
10:50-11:10	SP-02-2. System operation technology for the quantum computer 'A' testbed	Shinichi Yorozu	RIKEN
11:10-11:30	SP-02-3. Quantum Circuit Generation with Transformer-Based Generative AI	Shunya Minami	AIST
11:30-13:00	**Lunch Break & Networking**		
	SP-03. Innovation Creation Platform	**Shunsuke Okada #**	**Q-STAR**
13:00-13:30	SP-03-1. Next-Gen Computing – Bits, Qubits, and Neurons Unite	Heike Riel	IBM
13:30-13:50	SP-03-2. Quantum Universe: A Platform of Education for Creating Quantum Community	Masayuki Ohzeki	Tohoku University, Institute of Science Tokyo
13:50-14:10	SP-03-3. Challenges in the Development of the Quantum Workforce	Shinya Ogata	SKILLUP NeXt
14:10-14:25	**BREAK**		
	SP-04. Quantum Sensing	**Takeshi Oshima #**	**QST**
14:25-14:45	SP-04-1. Nanoscale Quantum Sensors for Ultra-Sensitive Body Fluid Diagnostics: Toward a Quantum Liquid Biopsy Platform	Ryuji Igarashi	QST
14:45-15:05	SP-04-2. Application of Dissolution Dynamic Nuclear Polarization using the Triplet Electrons in Pentacene	Makoto Negoro	QST, The University of Osaka
15:05-15:25	SP-04-3. SiC-based quantum sensors for automobile application	Katsuhiro Kutsuki	Toyota Central R&D Labs.
15:25-15:30	**CL. Closing**	**Hisayoshi Itoh**	**QST**

Grand Hall 1+2

	Session / Presentation	Chairperson# / Presenter	Affiliation
8:40-8:55	**Moonshot:Opening Opening Remarks**	**Masahiro Kitagawa**	**Program Director of Moonshot Goal 6, The University of Osaka**
	MS-01. Fault-tolerant Quantum Computing	**Shigeru Yamashita #**	**Ritsumeikan University**
8:55-9:40	MS-01-1. Quantum Error Correction Below the Surface Code Threshold	Volodymyr Sivak	Google Quantum AI
9:40-10:25	MS-01-2. Research and Development of Theory and Software for Fault-tolerant Quantum Computers	Masato Koashi	The University of Tokyo
10:25-10:45	**BREAK**		
10:45-11:30	MS-01-3. Development of Scalable Highly Integrated Quantum Bit Error Correction System (QUBECS)	Kazutoshi Kobayashi	Kyoto Institute of Technology
11:30-11:45	Discussion		
11:45-13:15	**Lunch Break & Networking**		
	MS-02. Quantum Computing (Superconducting)	**Yasunobu Nakamura #**	**RIKEN, The University of Tokyo**
13:15-14:00	MS-02-1. Toward Large-Scale Integration of Superconducting Quantum Circuits	Tsuyoshi Yamamoto	NEC
14:00-14:10	Discussion		
14:10-14:30	**BREAK**		
	MS-03. Quantum Computing (Neutral Atom)	**Shiro Kawabata #**	**Hosei University**
14:30-15:15	MS-03-1. Large-scale and high-coherence fault-tolerant quantum computer with dynamical atom arrays	Kenji Ohmori	National Institutes for Natural Sciences
15:15-16:00	MS-03-2. Nanofiber Cavity Quantum Electrodynamics Systems for Distributed Quantum Computing	Takao Aoki	Waseda University, RIKEN
16:00-16:15	Discussion		
16:15-16:35	**BREAK**		
	MS-04. Quantum Computing (Trapped ion)	**Nobuyuki Imoto #**	**The University of Tokyo**
16:35-17:20	MS-04. Fault-tolerant Quantum Computing with Photonically Interconnected Ion Traps	Hiroki Takahashi	OIST
17:20-17:30	Discussion		

August 2

Grand Hall 1+2

	Session / Presentation	Chairperson# / Presenter	Affiliation
	MS-05. Quantum Computing (Semiconductor)	**Hidemi Ishiuchi #**	**Former President EIDEC**
8:40-9:25	MS-05-1. Development of Semicondutor Qubit Systems	Seigo Tarucha	RIKEN
9:25-10:10	MS-05-2. Large-scale Silicon Quantum Computer	Hiroyuki Mizuno	Hitachi
10:10-10:25	Discussion		
10:25-10:45	**BREAK**		
10:45-11:45	**MS-06 . Quantum Computing (Photon)**	**Masanao Ozawa #**	**Nagoya University**
10:45-11:30	MS-06-1. Optical Quantum Computers with Quantum Teleportation	Akira Furusawa	The University of Tokyo, RIKEN
11:30-11:40	Discussion		
11:40-13:10	**Lunch Break & Networking**		
	MS-07. Quantum Communication and Network	**Nobuyuki Imoto #**	**The University of Tokyo**
13:10-13:55	MS-07-1. Development of Quantum Interfaces for Building Quantum Computer Networks	Hideo Kosaka	Yokohama National University
13:55-14:40	MS-07-2. Quantum Cyberspace with Networked Quantum Computer	Takashi Yamamoto	The University of Osaka
14:40-15:00	**BREAK**		
15:00-15:45	MS-07-3. Scalable and Robust Integrated Quantum Communication System	Shota Nagayama	Keio University
15:45-16:00	Discussion		
16:00-16:10	**CL. Closing**	**Masahiro Kitagawa**	**General Chair, Quantum Innovation 2025 Organizing Committee**

PL-01-5

The Quantum Europe Strategy: A Global Outlook and Opportunities for EU–Japan Cooperation

Oscar Diez

Head of Sector Quantum Computing, Quantum Technologies, DG CNECT, European Commission, EU

Biography

Oscar Diez is the Head of Sector for Quantum Technologies at the European Commission, where he leads strategic initiatives to position Europe as a global leader in the quantum domain. With a robust background in both academia and public sector innovation, he previously served as Head of the Datacentre at the European Medicines Agency in London. Dr. Diez holds a PhD in Computer Science from Universidad Politécnica de Madrid and a Master's in Open eGovernment from Stockholm University. He also shares his expertise as an adjunct professor at IE University in Madrid. His work focuses on fostering scientific excellence, supporting industrial innovation, and advancing Europe's competitive edge in quantum technologies.

Abstract

In July 2025, the European Commission launched the Quantum Europe Strategy, laying the foundation for Europe's long-term positioning in the global quantum race. The strategy outlines a comprehensive vision across five pillars, research and innovation, quantum infrastructures, quantum ecosystem, space/dual use and quantum skills, with the forthcoming Quantum Act serving as a legislative backbone to guide coordinated action across Member States and EU programmes.

In this keynote, Dr. Oscar Diez, Head of the Quantum Computing Sector at DG CONNECT, will present the core elements of this strategy and outline how international cooperation is embedded as a strategic enabler.

Japan is one of the EU's most valued quantum partners sharing a commitment to open science, responsible innovation, and economic security. This address will highlight areas for enhanced EU–Japan collaboration, including quantum computing, quantum sensing, benchmarking, secure communications, and standardisation. By aligning strategic priorities and pooling complementary strengths, the EU and Japan can help shape a trusted global quantum ecosystem that delivers tangible benefits for science, society, and industry.

PL-02-1

Policy

Taro Shimada

Q-STAR, Toshiba Corporation

Biography

Taro Shimada started his career at ShinMaywa Industries, Ltd., and subsequently held key positions at Siemens K.K. In October 2018, he joined Toshiba Corporation as Corporate Digital Business Chief Strategy Officer. In April 2019, he was appointed Chief Digital Officer, where he led Toshiba's digital transformation initiatives and spearheaded the creation and promotion of strategic business ventures. He was appointed President and CEO of Toshiba Digital Solutions Corporation in April 2020.

In March 2022, Mr. Shimada assumed the role of President and Chief Executive Officer of Toshiba Corporation. In May of the same year, he was named Chair of the Board of Q-STAR (Quantum STrategic industry Alliance for Revolution), a consortium that promotes business creation through quantum technologies. In August 2024, he was appointed Chairperson of the Quantum Ecosystem Promotion Working Group, Quantum Technology Innovation Council, Cabinet Office, Government of Japan.

PL-02-2

Denmark - the Deep Tech Harbour

Ditte Bjerregaard

Ministry of Foreign Affairs of Denmark

Biography

Tech diplomacy is a pioneering initiative elevating technology and digitalization to a cross-cutting foreign and security policy priority of the Danish government. Ditte Bjerregaard has been part of the Tech Department leadership in the Danish Ministry of Foreign Affairs for the last three years, with a special focus on the new Danish Strategy for Technological Diplomacy, the Danish Government's Quantum Strategy and establishing the International Quantum Hub in the Ministry of Foreign Affairs. Ditte joined the Danish Ministry of Foreign Affairs in 2007 and has as a career diplomat worked with especially new and emerging challenges and the Arctic. She has served as the first Representative in Greenland for the Ministry of Foreign Affairs, as a senior advisor in the Prime Minister's Office and as a team-leader on investment screening, non-proliferation, export control and the Arctic for several years in the Department for Security Policy in the Ministry of Foreign Affairs. Her career also includes postings in Nepal and Afghanistan.

PL-02-3

Policy

Ling Keok Tong

Singapore's National Quantum Office (NQO)

Biography

Mr Ling Keok Tong is the Executive Director of Singapore's National Quantum Office (NQO), hosted at A*STAR. He leads the development and implementation of Singapore's National Quantum Strategy (NQS), which advances quantum research, innovation, ecosystem building, and talent development. Mr Ling also serves in Singapore's National Quantum Steering Committee, the Governing Board of the Centre for Quantum Technologies (CQT) as well as the National Supercomputing Centre (NSCC) Steering Committee. Prior to this role, Mr Ling was Director of the Smart Nation & Digital Economy (SNDE) Directorate at the National Research Foundation (NRF), where he guided national investments in digital and emerging technologies. He has also held leadership roles at A*STAR in AI, Future of Manufacturing (FoM) and Information and Communications Technologies (ICT), and played a key role in advancing Singapore's digitalisation initiatives. Earlier in his career, Mr Ling served at the Infocomm Development Authority of Singapore (IDA) and its predecessor organisation,the then Telecommunications Authority of Singapore (TAS), where he had undertaken lead roles in standards, type approval, spectrum management, infrastructure development, strategic planning and technology development. Among his key accomplishments was being a key member of the pioneer team that developed the concept for the Next Generation National Broadband Network; a fibre to every home and building in Singapore. Mr Ling holds a Distinction in Master of Science Communications & Signal Processing from Imperial College, UK and a Bachelor of Electrical & Electronic Engineering (2nd Upper Honours) from Nanyang Technological University, Singapore. Mr Ling was awarded the Public Administration Medal (Bronze) and the Long Service Medal in the 2024 and 2015 National Day Awards respectively.

PL-02-4

Policy

Jonathan Legh-Smith

UK Quantum

Biography

Jonathan Legh-Smith is Executive Director for UKQuantum, the association for the UK's quantum industry. Jonathan represents the interests of UKQuantum members nationally and internationally. Jonathan is also a member of the UK National Quantum Technologies Programme Strategic Advisory Board, the National Quantum Computing Centre Strategic Advisory Committee, UK coordinator for the NATO Transatlantic Quantum Community Industry Network, NPL's Quantum Strategy Board and co-chair of the UK's Responsible Quantum Industry Forum. Jonathan was awarded an MBE for services to science & technology in 2024

PL-03-1

TBA

Daisuke Kawakami

Cabinet Office

PL-03-2

Denmark: A Quantum & Deep-Tech Harbour

Ditte Bjerregaard

Deputy Tech Ambassador, Danish Ministry of Foreign Affairs., Denmark

Biography

Tech diplomacy is a pioneering initiative elevating technology and digitalization to a cross-cutting foreign and security policy priority of the Danish government. Ditte Bjerregaard has been part of the Tech Department leadership in the Danish Ministry of Foreign Affairs for the last three years, with a special focus on the new Danish Strategy for Technological Diplomacy, the Danish Government's Quantum Strategy and establishing the International Quantum Hub in the Ministry of Foreign Affairs. Ditte joined the Danish Ministry of Foreign Affairs in 2007 and has as a career diplomat worked with especially new and emerging challenges and the Arctic. She has served as the first Representative in Greenland for the Ministry of Foreign Affairs, as a senior advisor in the Prime Minister's Office and as a team-leader on investment screening, non-proliferation, export control and the Arctic for several years in the Department for Security Policy in the Ministry of Foreign Affairs. Her career also includes postings in Nepal and Afghanistan.

Abstract

Since Niels Bohr's pioneering research, which laid the foundation for our understanding of quantum mechanics, some very strong research environments within quantum have been established in Denmark. Denmark remains at the forefront of quantum technology research and enjoys widespread international recognition.

Denmark's national quantum strategy aspires to position the country as a global leader in quantum technology by fostering innovation, commercialization, and international collaboration. The strategy emphasizes building a vibrant ecosystem where research excellence translates into real-world applications and economic growth. Key ambitions include establishing Denmark as a preferred location for quantum companies, ensuring national security through quantum-safe infrastructure, and attracting top global talent and investment. By integrating research, industry, and policy, Denmark aims to leverage its scientific legacy to drive technological advancement, strengthen critical infrastructure, and contribute meaningfully to the global quantum landscape.

In her intervention, Deputy Tech Ambassador, Ditte Bjerregaard, will outline the latest policy measures turning strategy into reality, the unique Danish ecosystem as well as the inherent international outlook that underpins Danish quantum policy.

PL-03-3

Building the Quantum Workforce: Europe's Strategy for Skills, Education, and Inclusive Talent Pipelines

Oscar Diez

Head of Sector Quantum Computing, Quantum Technologies, DG CNECT, European Commission, EU

Biography

Oscar Diez is the Head of Sector for Quantum Technologies at the European Commission, where he leads strategic initiatives to position Europe as a global leader in the quantum domain. With a robust background in both academia and public sector innovation, he previously served as Head of the Datacentre at the European Medicines Agency in London. Dr. Diez holds a PhD in Computer Science from Universidad Politécnica de Madrid and a Master's in Open eGovernment from Stockholm University. He also shares his expertise as an adjunct professor at IE University in Madrid. His work focuses on fostering scientific excellence, supporting industrial innovation, and advancing Europe's competitive edge in quantum technologies.

Abstract

Europe's Quantum Strategy recognises that technology leadership requires a strong and inclusive talent base. In this session, Dr. Oscar Diez will present the EU's multifaceted approach to developing a skilled quantum workforce, bridging research, education, and industry.

At the heart of the EU agenda is the upcoming Quantum Digital Skills Academies, designed to provide open, modular, and high-quality training resource. It establishes a central-sectoral academy delivering specialised quantum training and hands-on experience across all education levels.

This presentation outlines how the Academy addresses three strategic pillars:

1. **Knowledge, Education, and Training** – developing academic curricula (ISCED 7–8), modular courses, tutorials, and summer schools linked to ECTS, with internships and lab placements for non-expert professionals
2. **Building the Ecosystem** – partnering academia, industry (including SMEs), and research institutes to scale training, mentorship, bootcamps, and facility visits.
3. **Measuring Progress** – establishing KPIs for trainee numbers, employability outcomes, diversity (including gender balance), and monitoring via Digital Europe indicators.

Dr. Diez will also highlight synergies with the Quantum Virtual Academy and Horizon Europe programmes, and explore how mobility and exchange links with partners like Japan can deepen cooperation. By aligning Europe's efforts in strategic talent development with global partners, the Academy seeks to secure both Europe's and international quantum competitiveness. The Commission is also launching targeted initiatives to support PhDs and postdocs, dual-use talent development (including quantum for defense and space), and re-skilling pathways through Centers of Excellence.

Moreover, the EU promotes talent mobility and exchange programmes that can facilitate deeper collaboration with partners like Japan. As quantum enters mainstream industry, bridging gaps between academia and high-tech sectors—especially SMEs and start-ups is essential.

This presentation will also address diversity and inclusion as central pillars of the EU's skills roadmap, reflecting a broader commitment to democratic, trustworthy innovation. Europe welcomes joint efforts to build global talent pipelines and to promote human capital as the foundation of a competitive and responsible quantum future.

PL-03-4

Singapore’s National Quantum Strategy: Building Global Partnerships and Future-Ready Capabilities

Ling Keok Tong

Singapore’s National Quantum Office (NQO)

Biography

Mr Ling Keok Tong is the Executive Director of Singapore’s National Quantum Office (NQO), hosted at A*STAR. He leads the development and implementation of Singapore’s National Quantum Strategy (NQS), which advances quantum research, innovation, ecosystem building, and talent development. Mr Ling also serves in Singapore’s National Quantum Steering Committee, the Governing Board of the Centre for Quantum Technologies (CQT) as well as the National Supercomputing Centre (NSCC) Steering Committee. Prior to this role, Mr Ling was Director of the Smart Nation & Digital Economy (SNDE) Directorate at the National Research Foundation (NRF), where he guided national investments in digital and emerging technologies. He has also held leadership roles at A*STAR in AI, Future of Manufacturing (FoM) and Information and Communications Technologies (ICT), and played a key role in advancing Singapore’s digitalisation initiatives. Earlier in his career, Mr Ling served at the Infocomm Development Authority of Singapore (IDA) and its predecessor organisation,the then Telecommunications Authority of Singapore (TAS), where he had undertaken lead roles in standards, type approval, spectrum management, infrastructure development, strategic planning and technology development. Among his key accomplishments was being a key member of the pioneer team that developed the concept for the Next Generation National Broadband Network; a fibre to every home and building in Singapore. Mr Ling holds a Distinction in Master of Science Communications & Signal Processing from Imperial College, UK and a Bachelor of Electrical & Electronic Engineering (2nd Upper Honours) from Nanyang Technological University, Singapore. Mr Ling was awarded the Public Administration Medal (Bronze) and the Long Service Medal in the 2024 and 2015 National Day Awards respectively.

Abstract

Singapore’s National Quantum Strategy (NQS), launched in May 2024, outlines a coordinated approach to position Singapore as a leading trusted global hub for quantum technology development and deployment. With close to S$300 million committed to foundational research, industry translation, talent development and international partnerships, the NQS aims to unlock real-world impact through quantum computing, quantum communication and quantum sensing. In this plenary session, Ling Keok Tong, Executive Director of the National Quantum Office (NQO), will share key milestones and initiatives under the NQS, including the launch of the National Quantum Processor Initiative (NQPI), the National-level Quantum Programmes and the National Quantum Scholarships Scheme (NQSS). He will also highlight how Singapore is fostering a collaborative ecosystem with academia, startups and global technology leaders, while advancing international collaboration on quantum R&D.

PL-03-5

Superpositioned for Collaboration: The UK's National Quantum Technologies Programme

Marie-Louise Taylor

British Embassy Tokyo

Biography

Marie-Louise has been the UK Science and Technology Network's Regional Director for North-East Asia, based in Tokyo, since February 2022. The Science and Technology Network (STN) is the UK Government's official international representation on science, innovation and technology, comprised of approximately 130 staff working in over 65 locations around the world.
Prior to this, Marie-Louise worked on UK Government's COVID-19 response, leading a team in the Science Advice for Government Emergencies (SAGE) Secretariat, facilitating rapid expert advice to assist the Prime Minister to respond to the pandemic. She went on to lead strategy in the Department for Health and Social Care's COVID-19 Antivirals Taskforce. She has held a range of government science roles, including in UK Navy Command and the Science and Technology Facilities Research Council. Marie-Louise joined UK Government in 2016 having started her career at Deloitte in London, in Banking and Capital Markets Audit. She has a Masters degree in Physics and Astronomy.

Najwa Sidqi

NQCC

Biography

Dr. Najwa Sidqi is an experienced quantum technologies specialist with a strong background in knowledge transfer, network development, and applied research. She currently serves as the Quantum Cluster Manager at the Science and Technology Facilities Council (STFC), leading initiatives to grow Harwell's quantum ecosystem and foster cross-sector collaboration in areas including space, health, defence and energy.
Prior to joining the STFC, Dr. Sidqi was Knowledge Transfer Manager in quantum technologies at Innovate UK Business Connect, where she led industry engagement activities, completed the EU and UK quantum landscape mapping, and managed contributions to major initiatives such as the QuantERA consortium across Europe.
Her earlier roles include contributions to policy development for the UK quantum infrastructure during a secondment with the Royal Academy of Engineering, research in spintronics and nanofabrication at Helia Photonics Ltd, and process optimisation work at Saint-Gobain Sekurit Deutschland. She has also held technical engineering positions at SERMA Technologies and STMicroelectronics, focusing on semiconductor characterisation and reliability testing. Dr. Sidqi holds a PhD in Ultrafast Photonics from Heriot-Watt University, as well as master's degrees in Nanotechnology and Materials Science from INSA de Rennes.

Abstract

Since its creation in 2014, the UK Government's National Quantum Technologies Programme has put the UK on the map as a global leader in quantum research, regulation and commercialisation. With over £1.2bn of investment – nearly JPY240bn – from both public and private sectors since its inception, the Programme has built world-class university facilities supporting exceptional quantum research and developed a thriving business community.

The Programme represents a synthesised approach across the whole of UK government departments and agencies. It is truly a collaborative ecosystem, supporting the development of new real-world applications for quantum technology and building on the 2025 Quantum Skills Taskforce Report to forge

new pathways into the quantum sector and prepare for quantum adoption. Working closely with partners from across the world to shape international standards and governance frameworks on quantum technologies is part of this open and collaborative approach.

The UK last month published its ‘Modern Industrial Strategy’, a flagship strategy for the government that is underpinned by a series of sector plans to help realise goals for growth and economic output over the next 10 years. This includes a digital and technologies sector plan, in which Quantum is one of the six priority frontier technologies.

CP-01-1

Classical Simulation of Non-Gaussian Quantum Circuits

Robert Koenig

School of Computation, Information and Technology, Technical University of Munich, Munich Center for Quantum Science and Technology

Biography

Robert Koenig studied theoretical physics at ETH Zurich. He obtained a Ph.D. from the Department of Applied Mathematics and Theoretical Physics of the University of Cambridge, U.K. After postdocs at the Institute for Quantum Information of the California Institute of Technology, Pasadena and the Physics of Information group at IBM Watson, Yorktown Heights, he became an assistant professor at the Institute for Quantum Computation, Waterloo. In 2015, he moved to the Technical University of Munich where he became an associate professor in 2020. He is interested in all operational aspects of quantum mechanics.

Abstract

We review recent progress on the problem of simulating the behavior of quantum circuits by classical algorithms, a key computational tool for the assessment of quantum-information-processing proposals. A cornerstone result here is the Gottesman-Knill theorem which provides a means for efficiently simulating the dynamics of a Clifford circuit applied to stabilizer states. By incorporating phase-sensitivity in the simulation, this approach has successfully been extended to apply to non-stabilizer states and non-Clifford operations. We argue that simulation algorithms for (fermionic and bosonic) Gaussian circuits can similarly be modified to study circuits with non-Gaussian elements. In addition, we present a new reduction from strong to weak simulation. This enables efficient sampling from output distributions of measurements having continuous outcomes and is particularly relevant for the simulation of quantum optics with non-linearities.

This is joint work with Beatriz Dias.

[1] Beatriz Diaz and Robert Koenig, Classical simulation of non-Gaussian bosonic circuits, Phys. Rev. A 110, 042402 (2024)
[2] Beatriz Diaz and Robert Koenig, Classical simulation of non-Gaussian fermionic circuits, Quantum 8, 1350 (2024)
[3] Beatriz Dias and Robert Koenig, On the sampling complexity of coherent superpositions, arXiv:2501.17071

CP-01-2

Reducing the Number of Qubits in Quantum Factoring

Clémence Chevignard, Pierre-Alain Fouque, André Schrottenloher

University of Rennes

Biography

Clémence Chevignard is a PhD student in Rennes, at Inria, in the team CAPSULE. She is supervised by Pierre-Alain Fouque, Rémi Géraud-Stewart, and Alexandre Wallet. Her primary fields of interest are quantum algorithms and lattices. She has a master degree in cybersecurity.

Abstract

Shor's algorithm is a fundamental algorithm in quantum computing, that allows among other things to factor integers. Currently, its space complexity is too big for us to run it on actual quantum computers, in order to break RSA. We improve this aspect of the situation by proposing a space optimisation of Shor's algorithm. This optimisation applies when we intend to use this algorithm to factor RSA integers. It relies on a combination of previous ideas from Hekera and Hastad, May and Sliepper, and on careful arithmetic tricks, such as the Residue Number System. In the end, our optimisation that allows to factor an RSA integer using less qubits than what is required to store this integer, assymptotically. Typically, to factor an RSA-2048 instance, we estimate that 1730 logical qubits will suffice. This comes with a reasonnable tradeoff with the time complexity of the algorithm.

CP-01-3

Generalized Quantum Stein's Lemma and Second Law of Quantum Resource Theories

Hayata Yamasaki

Department of Computer Science, Graduate School of Information Science and Technology, The University of Tokyo, Japan

Biography

Hayata Yamasaki is an Associate Professor in the Department of Computer Science at the Graduate School of Information Science and Technology, the University of Tokyo. He received his Ph.D. in Physics from the University of Tokyo in 2019 under the supervision of Professor Mio Murao, focusing on entanglement theory in distributed quantum information processing. He subsequently held postdoctoral positions in the groups of Professor Masato Koashi at the University of Tokyo and Professor Marcus Huber at the Institute for Quantum Optics and Quantum Information (IQOQI) Vienna and TU Wien. From 2022 to 2025, he served as an Assistant Professor in the Department of Physics at the University of Tokyo before taking up his current position.

His research aims to establish a theoretical foundation for quantum information science, with particular emphasis on quantum resource theories, fault-tolerant quantum computation, and quantum machine learning. By investigating the optimal performance and fundamental limits of quantum information processing under the laws of quantum mechanics, his work bridges foundational theory and practical application, contributing to a deeper understanding of what is achievable through the scalable realization of quantum technologies.

Abstract

The second law of thermodynamics is the cornerstone of physics, characterizing the convertibility between thermodynamic states through a single function, entropy. Given the universal applicability of thermodynamics, a fundamental question in quantum information theory is whether an analogous second law can be formulated to characterize the convertibility of resources for quantum information processing by a single function. In 2008, a promising formulation was proposed, linking resource convertibility to the optimal performance of a variant of the quantum version of hypothesis testing. Central to this formulation was the generalized quantum Stein's lemma, which aimed to characterize this optimal performance by a measure of quantum resources, the regularized relative entropy of resource. If proven valid, the generalized quantum Stein's lemma would lead to the second law for quantum resources, with the regularized relative entropy of resource taking the role of entropy in thermodynamics. However, in 2023, a logical gap was found in the original proof of this lemma, casting doubt on the possibility of such a formulation of the second law. In this work, we address this problem by developing alternative techniques to successfully prove the generalized quantum Stein's lemma under a smaller set of assumptions than the original analysis. Based on our proof, we reestablish and extend the second law of quantum resource theories, applicable to both static resources of quantum states and a fundamental class of dynamical resources represented by classical-quantum (CQ) channels. These results resolve the fundamental problem of bridging the analogy between thermodynamics and quantum information theory.
The talk is based on the following paper.
https://arxiv.org/abs/2408.02722

SE-01-1

Imaging and sensing with “undetected photons”: From a scientific curiosity to new measurement tools

Frank Kühnemann

Fraunhofer Institute for Physical Measurement Techniques IPM and Institute of Physics, Freiburg University, Germany

Biography

Dr. Frank Kühnemann is Head of the Department "Photonics Systems" at the Fraunhofer Institute for Physical Measurement Technology (IPM) in Freiburg and “Privatdozent” (adjunct lecturer) at the Physics Institute of the University of Freiburg. His main research interests are nonlinear optical frequency conversion, laser-based spectroscopy and trace gas analysis and photonic quantum sensing.
After receiving his PhD in Experimental Physics from the Humboldt University in Berlin in 1991 he worked at Bonn University, University of Chicago and the German University in Cairo before joining Fraunhofer IPM in 2011. He published more than 50 papers in peer-reviewed journals, gave numerous invited talks and holds six patents.
At Fraunhofer IPM, the main mission is to facilitate the transfer of research results in the lab to solutions for industry and customers. His team has developed products like continuous-wave Optical parametric oscillators and provides customer-specific measurement services for the photonics industry.

Abstract

“Sensing with quantum light” deals with the use of non-classical light sources like squeezed light or entangled photon pairs. In 1991, the effect of “induced coherence” using spontaneous parametric downconversion (SPDC) as source of entangled photon pairs was first described: If photon pairs are generated by two coherently pumped but separate SPDC sources, the signal photons from both sources show interference whenever the idler photons share a common path and are hence indistinguishable. Blocking the idler path between the two sources breaks the indistinguishability and destroys the interference of the signal photons, and any partially transmitting object leads to reduced visibility of the signal interference pattern. Hence information collected by the idler photons can be recorded without ever detecting them. Using photons pairs far away from degeneracy (e.g. one visible, one midinfrared), allows one to perform midinfrared spectroscopy and imaging by detecting the coherence function of visible photons.
The talk will present current applications with emphasis on modalities which utilize “Quantum Fourier Transform Spectroscopy”: The nonlinear interferometer is not only used to measure the transmission of the sample through the interference contrasts of the signal photons but also to determine wavelength of the infrared photons which interact with the sample.

SE-01-2

Quantum-inspired classical optical metrology

Yoon-Ho Kim

Department of Physics, Pohang University of Science and Technology, Korea

Biography

Yoon-Ho Kim is a Professor of Physics at Pohang University of Science and Technology (POSTECH), Korea, since 2004, and was an Eugene P. Wigner Fellow at Oak Ridge National Laboratory from 2002 to 2004. His research spans quantum information science, quantum measurement theory, atom-photon coherent interactions, and quantum interferometry with entangled photons. He is recognized for pioneering experiments in quantum teleportation, the delayed-choice quantum eraser, and weak quantum measurement, including the use of measurement reversal to mitigate decoherence and preserve entanglement. His work has contributed to the understanding of foundational quantum phenomena and the development of techniques in quantum state manipulation, tomography, and metrology. He has also made significant contributions to photonic quantum technologies, including ultrafast entangled photon sources based on spontaneous parametric down-conversion, narrowband atomic photon sources, atomic quantum memories based on stationary light polaritons, correlation interferometry, and hyperentanglement-based quantum communication. His achievements have been recognized with the Korea Science Award (2021) and election as a Fellow of Optica (2022).

Abstract

Quantum metrology employs entanglement in quantum systems to surpass the standard quantum limit and approach the Heisenberg limit, which sets the fundamental bound on measurement precision. A key example is the use of N-photon entangled states, such as the N00N state, which enable phase sensitivity scaling as 1/N, beyond the standard quantum limit of 1/sqrt(N). Entanglement, however, is a fragile resource, and decoherence can degrade it into classical correlation, reducing its advantage for precision measurement. Certain classical correlations can mimic features of quantum interference in correlation-based interferometry, enabling robust and experimentally accessible metrology schemes. In this context, I will present second-order correlation interferometry using thermal light, which exhibits a 2ϕ phase modulation analogous to that of two-photon quantum interference, and an effective second-order coherence time far exceeding the natural coherence time of the thermal light source [Phys. Rev. Lett. 119, 263603 (2017); Opt. Lett. 45, 6748 (2020)]. This classical two-photon coherence enables new sensing approaches, such as coherent LIDAR with incoherent light, offering robustness against turbulence and ambient noise [Phys. Rev. Lett. 131, 223602 (2023)]. These results suggest a path toward extending classical correlation interferometry to multi-photon regimes, offering a practical framework for exploring classical analogues of quantum-enhanced sensing techniques.

SE-01-3

Quantum sensing using entangled photons

Shigeki Takeuchi

Department of Electronic Science and Engineering, Kyoto University, Japan
Photonic Quantum Sensing Science and Engineering Center, Kyoto University, Japan

Biography

After he received his Master's degree in Physics at Kyoto University in 1993, he became a researcher at Mitsubishi Electric Corporation. In 1999, he moved to Hokkaido University as a Lecturer, then became Associate Professor, and Professor at the Research Institute for Electronic Science, Hokkaido University in 2000 and 2007, respectively. He stayed at Osaka University with his whole group as an invited Professor from 2008 to 2014. In 2014, he became a Professor at Kyoto University. He received a Ph.D. degree from Kyoto University in 2000. He has received several awards, including the Scientific American 50 award in 2007, the Japan Society for the Promotion of Science Prize in 2010, the Osaka Science Prize in 2015, the JSAP Takuma Award in 2016, and the OITDA Kenjiro Sakurai Memorial Award in 2024.

Abstract

This talk will report our recent progress on quantum sensing using entangled photons, including quantum infrared spectroscopy (QIRS) and quantum optical coherence tomography (QOCT).

QIRS enables infrared absorption spectrometers using silicon-based visible light detectors [1]. We proposed and experimentally demonstrated quantum Fourier-transform infrared spectroscopy (QFTIR) [2] and further successfully developed a system of QFTIR in the far-infrared “fingerprint” region (8 - 10.5 μm) [3]. We also demonstrated QIRS in the broadband midinfrared region (2 - 5 μm) using a wavelength-tunable entangled photon source [4] and using a chirped quasi-phase-matched device [5]. Recently, we also demonstrated the high-resolution QIRS using pulse laser pumping [6], which will enable the use of QIRS for ultra-fast time-resolved quantum spectroscopy.

Another example is quantum optical coherence tomography (QOCT), which utilizes two-photon interference between entangled photon pairs. QOCT is a promising approach to overcome the problem with optical coherence tomography (OCT): As the resolution of OCT becomes higher, degradation of the resolution due to dispersion within the medium becomes more critical. We report on the realization of 0.54 μm resolution two-photon interference, which surpasses the current record resolution of 0.75 μm of low-coherence interference in an experiment of OCT [7]. In addition, the resolution for QOCT showed almost no change against the dispersion of a 1 mm thickness of water inserted in the optical path, whereas the resolution for OCT dramatically degraded. We successfully obtained a high-depth-resolution image of QOCT with dispersion tolerance [8].

We would like to thank collaborators and lab members for contributing to the presented works. These works were supported in part by MEXT Q-LEAP (JPMXS0118067634), JST ERATO (TAKEUCHI Super Quantum Entanglement (JPMJER2402)), and Grant-in-Aid from JSPS no. 24H00195 and 21H04444.

References [1] D. A. Kalashnikov, et. al., Nat. Photonics 10, 98 (2016). [2] Y. Mukai, et. al., Phys. Rev. Appl.15, 034019 (2021). [3] Y. Mukai, R. Okamoto, and S. Takeuchi, Opt. Express 30, 22624 (2022). [4] M. Arahata, et. al., Phys. Rev. Appl. 18, 034015 (2022). [5] T. Tashima, et. al., OPTICA Vol. 11, No. 1, 81 (2024). [6] J. Kaur, et. al., Phys. Rev. Appl. 22, 044015 (2024). [7] Okano et. al., Sci. Rep. 5, 18042 (2015). [8] K. Hayama, et. al., Opt. Lett. accepted (2022).

PL-04

Industry

Taro Shimada

Q-STAR, Toshiba Corporation, Japan

Biography

Taro Shimada started his career at ShinMaywa Industries, Ltd., and subsequently held key positions at Siemens K.K. In October 2018, he joined Toshiba Corporation as Corporate Digital Business Chief Strategy Officer. In April 2019, he was appointed Chief Digital Officer, where he led Toshiba's digital transformation initiatives and spearheaded the creation and promotion of strategic business ventures. He was appointed President and CEO of Toshiba Digital Solutions Corporation in April 2020.

In March 2022, Mr. Shimada assumed the role of President and Chief Executive Officer of Toshiba Corporation. In May of the same year, he was named Chair of the Board of Q-STAR (Quantum STrategic industry Alliance for Revolution), a consortium that promotes business creation through quantum technologies. In August 2024, he was appointed Chairperson of the Quantum Ecosystem Promotion Working Group, Quantum Technology Innovation Council, Cabinet Office, Government of Japan.

PL-04

Industry

Lisa Lambert

Quantum Industry Canada (QIC), Canada

Biography

Lisa Lambert is the inaugural CEO of Quantum Industry Canada (QIC), the country's industry-led consortium uniting quantum technology companies and strategic partners. She leads QIC's mission to transform Canada's quantum capabilities into global business success and national prosperity.

A recognized leader in innovation strategy, Lisa champions collaborative approaches to complex technology and policy challenges. Her career spans pioneering work at the intersection of science, technology, and economic strategy, building partnerships worldwide to accelerate innovation and strengthen national and global competitiveness.

Lisa holds multiple leadership and advisory roles in science, technology, and innovation organizations globally. She is also a member of the Canadian delegation to the NATO Transatlantic Quantum Community (NATO TQC) and advises on dual-use considerations for quantum and its convergence with other emerging technologies across multiple international forums.

PL-04

Industry

Thierry Botter

European Quantum Industry Consortium (QuIC)

Biography

Dr. Thierry Botter is a successful industry executive, and an expert in the area of quantum technologies. He is the Executive Director of the European Quantum Industry Consortium (QuIC), a pan-European industry association with over 200 members and affiliates dedicated to supporting and strengthening quantum companies on the global stage. He is also a long-standing contributor on quantum technologies at the World Economic Forum and serves as an advisor on various national, European and international councils. Dr. Botter previously held leadership roles at Airbus, include deputy-lead of the company's cross-divisional Research and Technology organisation. He also served as a member of the first strategic advisory board for the European Commission's Quantum Flagship. Dr. Botter holds a PhD in physics from the University of California, Berkeley, and a Master's degree in aerospace engineering from the University of Illinois at Urbana-Champaign.

PL-04

Industry

Celia Merzbacher

QED-C

Biography

Dr. Celia Merzbacher is Executive Director of the Quantum Economic Development Consortium (QED-C), a global consortium managed by SRI International that aims to enable and grow the quantum industry. Dr. Merzbacher has more than two decades of experience as a leader of large multidisciplinary partnerships and programs at the intersection of government and industry. She is a member of the U.S. delegation to the NATO Transatlantic Quantum Community. She serves on the board of the Novo Nordisk Foundation Quantum Foundry and on advisory boards for several quantum research institutes worldwide. She previously was Assistant Director of Technology R&D at the White House Office of Science and Technology Policy and Executive Director of the President's Council of Advisors on Science and Technology. Dr. Merzbacher is a Fellow of the AAAS.

PL-04-1

Scalable Qubit Controller

Yosuke Ito

QuEL, Inc., Japan

Biography

Yosuke Ito is a co-founder and CEO of QuEL, Inc., a spin-out startup from the University of Osaka.
He is a serial entrepreneur specializing in developing businesses based on cutting-edge technologies. After his previous semiconductor startup was successfully acquired, Yosuke established QuEL, Inc. in 2021 together with researchers at the University of Osaka and leads the company's business development. In 2024, he received the Minister of Science and Technology Policy Award, the second highest honor at the Japan Venture Awards (JVA).
Before being an entrepreneur, he worked as a management consultant, primarily for manufacturing companies, and as a corporate planning professional at an electronics component manufacturer.
He obtained a Master of Engineering from the University of Tokyo and an MBA from the Massachusetts Institute of Technology.

Abstract

Since its establishment in 2021, QuEL has supported world-leading quantum computing researchers by using its scalable qubit controller technologies.
First, QuEL has a strong track record in large-scale superconducting quantum computing systems, supporting Riken RQC's superconducting qubit systems (64-qubit system developed in 2023 and 144-qubit system developed in 2025).
Additionally, QuEL has also contributed to R&D of a variety of qubits, including neutral atoms, trapped ions, and silicon quantum dots, mainly through collaborations with research teams in Japan.
In order to advance these quantum computing research activities furthermore, in early 2026, QuEL will release the next-gen qubit controller, fully based on Direct Digital Synthesis (DDS) technology. Its size will be 1/6 smaller than its current one, so it will be able to support a large quantum computer with more than 1000 qubits.

PL-04-2

Advancing Toward FTQC: Practical Quantum Algorithm Initiatives

Yu-ichiro Matsushita

Quemix, Inc., Japan

Biography

After earning a Ph.D. in Engineering from the University of Tokyo, he held research and academic positions at the Max Planck Institute in Germany, the University of Tokyo, and Tokyo Institute of Technology (now Science Tokyo). In September 2020, he became CEO of Quemix Inc. He currently also serves as Project Chief at the National Institutes for Quantum Science and Technology (QST), and as a specially appointed associate professor at the University of Tokyo, continuing his research activities.

Abstract

Quemix is committed to developing practical quantum algorithms with the potential to become future industry standards. Our research targets high-impact domains—quantum chemistry, computer-aided engineering (CAE), and machine learning—where quantum computing is expected to deliver near-term value. In this presentation, we will highlight recent R&D breakthroughs, their technical significance, and emerging applications. We will also address the challenges of translating theoretical innovation into practical implementation. Through concrete examples, we will illustrate how our algorithms accelerate real-world simulations and computations. Finally, we will share our vision for quantum algorithm development and discuss how Quemix aims to contribute to the transition from exploratory research to scalable, fault-tolerant quantum computing.

PL-04-3

Building the Quantum Internet: LQUOM's Approach to Scalable Quantum Repeaters

Yuya Mochizuki

LQUOM, Inc, Japan

Biography

Yuya Mochizuki is the COO and CFO at LQUOM, Inc., a pioneering deep-tech startup originating from Yokohama National University. LQUOM specializes in developing quantum repeater systems. In his dual role, he leads business development and financial strategy, focusing on forging strategic partnerships and establishing testbed collaborations to accelerate the deployment of quantum communication infrastructure.

Prior to joining LQUOM, he amassed extensive experience in investment banking at Nomura, specializing in mergers and acquisitions, fundraising, and investor relations. Mr. Mochizuki holds a Bachelor of Arts in Policy Management from Keio University and an MBA from the Graduate School of Commerce at Hitotsubashi University.

Abstract

As quantum computing advances, the necessity for a secure and scalable quantum communication network becomes increasingly critical. LQUOM is at the forefront of this endeavor, developing quantum repeaters that facilitate long-distance quantum communication by integrating key technologies such as entangled photon sources, quantum memory, and frequency stabilization. Our quantum internet not only ensures secure quantum communication but also enables distributed quantum computing by connecting multiple quantum computers, significantly scaling computational power and capabilities.

In this presentation, I will delve into LQUOM's innovative approach to constructing quantum repeaters, highlighting our recent achievements, including successful field demonstrations. Additionally, I will discuss our strategic roadmap, encompassing product development and the formation of alliances aimed at commercializing quantum communication and distributed computing technologies. Through these initiatives, LQUOM is committed to laying the groundwork for a robust, scalable, and secure quantum internet.

PL-04-4

Expanding Real-World Applications of Quantum Optimization: From Classical Solvers to Quantum Hardware Integration

Yu Yamashiro

Jij Inc., Japan

Biography

Yu Yamashiro is the CEO of Jij Inc. While conducting quantum annealing research at the Nishimori Laboratory at Science Tokyo, he participated in the JST-START project. As a result of this project, he founded Jij Inc. in 2018. He previously researched quantum information processing using diamond NV centers at OIST. Under the mission of "making society computable and contributing to human progress," he leads Jij's overall business operations. He has been selected for Forbes 30 Under 30 Asia 2021 and Forbes Japan 30 UNDER 30 2023.

Abstract

As the quantum computing landscape matures, the central challenge shifts toward practical application and the effective integration of diverse hardware. This presentation will introduce Jij Inc.'s role at the forefront of this transition, focusing on our middleware platform designed to bridge the gap between quantum hardware and complex combinatorial optimization problems. We will detail the expansion of our technological base, which enables a seamless transition from classical solvers to quantum-inspired Ising machines and gate-based quantum computers. This hardware-agnostic approach empowers users to leverage the most advanced computational resources for their specific needs. To demonstrate the tangible impact, we will showcase a portfolio of real-world application examples from various industries. Furthermore, the talk will outline our strategic initiatives for global expansion, aimed at fostering a worldwide ecosystem to accelerate the practical and industrial adoption of quantum computing for optimization.

PL-04-5

Comparative Performance Analysis of Quantum Chemistry Algorithms on Projected Quantum Hardware Using a Full-Stack Software Framework

Tennin Yan

QunaSys Inc., Japan

Biography

Tennin Yan is QunaSys' founder and Chief Executive Officer, where he leads the company's strategy, product strategy and development to make quantum computing technology industrially useful. He has deep expertise in R&D and is specialized in quantum computer algorithms and applications. Tennin founded QunaSys in 2018 together with Prof. Keisuke Fujii with the goal to bring out quantum physics to the front stage and use it to tackle problems that cannot be achieved with conventional technology by actively taking advantage of quantum mechanics.

Abstract

The primary objective of this study is to provide a concrete, data-driven forecast for the advent of practical quantum advantage in industrial quantum chemistry. To achieve this, we have developed a comprehensive software stack, QURI, which facilitates the entire workflow from high-level algorithm creation to high-performance execution and resource estimation on simulators and hardware. Our methodology centers on a novel benchmarking framework, QURI Bench, which we use to evaluate leading quantum algorithms. We specifically compare a Time-Evolved Quantum Selected Configuration Interaction (TEQSCI) method, enhanced by a novel circuit depth reduction technique, against Statistical Phase Estimation (SPE). These algorithms are benchmarked against projected hardware roadmaps for leading platforms like superconducting and trapped-ion devices. Our results demonstrate that our software enables the efficient end-to-end simulation of complex systems, such as a 39-qubit quantum phase estimation circuit. The benchmark analysis reveals that for near-term hardware, the TEQSCI approach offers a faster path to solution than SPE. We project that quantum devices will be capable of solving intermediate-scale chemistry problems using this method within the next six years. This work provides a crucial roadmap for industry, bridging theoretical algorithms with practical hardware realities to guide future development and adoption.

PL-04-6

QuEra Computing: Advancing Quantum with Neutral Atoms

Ayumu Imai

Country Manager, QuEra Computing Japan, Inc., Japan

Biography

Ayumu Imai serves as the Japan Country Manager for QuEra Computing, a company at the forefront of neutral atom quantum computing. He has built his career around supporting innovation and business development across a range of technology sectors.
Prior to joining QuEra, Ayumu held leadership roles at several international companies. At Schneider Electric, he served as Vice President for the Secure Power division in Japan, which provides electrical and cooling infrastructure solutions to the data center industry. He also served as Japan Country Manager for Particle Measuring Systems and Protolabs, contributing to their growth in precision monitoring equipment and digital parts manufacturing.
Earlier in his career, Ayumu was involved in product planning and international launches at Sony and Philips, including work on multimedia PCs and healthcare IT systems. At Merck KGaA, he focused on expanding the business for advanced performance materials.
In addition to his industry work, Ayumu teaches ‘Business Transformation through Innovation’ at GLOBIS University, where he shares practical insights and experience with the next generation of business leaders.
He holds an MBA from Harvard Business School and a Master’s degree in Mechanical Engineering from Delft University of Technology.

Abstract

QuEra Computing is building quantum computers using a distinctive and powerful approach: neutral atoms. By trapping individual rubidium atoms with optical tweezers and leveraging the Rydberg blockade for entanglement, QuEra is developing platforms that are inherently scalable, highly flexible, and suited to a wide range of applications.
The company’s first-generation system, Aquila, operates in analog mode and is optimized for simulating quantum systems and many-body physics. Its second-generation platform, Gemini, is focused on digital quantum computing—with an emphasis on fault tolerance and integration into high-performance computing environments. Gemini is now installed at AIST in Japan, alongside an NVIDIA classical supercomputer.
QuEra works with partners across industries such as pharmaceuticals, chemicals, and finance to explore real-world use cases. Research collaborations with Harvard, MIT, and NVIDIA continue to advance work in drug discovery, materials science, and hybrid quantum-classical algorithms.
Through a combination of deep scientific expertise, industry engagement, and technology development, QuEra is helping shape the future of quantum computing—focused not just on building powerful machines, but on making them practical.

CP-02-1

Sample-based quantum diagonalization for quantum chemistry calculations with classical and quantum computers

Mario Motta

IBM T.J. Watson Research Center, USA

Biography

Mario Motta is a Senior Research Staff Member at IBM Quantum, T. J. Watson Research Center. He obtained a Ph.D. in physics in 2015 from the University of Milan (Italy) in the group of professor Davide Galli. Between 2016 and 2019 he was a postdoc in the groups of professors Shiwei Zhang (College of William and Mary) and Garnet Chan (Caltech), focused on classical and quantum computational methods for many-electron systems. He joined IBM Quantum in 2019, working on quantum simulation of electronic structure

Abstract

Electronic structure (ES) calculations are an anticipated application for quantum computing, with practical and challenging use cases around the 100- qubit scale. Until recently, however, such calculations were limited by low qubit and gate counts on available hardware.

This talk presents sample-based quantum diagonalization (SQD), which extends ES calculations to circuits with 77 qubits and over 3,000 two-qubit gates [2–4]. SQD is a selected configuration interaction method in which one [2,3] or more [4] quantum circuits read out electronic configurations. Error mitigation at the sample level enforces molecular symmetries, and the Schr¨odinger equation is classically solved in the subspace spanned by the mitigated configurations.

We provide an overview of SQD and describe results about the ground-state ES of iron-sulfur clusters [5] obtained using an IBM Heron device and the Fugaku supercomputer. This work demonstrates the benefit of sing classical and quantum computers in concert [1] to study more challenging and practical ES use cases.

References:

[1] Y. Alexeev et al, Fut. Gen. Comp. Sys 160, 666-710 (2024)

[2] J. Robledo Moreno et al, Science Advances 11, eadu9991 (2025).

[3] K. Kanno et al, arXiv:2302.11320 (2023)

[4] J. Yu et al, arXiv:2501.09702 (2025)

CP-02-2

Recent progress in early fault-tolerant quantum algorithms for eigenvalue problems

Lin Lin

Department of Mathematics, University of California, Berkeley, USA

Biography

Lin Lin is a Professor in the Department of Mathematics at UC Berkeley, and a Senior Faculty Scientist at Lawrence Berkeley National Laboratory. His research centers on solving quantum many-body problems by employing both classical and contemporary methods with applications across various domains, including quantum chemistry, quantum physics, materials science, and quantum information theory. He is a recipient of the Sloan Research Fellowship, the National Science Foundation CAREER award, the Department of Energy Early Career award, the SIAM Computational Science and Engineering (CSE) early career award, and the Presidential Early Career Awards for Scientists and Engineers (PECASE), the ACM Gordon Bell prize (Team), and the Simons Investigator in Mathematics award.

Abstract

Estimating the ground and excited state energies of quantum Hamiltonians is a central and promising application of early fault-tolerant quantum computers. In recent years, there has been substantial progress in the development and analysis of "post-Kitaev" algorithms, which retain the circuit structure of Kitaev's phase estimation using a single ancilla qubit but incorporate significantly more advanced classical post-processing techniques. In this talk, I will highlight recent advances in this direction and discuss ongoing efforts to address the challenges posed by nearly degenerate eigenvalues.

[1] L. Lin, Y. Tong, Heisenberg-limited ground state energy estimation for early fault-tolerant quantum computers, PRX Quantum. 3, 010318, 2022

[2] Y. Dong, L. Lin, Y. Tong, Ground state preparation and energy estimation on early fault-tolerant quantum computers via quantum eigenvalue transformation of unitary matrices, PRX Quantum, 3, 040305

[3] Z. Ding, L. Lin, Even shorter quantum circuit for phase estimation on early fault-tolerant quantum computers with applications to ground-state energy estimation, PRX Quantum 4, 020331, 2023

[4] Z. Ding, H. Li, L. Lin, H. Ni, L. Ying, R. Zhang, Quantum Multiple Eigenvalue Gaussian filtered Search: an efficient and versatile quantum phase estimation method, Quantum 8, 1487, 2024

CP-02-3

Double-bracket quantum algorithms for ground-state preparation via cooling

Yudai Suzuki

Institute of Physics, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland

Biography

Yudai Suzuki is a postdoctoral researcher at École Polytechnique Fédérale de Lausanne (EPFL), Switzerland, working on the intersection of quantum computing and machine learning. He received his undergraduate degree in Mechanical Engineering (2019), M.S. (2021) and Ph.D. degree (2024) from Keio University, Japan. His research interests include quantum machine learning and near-term/modern-term quantum algorithms, such as quantum kernel methods, quantum reservoir computing and quantum optimization algorithms.

Abstract

Preparing ground-states of Hamiltonians is a fundamental task in quantum computation with wide-ranging applications. While efficiently preparing approximate ground-states on quantum hardware is challenging, nature is innately adept at this. This has motivated the study of thermodynamically-inspired approaches to ground-state preparation that aim to replicate cooling, such as imaginary-time evolution (ITE). However, synthesizing quantum circuits that efficiently implement such cooling methods is itself difficult. In this work, we propose cooling approaches for ground-state preparation by exploiting recently-established Double-Bracket Quantum Algorithms (DBQA). More specifically, we propose a new algorithm called Double-Bracket Quantum Imaginary-Time Evolution (DB-QITE) that compiles quantum circuits for ITE without requiring measurements. We then provide rigorous guarantees that DB-QITE systematically lowers the energy of a state and increases its fidelity with the ground-state. Moreover, we develop a more general framework called Double-Bracket Quantum Signal Processing (DB QSP), which realizes quantum circuits for ground state preparation and extends to broader tasks involving polynomial transformations of Hamiltonians. We expect our algorithm to be used as a standalone ground-state preparation method in the early fault-tolerant era, as well as in conjunction with more established and heuristic approaches to ground-state preparation.

CC-01-1

Quantum Repeaters: Fermions or Bosons?

Peter van Loock

Institute of Physics, University of Mainz, Germany

Biography

Professor of Theoretical Quantum Optics and Quantum Information at Mainz University, Germany (since 2012)
Emmy Noether Junior Research Group Leader at University Erlangen/Nuremberg and Max Planck Institute for the Science of Light, Germany (2007 – 2012), Visiting Associate Professor at NII in Tokyo, Japan (2004 – 2007)
PostDoc at University Erlangen/Nuremberg (2001 – 2003), PhD at the University of Wales, Bangor, UK (2001)

Abstract

There are various routes towards building a quantum repeater for long-range quantum key distribution or more general quantum network applications. Depending on the specific application, such as high-rate long-range QKD or high-fidelity long-distance distribution of quantum information, the available infrastructure, such as fiber-based or satellite-based networks, and the experimental feasibility of realizing long-lived stationary qubits or loss-tolerant flying qubits, one approach may be preferable over the other. We shall discuss protocols based upon bosonic quantum error correction codes where logical qubits can be made more robust against excitation loss when transmitted through the optical communication channel or stored at the repeater stations (e.g., in a collective spin mode). In principle, the bosonic approach allows to transmit more information per channel use (e.g., in the form of logical qudits) and to achieve higher loss tolerance with a smaller number of modes (in principle, even with only a single mode). In practice, the initial quantum state engineering and the implementation of the logical quantum gates may be a complication for bosonic codes. We shall compare some of the bosonic schemes with their “fermionic” counterparts based on single spins (and single photons).

CC-01-2

TBA

Tomoyuki Morimae

Kyoto University, Japan

CC-01-3

Our Recent Progress in Photonic Quantum Technologies Toward the Quantum Internet

Rikizo Ikuta

Graduate School of Engineering Science, The University of Osaka, Japan
Center for Quantum Information and Quantum Biology, The University of Osaka, Japan

Biography

Rikizo Ikuta received his Ph.D. in Science from Osaka University, Japan, in 2011. He is an Associate Professor at the Department of Materials Engineering Science, Graduate School of Engineering Science, The University of Osaka, and concurrently affiliated with the Center for Quantum Information and Quantum Biology (QIQB) at The University of Osaka. His research interests lie in the fields of quantum internet, quantum optics, and quantum information processing using photons. Since his doctoral studies, he has been working on the realization of quantum networks, including research on quantum frequency conversion and on quantum repeaters based on frequency manipulation technology. His recent work focuses on the integration of quantum systems with photonic devices toward efficient and scalable quantum communication platforms. Dr. Ikuta also serves as a board member of the Quantum Internet Task Force (QITF), an organization in Japan focused on the promotion and development of quantum internet technologies.

Abstract

In recent years, there has been significant progress in the development of various quantum information technologies, including quantum computers, quantum measurement, and quantum sensors. Networking these quantum devices is expected to enable functionalities that open up fundamentally different applications from those of individual systems, as today's internet enables a wide range of applications and services. This emerging paradigm, known as the quantum internet, has become one of the major focuses of research. While quantum devices are being developed using various physical systems such as atoms, ions, and superconductors, photons play a unique role as the only carrier of quantum information over long distances. Therefore, advancing photonic quantum technologies is essential for realizing scalable quantum networks. In this talk, we present our recent work toward the quantum internet, focusing on quantum frequency conversion for interconnecting heterogeneous quantum systems and its application to frequency-multiplexed quantum communication.

CP-03-1

Quantum Advantage with Continuous Variable Optical Systems

Ulrik Lund Andersen

Department of Physics, Technical University of Denmark, Denmark

Biography

Ulrik L. Andersen is a professor of quantum physics at the department of Physics at the Technical University of Denmark (DTU). He is heading the section on Quantum Physics and Information Technology (QPIT) and he is the director of the Danish National Research Council Center of Excellence on Macroscopic Quantum States (bigQ). In 2022 & 2024, he co-founded the companies Alea Quantum Technologies & Diasense, specializing in the development and commercialization of quantum safe communication systems & quantum sensors for healthcare.

Abstract

Continuous variable (CV) optical quantum systems are achieving remarkable milestones in quantum information science and technology. Recent breakthroughs include the demonstration of quantum computation through Gaussian boson sampling and the application of squeezed states for extreme quantum sensing in gravitational wave detection. These advancements lay the groundwork for future experiments with CV systems.

In this talk, I will present my group's efforts to leverage CV optical quantum systems for achieving quantum advantage in learning, and computation. Highlights include demonstrating massive quantum advantage in quantum learning and making critical progress toward quantum computational advantage. I will discuss these developments, address key challenges, and provide an outlook for the future of CV quantum information science.

CP-03-2

Optical Parametric Amplifiers based on PPLN waveguides for Continuous-variable Optical Quantum Computing

Takeshi Umeki

Device Technology Labs., NTT, Inc, Japan

Biography

Dr. Takeshi Umeki received a B.S. in physics from Gakushuin University, Tokyo, Japan, in 2002, and an M.S. in basic science and a Ph.D. in the area of nonlinear optics from the University of Tokyo, Tokyo, in 2004 and 2014, respectively. He joined NTT Photonics Laboratories, Atsugi-shi, Japan, in 2004. Since then he have been involved in research on nonlinear optical devices based on periodically poled LiNbO3 (PPLN) waveguides and their applications to telecom and quantum information science. He also spent a year as a Visiting Researcher at National Institute of Standards and Technology (NIST) from 2020 to 2021. He is currently a Senior Distinguished Researcher in Device Technology Labs., NTT, Inc.

Abstract

Continuous-variable (CV) optical quantum computing has emerged as a promising approach to scalable and high-speed quantum information processing. A key enabling technology in this approach is the optical parametric amplifier (OPA), which enables the generation of squeezed and non-Gaussian states of light—essential resources for quantum entanglement, universal quantum gates, and error correction protocols. OPAs also support ultra-fast detection and feedforward, both essential for measurement-based quantum computing. Recent efforts have focused on developing OPAs based on directly-bonded periodically poled LiNbO3 (PPLN) waveguides, integrated into compact, fiber-compatible modules. This presentation reviews recent progress in OPA development for CV quantum computing, highlighting their expanding role in the advancement of optical quantum systems.

Acknowledgement
This work was partly supported by Japan Science and Technology Agency (JPMJMS2064).

CP-03-3

Quantinuum's Trapped-Ion Quantum Computers

Brian Neyenhuis

Quantinuum, USA

Biography

Brian Neyenhuis is the Sr. Engineering Director of the Cloud Operations group at Quantinuum, where he leads a team of scientists, engineers, and technicians who upgrade and operate Quantinuum's commercial quantum computers. Dr. Neyenhuis did his postdoctoral research at the University of Maryland where he focused on quantum simulation and the development of new quantum technologies. Brian earned a B.S. in Physics at Brigham Young University and a Ph.D. in Physics from the University of Colorado.

Abstract

Quantinuum's Quantum Computers use a fully reconfigurable array of trapped atomic-ions to provide universal quantum computation with high-fidelity operations, arbitrary connectivity, and mid-circuit measurement. I will give an overview of the unique features of our machines along with specifications and performance metrics. I will present some recent results that go beyond the current limits of classical computing. I will also share our long-range roadmap to large-scale fault-tolerant quantum computing.

SE-02-1

Quantum sensing with molecular systems

Ashok Ajoy

Department of Chemistry, University of California, Berkeley, USA

Biography

Ashok Ajoy is an Assistant Professor in the Department of Chemistry at U.C. Berkeley, and Faculty Scientist at the Lawrence Berkeley National Laboratory. He is an expert in quantum sensing and magnetic resonance. His Ph.D. at MIT was recognized with the Manson Benedict Award and Del Favero Prize for best thesis. Recent honors have included the Google Faculty Research Scholar Award (2020), AFOSR Young Investigator award (2022), CIFAR Azrieli Global Scholar (2022), and the Caldarelli Prize (2022), Anatole Abragam Prize (2023), Ampere Prize (2023), and Atreya Prize (2025) in magnetic resonance. Most recently, he was named a Camille Dreyfus Teacher-Scholar and awarded the Hellman Fellowship (2025).

Abstract

I will present our recent efforts to harness out-of-equilibrium electron and nuclear spins in molecular systems for developing highly sensitive quantum sensors. I will begin with complementary advances in semiconductor platforms—specifically NV centers and 13C nuclei in diamond—where we achieve high nuclear polarization and remarkably long nuclear spin coherence lifetimes (T2'>800 s). These features enable precision sensing of time-varying magnetic fields, with applications ranging from fundamental studies to chemical assays.

Building on this foundation, I will then discuss emerging molecular systems based on polyaromatic molecules hosting triplet-state polarizable electrons. These systems offer several compelling advantages: the ability to grow large crystals (cm-scale) at low cost, high levels of nuclear spin polarization, and extremely long spin lifetimes. Moreover, their inherent chemical tunability provides a versatile platform for sensor design. Together, these attributes open new directions for practical quantum sensing across a wide range of disciplines.

SE-02-2

Nuclear Zeeman and Singlet State Relaxation from Experiment and Computation

Alexej Jerschow

Department of Chemistry, New York University, USA

Biography

Alexej Jerschow is a Professor of Chemistry at New York University, leading a research group specializing in magnetic resonance (NMR/MRI) with applications in quantum sensing, battery technology, and materials sciences. His work includes probing nuclear spin singlet states and studying the lifetimes of spin states via a combined computational-experimental approach. Jerschow is the recipient of the inaugural Carl-Zeiss-Humboldt Research Award.

Abstract

Nuclear spin lifetimes determine the time for which memory could be retained in magnetization states for information storage and set the dynamic range for quantum information and quantum sensing applications. Over the years, several spin relaxation mechanisms have been identified, including dipolar coupling, chemical shift anisotropy, paramagnetic relaxation, spin rotation and spin-internal motion, and the scalar relaxation of the second kind. While in principle, many of the mechanisms are well understood, estimating their size can be difficult. Furthermore, multiple experimental examples have been found that decidedly defy expectations.

We present here work on directly estimating spin-lattice and singlet order relaxation mechanisms from molecular dynamics simulations. Nuclear spins states have been shown to exceed spin-lattice relaxation times several fold, with impressive demonstrations of singlet lifetimes of more than an hour in organic molecules in solution. Here we show calculations for intermolecular mechanisms and find good agreement with experiment.

In addition, the spin-rotation relaxation mechanism is shown to be pronounced for both singlet and Zeeman order. Good agreement between experiment and computation is achieved. Furthermore, we discuss the importance of taking into account internal motion when calculating spin-rotation tensors.

Calculations of this sort may help in the design of particularly long-lived states, or could be used to identify new probes for dynamics, and to devise magnetization storage and quantum sensing protocols.

SE-02-3

Crystal Engineering of Polarization Solids at Room Temperature

Munehiro Inukai

Graduate School of Technology, Industrial and Social Sciences, Tokushima University, Japan

Biography

Munehiro Inukai is an associate professor at Tokushima University, Japan. He received his Ph.D. in science from Osaka University in 2009, following his undergraduate studies at Shinshu University and graduate training at Osaka University. His research focuses on solid-state NMR spectroscopy and dynamic nuclear polarization (DNP), with a particular emphasis on room-temperature triplet DNP using crystal-engineered polarization solids.

He is also actively engaged in NMR studies of metal–organic frameworks (MOFs), with a focus on probing the dynamics and orientation of guest gas molecules within porous frameworks. His work integrates physical chemistry, materials science, and advanced NMR methodologies to elucidate structure–function relationships in functional materials. He received the Progress Award from the NMR Society of Japan in 2024 and the Quantum Life Science Promotion Award in 2025.

Abstract

Triplet dynamic nuclear polarization (triplet-DNP) is a promising method for achieving room-temperature nuclear spin hyperpolarization without cryogenic liquids or high-frequency microwave sources. However, realizing efficient polarization transfer requires overcoming two critical challenges that are uniform dispersion of the triplet-based polarizing agents and sufficiently long T_1 relaxation times.

To address these challenges, we have developed a strategy based on supramolecular co-crystallization. Co-crystalline matrices composed of analytes, hydrogen-bonding coformers (e.g., benzoic acid derivatives), and trace amounts of triplet polarizing agents (e.g., pentacene) enable uniform molecular packing and long T_1. These matrices have successfully hyperpolarized biologically relevant molecules including MRI probe candidates.

Most recently, we developed a co-crystallization relay DNP method, where a liquid analyte is rapidly co-crystallized with a pre-polarized solid inside the NMR tube. For example, triplet-DNP-polarized picolinamide spontaneously forms a cocrystal with pyruvic acid, and the polarization is transferred via spin diffusion. Enhanced solid-state and dissolution-state NMR signals of pyruvic acid were clearly observed at room temperature. This approach opens a new avenue for room-temperature spin polarization using crystal engineering and contributes to sensitive molecular detection for biomedical NMR and DNP-enhanced MRI applications.

CC-02-1

Progress in Security Analysis of Practical Quantum Key Distribution

Norbert Lütkenhaus

Institute for Quantum Computing, University of Waterloo, Canada

Biography

Norbert Lütkenhaus is the Executive Director of the Institute for Quantum Computing (IQC) at the University of Waterloo, and a professor in the Department of Physics and Astronomy. He began researching quantum information in 1993, earning his PhD from the University of Strathclyde in Scotland, UK. His PhD research built the foundation of the ongoing security analysis of optical implementations of quantum key distribution (QKD). His research contributed significantly to the journey of QKD from a basic idea to practical reality and is a driving force on the journey to certification.

His career has included research positions in Austria, Finland, and Germany. He has spent time in industry, working on the first commercial realization of quantum key distribution in 2000. He has also authored several patents and is co-founder and CTO of evolutionQ Inc. He serves on the Advisory Board of several international high profile research networks, conference, and workshop series, and also serves as Vice-Chair of the ETSI Industry Specification Group on Quantum Key Distribution. He is an Affiliate Member of the Perimeter Institute for Theoretical Physics. His international leadership is recognized through his election as Fellow of the American Physical Society.

Abstract

Security Analysis of Quantum Key Distribution protocols are necessary to demonstrate the security claim of implementations. We will clearly lay out the distinction between protocol security, where we assume particular models of devices, and implementation security, where we anticipate deviations of the models used in security proofs. Moreover,we will clarify the final security claim of QKD implementations. Progress in security proof techniques allows to increase the performance of QKD applications in the situation where we have finite block length. We will report on an analysis for decoy state QKD using a Renyi Entropy Accumulation type of approach.

Security proofs need to be able to handle model deviations once we move from protocol to security implementations, and they need to be able to handle choices in the practical protocol definition that emerge in practical implementations, owing to different deployment scenarios, such as satellite to ground QKD, or fiber based QKD.

CC-02-2

Entanglement in Science and Technology for Quantum Key Distribution

Akihisa Tomita

Quantum ICT Collaboration Center, National Institute of Information and Communications Technology, Japan

Biography

Akihisa Tomita received his B.S. and M.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 engaged in research on photonics, and from 1998 to 2010, he conducted research on quantum information technology, both at NEC Corporation. From 2000 to 2010, he led the group for quantum information experiments in Quantum Computation and Information Project, ERATO and SORST, JST. From 2010 to 2025, he was a professor at the Faculty of Information Science and Technology at Hokkaido University. He is currently serving as a supervising researcher at the Quantum ICT Collaboration Center and Advanced ICT Research Institute, National Institute of Information and Communications Technology. His research covers fundamental and applied studies on photonics for quantum information processing and quantum communication. Dr. Tomita co-founded of Quantum Forum in 2019 and served as a representative director to 2025, promoting industry-government-academia collaboration in quantum technology.

Abstract

In quantum information technology, fundamental concepts of quantum mechanics play a crucial role in the implementation of the protocols. Quantum entanglement, for instance, can be regarded as a mechanism behind the security of quantum key distribution (QKD). This mechanism is based on the property of entanglement monogamy, which states that when two parties are maximally entangled, the state of the third party must be separated from the entangled state. Furthermore, the equivalence between the entanglement-based protocols and the prepare-and-measure protocols provides simple and robust security proofs, as well as insights into the configurations of QKD devices. In this presentation, we will discuss several applications of quantum optics in the characterization of QKD devices implementing the Bennett-Brassard 1984 (BB84) protocol. We will demonstrate how quantum optics simplifies the evaluation of QKD apparatus, ensuring implementation security. This is a critical consideration in the social deployment and standardization of current QKD technology. These examples demonstrate the significant interconnection between science and engineering in the field of quantum information technology.

CC-02-3

A Security Framework for Quantum Key Distribution Implementations

Kiyoshi Tamaki

Faculty of Engineering, University of Toyama, Japan

Biography

Kiyoshi Tamaki received his Ph.D. in March 2004 from the Graduate University for Advanced Studies (SOKENDAI), Japan. He subsequently joined the Perimeter Institute for Theoretical Physics as a long-term visitor, and later moved to the University of Toronto as a postdoctoral fellow. In January 2006, he joined NTT Basic Research Laboratories as a research scientist. Since April 2017, he has been with the Faculty of Engineering at the University of Toyama. His research interests include quantum information theory, with a particular focus on the security analysis of quantum key distribution.

Abstract

Quantum key distribution (QKD) can, in principle, achieve information-theoretic security. However, in practice, this goal cannot be fully realized due to discrepancies between theory and implementation. Thanks to the development of the time-reversed QKD and the measurement-device-independent QKD, all implementation vulnerabilities related to the measurement unit are eliminated. The remaining task is to secure the source.

In this talk, I present a method to represent information leakage as a quantum state, and then introduce our security proof based on this state representation. This proof is valid against the most general attacks and incorporates any source flaws without requiring complete state characterization, while still achieving high performance. Future challenges will also be discussed.

Support from JSPS KAKENHI Grant Numbers 23H01096 is acknowledged.

CP-04-1

Universal Gate Set for Bosonic Logical Qubits in Mechanical Oscillators of Trapped Ions

Ting Rei Tan

School of Physics, The University of Sydney, Australia

Biography

Dr Ting Rei Tan is an experimental physicist focusing on quantum computing, quantum simulations, and quantum sensing. He was trained at the United States National Institute of Standards and Technology by David Wineland, a Nobel Laureate in Physics (2012). In 2016, Ting Rei's results on trapped-ion quantum computing were selected as one of the "Top 10 breakthroughs in Physics." Presently, he is a Sydney Horizon Fellow and an Australian Research Council Future Fellow in the School of Physics at the University of Sydney.

Abstract

Scalable quantum information processing will require fault-tolerant quantum error correction, typically involving encoding a logical qubit into many physical qubits—a resource-intensive approach that poses challenges for near-term devices. An alternative strategy encodes error-correctable logical qubits—such as the Gottesman-Kitaev-Preskill (GKP) code—in single bosonic modes, reducing hardware overhead at the cost of increased control complexity. In this talk, I will present recent advances in preparing and manipulating GKP logical qubits in the mechanical motion of a trapped-ion system. We employ optimal quantum control to prepare GKP qubits with a measured squeezing and logical fidelity as high as 7.5 dB and 0.94, respectively. Furthermore, we demonstrate a universal gate set for GKP codes, including a two-qubit entangling gate and the preparation of an entangled GKP Bell state. Our scheme is coherent, deterministic, and designed to avoid code word distortion of finite-energy GKP states. The experiments highlight the opportunity to leverage optimal control strategies as a key accelerant towards fault tolerance.

[1] D. Gottesman, A. Kitaev, and J. Preskill, "Encoding a qubit in an oscillator" Phys. Rev. A 64, 012310 (2001).
[2] V. G. Matsos et al., "Robust and deterministic preparation of bosonic logical states in a trapped ion", Phys. Rev. Lett. 133, 050602 (2024).
[3] V. G. Matsos et al., Universal quantum gate set for Gottesman-Kitaev-Preskill Logical Qubits", arXiv:2409.05455 (2024).

CP-04-2

Benchmarking and Fault-Tolerant Operation of a Neutral Atom Quantum Processor

Thomas Noel

Quantum Computing, Infleqtion, USA

Biography

Dr. Tom Noel is Vice President for Quantum Computing at Infleqtion where he leads a multidisciplinary team of scientists and engineers focused on development, deployment, and commercialization of neutral atom quantum computing systems. As part of this role, Dr. Noel directs efforts to deliver of quantum computing subsystems for the Cold-Atom Quantum Computing Project led by Professor Ohmori of the Institute for Molecular Science in Okazaki, Japan.

Dr. Noel earned his Ph.D. in Physics from the University of Washington (Seattle, WA, USA) where his research advanced methods for generating entanglement between trapped ions and single photons. His work contributed to foundational technologies for quantum networking and the scalable architecture of trapped-ion quantum processors.

Abstract

Neutral atoms have emerged as a strong candidate architecture for scalable, fault-tolerant quantum computing. A popular approach for neutral atom gates involves shuttling atoms to and from a shared interaction zone. While atom shuttling enables parallel execution of multiple gates, local qubit addressing comes with distinct advantages, such as faster overall execution speed and the ability to perform non-identical gates in parallel. We present benchmarking results from a full-stack universal quantum computing architecture featuring individual optical addressing of single atoms for fast gate execution without the requirement for atom shuttling. We demonstrate reduction in computational error by encoding physical qubits into logical qubits using the [[4,2,2]] quantum-error-detecting code where performance is evaluated by executing a variety of quantum circuits with and without logical encoding. We show that logical performance surpasses physical performance for Bell state generation (12x error reduction), Gottesman random circuits (15x), and an Anderson Impurity Model ground state solver for materials science applications (up to 6x). Finally, we present preliminary results on scaling to larger qubit arrays and implementing more complex quantum error correction codes, laying the groundwork for larger, fault-tolerant systems.

CP-04-3

Development of Ytterbium Atom Tweezer Array For Quantum Computing

Yoshiro Takahashi

Department of Physics, Graduate School of Science, Kyoto University, Japan

Biography

Yoshiro Takahashi obtained PhD from Kyoto University in 1992. He has been working in Graduate School of Science of Kyoto University as an Assistant Professor in 1990-1994, a Senior Assistant Professor in 1994-2000, an Associate Professor in 2000-2007, and a Professor from 2007 until now.

Abstract

We report the realization of a dual-isotope ytterbium (Yb) atom array, which consists of a nuclear spin qubit of fermionic ^{171}Yb as a data qubit and an optical clock qubit of bosonic ^{174}Yb as an ancilla qubit with a capacity of nondestructive qubit readout. The crosstalk measurements between these two kinds of qubits reveal the retainment of the nuclear spin qubit coherence by 99.1 (1.8)% while measuring the ancilla qubits with a discrimination fidelity of 0.9992 and a survival probability of 0.988, highlighting the potential of this hybrid-Yb atom array for QEC protocols.

In addition, we report the successful demonstration of a three-dimensional ^{171}Yb atom array. In particular, by exploiting the magnetic sensitive ultranarrow optical clock transition, we achieved plane-by-plane initialization of nuclear spin qubits and plane-dependent coherent temporal evolution of qubits, as well as plane-selective qubit manipulation. These are crucially important for quantum computing and quantum simulation in three-dimensional multilayer architectures.

Our efforts towards a two-qubit gate operation will be also reported.

SE-03-1

Development of Hyperpolarized Carbon-13 Molecular Imaging for Novel Human Clinical-Research Studies

Daniel B. Vigneron

Department of Radiology and Biomedical Imaging, University of California, San Francisco, USA

Biography

Dr. Daniel Vigneron Ph.D. is a Professor in the Department of Radiology & Biomedical Imaging and at the University of California, San Francisco. He also has joint appointments in the Departments of Bioengineering & Therapeutic Sciences and Neurological Surgery at UCSF and is a member of the UCB/UCSF Bioengineering graduate group. He is the Director of the NIH NIBIB-funded Hyperpolarized C-13 MRI Technology Resource Center at UCSF that was recently renewed with 20 external collaborative and service projects. This Center also sponsors numerous training and education opportunities including symposia/workshops focused on the development and dissemination of new HP-MRI techniques. Dr. Vigneron was elected Fellow of the International Society of Magnetic Resonance in Medicine in 2009 and to the College of Fellows of the American Institute for Medical and Biological Engineering in 2007. He received the Academy of Radiology Research Distinguished Investigator Award in 2013 and with colleagues was awarded the Gold Medal of the World Molecular Imaging Society in 2014. Prof. Vigneron's research is focused on the development of metabolic MRI techniques for research and clinical assessments of human diseases that has been reported in over 350+ publications resulting in over 43,000 citations with an h-index of 112.

Abstract

Hyperpolarized Carbon-13 (HP C-13) MR is an emerging molecular imaging technique that utilizes a stable-isotope agent polarized in a separate instrument at 5 T and 1 K that is then injected into the patient in a 3T MRI scanner to provide information on cellular metabolism, cancer aggressiveness and response to therapy. While similar to PET in that it uses an injected isotope, HP C-13 differs in several ways. It is a metabolic contrast agent that detects not only the isotope uptake but also its downstream metabolites enabling quantification of enzymatic conversion rates in biomedically-important metabolic pathways. C-13 is not radioactive, rather it is a stable isotope that is present in all naturally-occurring endogenous molecules such as ^{13}C-pyruvate. It has an excellent safety profile in 1000+ patient and normal volunteer studies with fast dynamic acquisitions. We developed and applied this technology to address unmet clinical needs in the management of prostate cancer, brain tumors, kidney disease, metastatic breast cancer, pancreatic cancer, and cardiac disease. These studies have shown the ability of HP C-13 MRI to detect biomarkers of cancer aggressiveness, biopsy guidance and response to therapy in a 2-minute acquisition added to MRI exams.

SE-03-2

Shaping the Future of Clinical Metabolic Imaging with Hyperpolarized ^{13}C MRI

Arnaud Comment

GE HealthCare, UK

Biography

After having studied physics at EPFL, Arnaud Comment joined the group of Prof. Charles P. Slichter at the University of Illinois, Champaign-Urbana, for a PhD in the field of solid-state nuclear magnetic resonance. He then spent the following one and half years working in condensed matter physics at the Grenoble High Magnetic Field Laboratory. In 2005, he launched a dynamic nuclear polarization (DNP) project at EPFL and continued his research at the Faculty of Biology and Medicine of the University of Lausanne to lead the developments of biomedical applications of hyperpolarized MRI in Lausanne. In 2011, he was awarded a professorship grant from the Swiss National Science Foundation and became assistant professor at EPFL. In 2015, he joined GE HealthCare as senior scientist to further develop the clinical applications of hyperpolarized ^{13}C imaging. Between 2016 and 2022, he also worked at the Cancer Research UK Cambridge Institute of the University of Cambridge on projects aimed at improving metabolic imaging and supported by European Research Council (ERC) grants. Arnaud Comment became manager of the GE HealthCare Hyperpolarized ^{13}C Imaging program in 2020, and he has been leading the development of clinical metabolic imaging by hyperpolarized ^{13}C MRI since then.

Abstract

Hyperpolarization via dynamic nuclear polarization, a quantum process driven by microwaves, enhances the ^{13}C magnetic resonance (MR) signals from injectable ^{13}C-labeled metabolic substrates and their downstream products by up to 5 orders of magnitudes. This technology enables non-invasive in vivo real-time molecular and metabolic imaging, providing a unique and invaluable tool to follow and evaluate disease progression and treatment response. 16 research hospitals across the globe are currently performing hyperpolarized ^{13}C MRI studies on patients and, to date, more than 1500 healthy and patient volunteers have been scanned following the intravenous injection of hyperpolarized ^{13}C-pyruvate. Although relatively complex operations were originally required to perform such studies, several recent developments have tremendously simplified the workflow for clinical applications of hyperpolarized ^{13}C MRI. In this lecture, I will present the most recent clinical results as well as novel methods and hardware that open new opportunities through the circumvention of some of the limitations of the current hyperpolarization technology. Central to these developments is the second-generation hyperpolarizer, the Emerald SPINlab system, together with the development of a new pharmacy kit designed for the production of sterile doses of hyperpolarized ^{13}C-molecules.

SE-03-3

New Horizons in Hyperpolarized MRI using Quantum Technologies

Ilai Schwartz

NVision Imaging Technologies GmbH, Germany

Biography

Ilai Schwartz is the Chief Technology Officer of NVision, bringing a diverse background in R&D management, deep quantum physics and management consulting. He has over 15 years of experience leading technological R&D projects and product development, including in Unit 8200 in the Israeli military intelligence, as an R&D project lead in cyber security start-ups and as coordinator of large-scale quantum physics projects. Ilai is also a McKinsey & Company alumni, having gained valuable experience in corporate strategy and PharmaCo operations. He is an inventor of several breakthrough concepts in quantum hyperpolarization, having led the NVision development team in achieving the first viable, room-temperature polarizer for metabolic MRI. Ilai is the principal investigator on numerous high-profile hyperpolarized MRI projects. He received his MSc in Physics at the Hebrew University of Jerusalem and a PhD from Ulm University (Summa Cum Laude).

Abstract

Recent advancements in MRI have been driven by nuclear hyperpolarization techniques, which can enhance MRI sensitivity by over 10,000-fold. This enables real-time monitoring of tissue metabolism, particularly the metabolic transformation of ^{13}C-pyruvate in cancer cells. Even though hyperpolarization has shown clear value in clinical studies, the complexity, cost and slowness of current equipment limits its widespread use. This is mainly due to the need in dissolution dynamic nuclear polarization (d-DNP), the gold standard, of cooling samples down to 1K and requiring over an hour of polarization time.

In this talk I will present how by utilizing parahydrogen, a highly pure quantum state of hydrogen gas, hyperpolarization can be achieved at room temperature. We exploit the unique properties of parahydrogen, namely the room-temperature singlet relaxation time on the order of months, as well as sophisticated spin-control sequences, to develop the first viable room-temperature polarizer, capable of polarizing metabolites within 2 minutes in an automated, easy to use fashion.

CC-03-1

Standardisation and Assurance of Quantum Security Technologies

Martin Ward

Cambridge Research Laboratory, Toshiba Europe Limited, UK

Biography

Martin has developed semiconductor quantum devices, including single and entangled photon pair sources at telecom wavelengths, and works on schemes for the security assurance of Quantum Key Distribution (QKD). He leads Toshiba Europe's standardization activities on quantum technologies and is Chair of ETSI's Industry Specification Group on QKD. He holds a doctorate in Physics from the University of Oxford.

Abstract

Standardisation and assurance of QKD systems and networks is an increasing priority for vendors and network operators, as well as potential end users. Assuring the security of QKD products and other devices used in QKD networks are important to expand adoption in both regulated and unregulated market sectors. As networks expand across network-operator and international boundaries, standards to enable interoperation are needed. The current state of standardisation and assurance of QKD modules and QKD network devices will be considered. Areas that have been addressed will be discussed, along with opportunities and challenges that quantum technologies present to standards developing organisations and cyber security bodies, along with approaches under consideration.

CC-03-2

Recent Developments in Post-Quantum Cryptography

Tsuyoshi Takagi

Department of Mathemaical Informatics, University of Tokyo, Japan

Biography

Tsuyoshi Takagi received the B.Sc. and M.Sc. degrees in mathematics from Nagoya University in 1993 and 1995, respectively. He was engaged in research on network security at NTT Laboratories from 1995 to 2001. He received the Ph.D. from the Technical University of Darmstadt in 2001. He was an Assistant Professor in the Department of Science at Technical University of Darmstadt until 2005. He is currently a Professor in the Graduate School of Information Science and Technology at University of Tokyo. He received DOCOMO Mobile Science Award in 2013, IEICE Achievement Award in 2013, and JSPS Prize in 2014. He was a Program Chair of the 7th International Conference on Post-Quantum Cryptography, PQCrypto 2016. He has been a chairperson in the Cryptographic Technology Evaluation Committee in CRYPRTREC since 2019.

Abstract

The security of current public-key cryptosystems relies on the hardness of factoring large integers or solving discrete logarithm problems. However, these computational problems can be solved in polynomial time using a quantum computer.

This vulnerability has prompted research into post-quantum cryptography (PQC) using alternative mathematical problems that are secure in the era of quantum computers. In this talk, we give an overview of recent developments in the research on PQC. We explain a standardization project of PQC conducted by the National Institute of Standards and Technology (NIST). We then introduce an efficient digital signature, QR-UOV, based on the hardness of solving a system of multivariate quadratic polynomial equations over a finite field (the MQ problem). We also introduce a computational challenge problem, Fukuoka MQ Challenge, which aims at evaluating the hardness of the MQ problem with practical parameters.

CC-03-3

Standardization and Certification of QKD and PQC

Martin Ward

Cambridge Research Laboratory, Toshiba Europe Limited, UK

Biography

Martin has developed semiconductor quantum devices, including single and entangled photon pair sources at telecom wavelengths, and works on schemes for the security assurance of Quantum Key Distribution (QKD). He leads Toshiba Europe's standardization activities on quantum technologies and is Chair of ETSI's Industry Specification Group on QKD. He holds a doctorate in Physics from the University of Oxford.

CC-03-4

Standardization and Certification of QKD and PQC

Norbert Luetkenhaus

Institute for Quantum Computing, University of Waterloo, Canada

Biography

Norbert Lütkenhaus is the Executive Director of the Institute for Quantum Computing (IQC) at the University of Waterloo, and a professor in the Department of Physics and Astronomy. He began researching quantum information in 1993, earning his PhD from the University of Strathclyde in Scotland, UK. His PhD research built the foundation of the ongoing security analysis of optical implementations of quantum key distribution (QKD). His research contributed significantly to the journey of QKD from a basic idea to practical reality and is a driving force on the journey to certification.

His career has included research positions in Austria, Finland, and Germany. He has spent time in industry, working on the first commercial realization of quantum key distribution in 2000. He has also authored several patents and is co-founder and CTO of evolutionQ Inc. He serves on the Advisory Board of several international high profile research networks, conference, and workshop series, and also serves as Vice-Chair of the ETSI Industry Specification Group on Quantum Key Distribution. He is an Affiliate Member of the Perimeter Institute for Theoretical Physics. His international leadership is recognized through his election as Fellow of the American Physical Society.

CC-03-5

Standardization and Certification of QKD and PQC

Tsuyoshi Takagi

The University of Tokyo, Japan

Biography

Tsuyoshi Takagi received the B.Sc. and M.Sc. degrees in mathematics from Nagoya University in 1993 and 1995, respectively. He was engaged in research on network security at NTT Laboratories from 1995 to 2001. He received the Ph.D. from the Technical University of Darmstadt in 2001. He was an Assistant Professor in the Department of Science at Technical University of Darmstadt until 2005. He is currently a Professor in the Graduate School of Information Science and Technology at University of Tokyo. He received DOCOMO Mobile Science Award in 2013, IEICE Achievement Award in 2013, and JSPS Prize in 2014. He was a Program Chair of the 7th International Conference on Post-Quantum Cryptography, PQCrypto 2016. He has been a chairperson in the Cryptographic Technology Evaluation Committee in CRYPRTREC since 2019.

CC-03-6

Standardization and Certification of QKD and PQC

Masato Koashi

Graduate School of Engineering, The University of Tokyo, Japan

Biography

Masato Koashi is a professor and the head of Research Institute for Photon Science and Laser Technology at the University of Tokyo. After he was awarded PhD at the Univ. of Tokyo in 1995 for experimental studies on quantum optics, he started theoretical research in the field of quantum information at the NTT Basic Research Laboratories. He continued the research in this field while he moved to the Graduate Univ. for Advanced Studies (SOKENDAI), Osaka University, and the Univ. of Tokyo. His research has covered a wide range of topics in quantum information theory, and the notable contribution includes fundamental studies on quantification of quantum information, security proofs for various important protocols of quantum key distribution (QKD), discovery of a QKD protocol built on a new principle, and new ideas on quantum error correcting codes and fault tolerant quantum computation. Since 2020, he has been appointed to a Project Manager in the Moonshot Goal 6 Program.

CP-05-1

Challenges in Achieving Practical Quantum Computing

Shintaro Sato

Quantum Laboratory, Fujitsu Research, Fujitsu Limited, Japan
RIKEN RQC-Fujitsu Collaboration Center, RIKEN, Japan

Biography

Shintaro Sato is Fellow and Head of Quantum Laboratory at Fujitsu Research in Japan. He also holds a concurrent position as Deputy Director of the RIKEN RQC-Fujitsu Collaboration Center at RIKEN. His responsibilities at Fujitsu include leading research on all technology layers of quantum computing: quantum devices, platforms, algorithms, and applications. Prior to his work in quantum computing, he conducted research and development on post-silicon devices using carbon nanotubes and two-dimensional materials. He holds a Ph.D. in Mechanical Engineering from University of Minnesota, USA, and an MS in Science and Engineering (Physics) from University of Tsukuba, Japan. His research areas include quantum computing, nanoelectronics, and nanomaterials.

Abstract

Fujitsu is actively pursuing quantum computing to tackle societal challenges intractable for conventional computers. We are committed to research and development (R&D) across all layers of quantum computing, from quantum devices to algorithms and applications. Our R&D efforts are conducted in collaboration with world-leading research institutions, including RIKEN, Delft University of Technology (TU Delft), and University of Osaka.

In collaboration with RIKEN, we are advancing superconducting qubit technology. We launched a 64-qubit superconducting quantum computer at the RIKEN RQC-Fujitsu Collaboration Center in October 2023 [1]. Furthermore, we have recently developed a 256-qubit system [2], highlighting the scalability of our qubit-chip architecture. This presentation will briefly outline our efforts to enhance qubit uniformity [3] and construct large-scale systems.

Our partnership with TU Delft is focused on developing diamond-spin qubit-based quantum computers. We leverage electron spins associated with tin-vacancy (SnV) centers in diamond as qubits [4], and also utilize nearby ^{13}C nuclear spins. This technology's photonic interconnect allows for flexible qubit connectivity, potentially enabling novel quantum error correction codes for our diamond spin qubits, which could reduce future error correction overhead.

Our collaboration with Osaka University focuses on fault-tolerant quantum computing (FTQC) software, including error correction [5] and logical gate operations. We have recently proposed a novel quantum computing architecture that incorporates error correction [6, 7]. This "partially" fault-tolerant quantum computing approach aims to significantly reduce the number of qubits and gate operations required for practical quantum computing.

We are also actively developing practical quantum computer applications. In 2022, we initiated research collaborations with end-users in materials science, drug discovery, and finance, leveraging Fujitsu's quantum computer simulator, which builds upon our expertise in high-performance computing (HPC). We now offer end-users a hybrid quantum computing platform comprising our 64-qubit and 256-qubit quantum computers, along with a 40-qubit quantum computer simulator, for application development.

This presentation provides a concise overview of Fujitsu's comprehensive quantum computing research.

Reference

[1]https://www.fujitsu.com/global/about/resources/news/press-releases/2023/1005-01.html

[2] https://www.fujitsu.com/global/about/resources/news/press-releases/2025/0422-01.html

[3] T. Takahashi, et. al., Jpn. J. Appl. Phys. 62, SC1002 (2023). [4] M. Pasini et al., Phys. Rev. Lett. 133, 023603 (2024).

[5] J. Fujisaki, et al., Phys. Rev. Research 4, 043086 (2022). [6] Y. Akahoshi, et al., PRX Quantum 5, 010337 (2024).

[7] R. Toshio, et al., Phys. Rev. X 15, 021057 (2025).

CP-05-2

Quantum computing from chips to applications at IQM

Juha Hassel

IQM Quantum Computers, Finland

Biography

Dr. Juha Hassel received his PhD title in 2004 from Helsinki University of Technology (now Aalto University). As of March 2024, he holds the position of Vice President of Quantum Technologies at IQM Quantum Computers, where he has worked in different leadership positions since 2019. Before joining IQM, he served as Principal Scientist at VTT Technical Research Centre of Finland, where he also led the Applied Quantum Electronics team within the national Centre of Excellence – Quantum Technology Finland.

Abstract

Superconducting qubits offer a platform for high-quality scalable quantum computing thanks to their several favorable features including speed, demonstrated high fidelities, and scaling potential. In this talk, we introduce the technological approach of IQM Quantum Computers, showing the implementation and characteristics reached with the qubits and tunable couplers, including measured T1 coherence times of up to 0.96 ms and 2-qubit gate fidelities (CZ) of 99.93%. We also present benchmarking data from 20-qubit and 54-qubit quantum computing systems, both yielding 2-qubit gate fidelities of about 99.5 % (median), and discuss factors affecting the performance and possibilities to improve on fundamental and system level. Furthermore, we will present examples of running quantum algorithms providing perspective on the capacities today. We also address future prospects, discussing the roadmap towards fault-tolerant quantum computing and industrial quantum advantage building on high-quality gate operations, scaling, and topological choices enabling high encoding-rate solutions for quantum error correction.

CP-05-3

Imaging defects in live superconducting quantum circuits: revealing sources of decoherence

Sebastian de Graaf

Quantum Technologies department, National Physical Laboratory, UK

Abstract

The low-temperature physics of structurally amorphous materials is governed by low-energy two-level system defects (TLS). Being impervious to much of traditional condensed matter probes, the exact origin and nature of TLS remain elusive. Despite decades of study very little is known about the materials origin and chemical nature of TLS. Recent advances towards realising stable high-coherence quantum computing platforms have increased the importance of studying TLS in solid-state quantum circuits, as they are a persistent source of decoherence and instability, limiting scalability. By using a scanning gate microscope (SGM) operating at mK temperatures in a highly coherent environment we image live superconducting circuits. With this tool we can locate and image individual TLS defects in the circuit as well as deducing the three-dimensional orientation of individual TLS electric dipole moments. Combining such insights with structural information of the underlying materials can help reveal the detailed microscopic nature and chemical origin of TLS as well as unravel new mechanisms for decoherence, directing targeted strategies for improved device coherence.

SE-04-1

Nanoscale Quantum Sensing

Jörg Wrachtrup

Center for Applied Quantum Technology, University of Stuttgart, Germany

Biography

Director of the Center for Applied Quantum Technology. Fields of expertise are solid state quantum technology comprising quantum computing, quantum networks and quantum sensing. Fellow of the Max Planck Society.

Abstract

Spin defects in wide band gap semiconductors are leading contenders in various areas of quantum technology. Early forerunners in the field, like the NV center in diamond have shown impressive progress for sensing, communication, and quantum computing. Single NV electron spin qubits, e.g., have matured into a new tool for imaging and sensing in material science. Multiple interacting spins in a spin network enable quantum algorithms for signal analysis, for example via a quantum Fourier transformation of AC signals. In the talk I will highlight the use of new multiqubit spin systems to apply quantum algorithms to quantum sensing. We apply this method to measure a variety of parameters on nanoscale length scales. Material properties related to magnetic fields can be specifically well probed. This comprises magnetic nanostructures but also electronic properties. We e.g. observe fractional vortices in low dimensional 2D NbSe2 superconductors. A close inspection reveals vortex dynamics leading to enhanced dephasing of the NV probe. We interpret our results by the unconventional band structure of the material

SE-04-2

About the electronic structure and charge state dynamics of nitrogen-vacancy centers in diamond

Ronald Ulbricht

Max-Planck Institute for Polymer Research, Germany

Biography

Dr. Ronald Ulbricht received his diploma in physics at the Technical University of Dresden in Germany and subsequently began his doctoral studies at the FOM Institute AMOLF in Amsterdam, where he obtained a PhD for his work on investigating charge carrier dynamics in semiconductors using Terahertz spectroscopy. He then embarked on a series of postdoctoral positions: as a JSPS fellow at Hokkaido University working on picosecond photoacoustics, as a Rubicon fellow at the University of Colorado, Boulder working with optical near-field scanning probe microscopy and as a DFG fellow at Nanyang Technological University in Singapore investigating the transient optical dynamics of nitrogen-vacancy centers in diamond. He is now a group leader in the department of Molecular Spectroscopy of the Max-Planck Institute for Polymer Research in Mainz, Germany. The research group currently has a strong focus on utilizing time-resolved spectroscopy techniques to study color centers in diamond and silicon carbide.

Abstract

The negatively-charged nitrogen-vacancy center (NV–) in diamond possesses an interesting combination of spin and optical properties that can be exploited as multi-purpose quantum sensors for electric and magnetic fields, temperature and strain. Such applications are realized due to the zero-field splitting of the NV– spin triplet ground state and the ability to polarize and read out the spin states via optically detected magnetic resonance (ODMR). Despite research related to NV spanning many decades, a full picture of the electronic structure and dynamics of NV has not yet been established. This is particularly true for the physics of photoionization and charge state conversion between the negative and neutral NV0 charge states, which are important for further developments of new techniques, for example photoelectric detection of magnetic resonance (PDMR).

I present some of our results on studying NV centers using a range of time-resolved spectroscopic techniques such as transient absorption (TA) spectroscopy and THz time-domain spectroscopy to investigate the relaxation dynamics of ensembles of NV centers in bulk diamond after photoexcitation by probing the transient response of its optical signatures. This allows probing high-energy excited states of NV and monitoring complex processes such as photoionization and charge state conversion. We also assess the role of single substitutional nitrogen in these processes.

SE-04-3

Precision current comparator for AC and DC current ratio measurements using a nitrogen-vacancy center in a diamond

Yasutaka Amagai

National Institute of Advanced Industrial Science and Technology(AIST), Japan
Global Research and Development Center for Business by Quantum-AI technology (G-QuAT), Japan

Biography

He is a Team Leader of the quantum sensing research team in the Global Research and Development Center for Business by Quantum-AI Technology (G-QuAT), AIST. He is also an Associate Professor with Tokyo University of Science. Since 2009, he has been with the areas of ac-dc difference, including research into novel voltage and current thermal sensors, quantum ac voltage standards, current sensors with a nitrogen-vacancy center in a diamond, and their applications to thermophysical property measurement methods. From 2018 to 2019, he was a Guest Researcher with the Quantum Measurement Division, National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA. Dr. Amagai was selected as the Top 70 most published author in the past seven years of IEEE Transactions on Instrumentation and Measurement in 2020. He is an Associate Editor of IEEE Transactions on Instrumentation and Measurement (TIM).

Abstract

Accurate current ratio measurements are fundamental to electrical metrology and underpin the calibration of instruments used in power systems such as transformers. However, conventional current comparators for AC and DC rely on separate technologies: typically electromagnetic induction for AC and superconducting quantum interference devices (SQUID) for DC. This results in a fragmented and complex traceability system. Here, we report an AC/DC current comparator that integrates a diamond-based magnetometer using nitrogen-vacancy centers as a magnetic flux detector. This solid-state quantum sensor enables high-sensitivity current ratio measurements across both DC and AC under ambient conditions. Such integration offers a promising path toward compact, high-precision instruments that overcome the limitations of conventional designs. By eliminating reliance on conventional coil- or SQUID-based current comparators.", NV sensors may enable more flexible architectures and potentially extend current ratio measurements to include both AC and DC domains. This approach may offer a novel pathway to quantum-enhanced metrology, fostering new synergies between cutting-edge quantum sensing technologies and practical electrical measurement systems.

Acknowledgements
This work was supported by MEXT Quantum Leap Flagship Program (MEXT Q-LEAP) Grant Number JPMXS0118067395, and the CSTI, the Cross-ministerial Strategic Innovation Promotion Program (SIP), “Promoting the application of advanced quantum technology platforms to social issues.”

CC-04-1

Quantum communication in Space – An important step towards a global quantum internet

Thomas Jennewein

Department of Physics, Simon Fraser University, Canada
Institute for Quantum Computing, University of Waterloo, Canada

Biography

Dr. Jennewein completed his PHD in 2002 at the University of Vienna on Quantum Key Distribution and Teleportation Experiments. After a year in the automotive industry, he was a senior scientist at the IQOQI of the Austrian Academy of Sciences (2005). In 2009 he took moved to Canada to take a faculty position at the University of Waterloo / Institute for Quantum Computing. In 2024 he was awarded a Canadian Excellence Research Chair for Global Quantum Internet Systems and Professor in Physics at Simon Fraser University.

Dr. Jennewein's research vision is to build capable and scalable quantum communication technology for long range and satellite quantum networks. He initiated and leads the Canadian Satellite mission called Quantum EncrYption and Science Satellite (QEYSSat), which aims to demonstrate quantum communication and Quantum Key Distribution (QKD) between space and ground with stations across Canada and internationally. With his interest in the application of quantum technologies he also co-funded three quantum-tech startups, to develop and sell satellite based secure communication, sensing and research instrumentation.

Abstract

Quantum communication in space allows to transfer quantum encoded signals over large distances and represents an important step towards building a global quantum internet. I will present the development of our Canadian QEYSSat space mission, which can operate primarily a quantum receiver, as well as a weak coherent pulse quantum key distribution source. The receiver function is scientifically very interesting as it allows ground to space links using several different quantum light emitters and maybe even memories on the ground. I will introduce the QEYSSat mission architecture and discuss some of the development achievements leading up to its design including performing steps free-space quantum communications to a quantum receiver on a pickup truck and an airplane, as well as the expected radiation impact experienced by the system in space. Looking beyond QEYSSat, I will give an overview of our studies on novel directions and architectures for a quantum links involving satellites including time-bin, frequency bin and interfaces to quantum processors. Finally I will discuss a future mission, QEYSSat 2.0, which aims to demonstrate quantum teleportation across Canada.

CC-04-2

Free-space optical communication technology for quantum key distribution via satellite

Hideki Takenaka

Department of Aerospace Systems Engineering, Faculty of System Design, Tokyo Metropolitan University, Japan

Biography

He received M.A. degree in engineering at the University of Electro-Communications and joined the National Institute of Information and Communications Technology (NICT), Japan, in 2010. He earned Ph. D. from the University of Electro-Communications in 2014. Since 2021, he has been working at the Department of Aerospace Systems Engineering, Faculty of System Design, Tokyo Metropolitan University His current research interests are machine-learning, error-correcting code and satellite-to-ground optical communication links.

Abstract

Satellite-based Quantum Key Distribution (QKD) has garnered significant attention as a promising technology for establishing secure global communication infrastructures. Although fiber-based QKD systems are technically mature, their applicability over long distances is fundamentally limited by exponential transmission losses in optical fibers. In contrast, free-space optical channels particularly those involving satellite links offer distinct advantages, including lower attenuation and broader coverage, thereby enabling intercontinental QKD.

This study provides a comprehensive comparison between fiber-based and free-space QKD implementations, highlighting their respective strengths and limitations. Particular emphasis is placed on the technical challenges specific to satellite QKD, including atmospheric turbulence, the accuracy of orbital determination, and high-precision optical beam tracking.

CC-04-3

Study on QKD Using Optical Wireless Technology: Challenges and Future Prospects for Practical Use of Quantum Cryptography

Masayuki Miyashita

Research Institute of Advanced Technology, SoftBank Corp, Japan

Biography

Masayuki Miyashita Received The B.S. And M.S. Degrees From Tokyo University Of Science In 2001 And 2003, Respectively. He Joined SoftBank Telecom Corp. In 2008. Since April 2009, He Has Also Been A Research Engineer With The Wireless System Research Center At SoftBank Mobile Corp. (Currently, SoftBank Corp.). His Research Focuses On Mobile Communication Systems, Quantum Information Communication Theory, And The Development Of Quantum Information Communication Systems. He Is A Member Of The Institute Of Electronics, Information And Communication Engineers (IEICE) And The Japan Society For Industrial And Applied Mathematics (JSIAM). He Is Currently Engaged In Research And Development In The Fields Of Quantum Information Communication And Mobile Communication Technologies.

Abstract

It is expected that fault-tolerant quantum computers will emerge in the 2030s. Once realized, these quantum computers may be capable of breaking RSA encryption, which is widely used today. Moreover, the risk of harvesting attacks—in which encrypted data is stored for future decryption once sufficient quantum-computing power is available—is increasing, especially for sensitive information that retains value over the long term. To counter these threats, quantum-resistant security technologies are becoming essential. Among them, quantum key distribution (QKD) has gained attention as an elemental technology capable of enabling information-theoretically secure communication, regardless of quantum-computing capabilities. Traditionally, QKD has relied on optical-fiber links between fixed nodes, but this approach faces practical limitations in areas where fiber installation is difficult or time-consuming. In this work, we propose a hybrid architecture that combines optical fiber and optical wireless communication to overcome these challenges. Our goal is to expand urban QKD secure networks with greater flexibility and speed. As an initial step, we conducted a proof-of-concept demonstration in an anechoic chamber. This presentation reports on the experimental results.

CP-06-1

Silicon Spin Qubits: Advances and Insights from SiGe and FDSOI Technologies

Elena Blokhina

Equal1 Laboratories, Ireland

Biography

Elena Blokhina holds a Habilitation (D.Sc.) in engineering from Sorbonne University, a Ph.D. in physical and mathematical sciences, and an M.Sc. in physics with highest honours from Saratov State University. She is the Chief Scientific Officer of Equal1 Laboratories. She serves on the Steering Committee of the UCD Centre for Quantum Engineering, Science, and Technology (CQuEST), and is a member of the National Advisory Forum for Quantum Technologies Ireland. She has held multiple leadership roles, including a member of the Board of Governors of the IEEE Circuits and Systems Society, Deputy Editor-in-Chief of IEEE TCAS-I, and is currently a member of the Technical Committee on Quantum Information Systems and Applications within the IEEE Microwave Theory and Technology Society. Her research interests include semiconductor devices for quantum computing, semiconductor qubits, and on-chip quantum information processing.

Abstract

The talk will explore two technologies for silicon spin qubits. The first technology is based on SiGe heterostructures. This technology has already demonstrated multiple advances for spin qubits, including high-fidelity one-qubit (1Q) and two-qubit (2Q) gates, spin–photon coupling, and qubit shuttling for scalable architectures. Our motivation and recent results focus on achieving high-temperature operation, since elevated temperatures fall within the realistic thermal budget for integrated or co-packaged cryogenic electronics. The performance of SiGe spin qubits at 300 mK and above 700 mK, including benchmarking of 1Q and 2Q gates and analysis of Bell states, will be presented and discussed. The second part of the talk will cover the prospects of industry-standard fully depleted silicon-on-insulator (FDSOI) CMOS structures, a promising approach to scalable qubit architectures. FDSOI processes are capable of demonstrating qubits, but the research community is particularly interested in commercial processes. Measurement results from a commercial nanostructure fabricated using the GlobalFoundries 22FDX™ industrial process will be presented, focusing on the formation of quantum dots with controlled tunnel coupling and the detection of their charge state via a single-electron box sensor.

CP-06-2

Engineering Substrates to Accelerate the Quantum Leap

Cesar Roda Neve

SOITEC, France

Biography

Cesar Roda Neve received his Msc. Engineer degree from the ICAI Universidad Pontificia de Comillas, Madrid, Spain, in 2000. In 2004 he joined the University Carlos III of Madrid where he worked on optoelectronic devices for ROF links. In 2006 he joined the Microwave Laboratory of the UCLouvain, Belgium, where he specialized on the use of Si-based substrates for RF applications, in particular trap-rich HR-SOI. He received his Ph.D. degree by UCLouvain in engineering sciences in 2010. Since then, he has worked on R&D and new technologies development at several companies and for a wide variety of topics, from RF and large signal characterization, 2.5D/3D integration, to GNSS and UAV/satellite communications. In 2021 he joined Soitec as R&D Program Manager, working on strategic research applications and emerging technologies, focusing on quantum technologies and applications, as well as on RF, 6G, and advanced CMOS technologies.

Abstract

The advancement of quantum computing hinges on the development of engineered substrates that enhance qubit performance, scalability, and integration. This paper explores how innovations in substrate engineering and materials—specifically the utilization of Silicon-on-Insulator (SOI) substrates, —can be key in accelerating the scalability of future quantum systems.

SOI substrates, particularly Fully Depleted SOI (FD-SOI), offer reduced parasitic capacitance and improved thermal management, leading to lower power consumption, and in combination with the use of 28Si, can enhance qubit coherence. These properties are crucial for integrating quantum devices with classical control electronics, facilitating the development of hybrid systems that combine quantum and classical computing elements.

Soitec's expertise in thin layer transfer methods, and specifically Smart Cut^{TM}, will help to facilitate the integration of materials with disparate properties by transferring ultra-thin layers onto target substrates. These techniques enable the combination of optimal materials for different device components, such as high quality material layers (e.g. SiC, diamond or lithium niobate) for different qubits fabrication technologies onto targeted substrates. Quantum dedicated engineered substrates can be built, consisting of material combinations that are not physically possible to coexist or being grown using known techniques, and enabling discovering new properties as well as integration and operation schemes.

By leveraging these substrate engineering strategies, researchers can address key challenges in quantum computing, including qubit coherence, scalability, and integration with existing semiconductor technologies. This paper provides a comprehensive overview of current advancements in substrate engineering and discusses their implications for the future of quantum computing.

CP-06-3

Toward Stable Operation of Si Spin Qubits: Origin of Long-period Charge Fluctuation in Fin-type Quantum Dots

Hiroshi Oka

Semiconductor Frontier Research Center, National Institute of Advanced Industrial Science and Technology (AIST), Japan

Biography

Hiroshi OKA received the M.S. and Ph.D. degrees from the Division of Advanced Science and Biotechnology, Osaka University, in 2015 and 2018, respectively. He is currently a Senior Researcher with the Semiconductor Frontier Research Center, National Institute of Advanced Industrial Science and Technology (AIST), Japan. His research interests include the Si spin qubits, cryogenic CMOS, and high-mobility CMOS.

Abstract

Recently, the development of Si spin qubits has progressed rapidly, including the demonstration of long coherence-time and high-fidelity two-qubit gate operation. In addition to improving the performance of Si spin qubits, electrical instability is a serious problem that needs to be addressed for future practical operations, as it necessitates stability checks and the subsequent calibrations at certain intervals between calculation jobs. However, the cause-and-effect of long-period charge fluctuation of Si spin qubits has not been thoroughly discussed. In this work, we conducted an experimental study focusing on the long-period charge fluctuation of Si fin-type quantum dots. We found that charge fluctuation with a period of over 10 seconds occurs under a specific gate bias condition, in which the Fermi level is aligned close to the conduction band minimum possessing the band-edge states. TCAD analysis reveals that such long-period charge fluctuation is generated at the MOS interface around the top of the fin; thus, the quality of the MOS interface at the fin-top is of particular importance for the stable operation of Si quantum computers.

This work is based on results obtained from project, MEXT Q-LEAP Grant No. JPMXS0118069228, Japan.

SE-05-1

Spin Defects in Low-Dimensional Materials for Quantum Sensing

Vladimir Dyakonov

Experimental Physics 6 and Würzburg-Dresden Cluster of Excellence ct.qmat, Julius Maximilian University of Würzburg, Germany

Biography

Professor Vladimir Dyakonov holds the Chair of Experimental Physics on the Faculty of Physics and Astronomy of Julius-Maximilian University of Würzburg, Germany since 2004. He studied physics at the University of Leningrad and received his diploma degree in 1986. Since 1990, he has been a visiting researcher at the universities of Bayreuth (Germany), Antwerp (Belgium) and Linz (Austria). He finished his habilitation in experimental physics at the University of Oldenburg (Germany) in 2001. In 2007-2009 he was the Vice-dean and in 2013-2015 the Dean of the Faculty of Physics and Astronomy at the University of Würzburg. Dyakonov's main research interests are in the fields of optical and spin-resonance spectroscopy, thin-film organic and hybrid photovoltaics, organic light-emitting diodes and quantum sensors. He published ca. 230 peer-reviewed scientific papers and has h-index of 87. Dyakonov is the holder of an ERC Advanced Research Grant in 2022.

Abstract

Two-dimensional (2D) materials have emerged over the last decade as the new playground for quantum photonics devices. Among them, hexagonal boron nitride (hBN) is an interesting candidate, mainly because of its crystallographic compatibility with different 2D materials, but also because of its ability to harbor optically active defects that generate single photons. The negatively charged boron vacancy was the first intrinsic, optically addressable spin defect in hBN that allows coherent control at room temperature, as reported by our group in 2020. [1] Although other types of spin centers have been found in this material since then, this spin-1 color center remains the only one with a clearly elucidated structure. Practical applications of hBN spin centers as intrinsic magnetic field, temperature, pressure, etc. sensors in van der Waals heterostructures are hence envisioned. To further boost the quantum sensing applications of this spin defect in hBN, we are currently investigating the dynamics of the intermediate state, also known as the metastable state, because it is likely to trap electrons for a certain time, which affects the subsequent sensing protocol when the pulsed magnetic resonance experiment is designed.[2]

[1] A. Gottscholl et al. Nat. Mater. 19, 540 (2020)
[2] P. Konrad et al. arXiv:2503.22815 [quant-ph] (2025)

SE-05-2

Harnessing Quantum Defects in Fluorescent Nanodiamonds for Semiconductor Applications

Huan-Cheng Chang

Institute of Atomic and Molecular Sciences, Academia Sinica, Taiwan

Biography

Huan-Cheng Chang received his Ph.D. in Physical Chemistry from Indiana University at Bloomington, U.S.A., in 1990. After completing postdoctoral research at Harvard University, he joined the Institute of Atomic and Molecular Sciences (IAMS) at Academia Sinica in 1994 and currently serves as a Distinguished Research Fellow. Dr. Chang's research lies at the intersection of physical chemistry, nanoscience, and biomedical engineering. In 2005, he pioneered the development of fluorescent nanodiamonds (FNDs) and demonstrated their use in cellular imaging, marking a significant advancement in the field of nanotechnology. He further contributed to the field by developing a method for the mass production of FNDs in 2008, bridging the gap between fundamental research and practical biomedical applications. His innovations culminated in a U.S. patent for Luminescent Diamond Particles in 2012. Beyond his technical contributions, Dr. Chang has authored over 150 peer-reviewed publications, including the comprehensive monograph titled Fluorescent Nanodiamonds in 2019. His current research focuses on advancing FND-based technologies and their emerging applications in semiconductor systems.

Abstract

Fluorescent nanodiamonds (FNDs) containing nitrogen-vacancy (NV) centers are among the most advanced solid-state quantum sensors, known for their room-temperature spin detection, photostable fluorescence, and outstanding biocompatibility. This lecture presents two emerging applications of these quantum sensors in semiconductor systems. First, we demonstrate that FNDs enable real-time, long-term diagnostics of radiation in extreme ultraviolet (EUV) lithography, a cutting-edge technology in modern semiconductor chip manufacturing. Conventional scintillators face durability issues due to the shallow penetration depth (<100 nm) of EUV radiation. In contrast, FNDs exhibit exceptional photostability and emit bright red fluorescence from NV0 centers when excited by EUV light. By integrating uniform FND films with fiber-optic plates and optical image sensors, we create platforms capable of highly sensitive detection of EUV and soft X-ray radiation from various sources. Second, we show that ultrathin FND films coated directly onto semiconductor devices enable in operando measurements of magnetic fields and temperatures using NV– centers. Initial detection is performed via optically detected magnetic resonance (ODMR). Next, we introduce a novel technique, FND-based lock-in photoluminescence thermography, allowing for wide-field, real-time temperature mapping of operating transistors with nanoscale spatial and millisecond temporal resolution. Compared to ODMR, the new method offers greater ease of use and practical applicability.

SE-05-3

Fluorescent nanodiamonds for thermal biology

Yoshie Harada

Premium Research Institute for Human Metaverse Medicine (WPI-PRIMe), The University of Osaka, Japan

Biography

Dr. Yoshie Harada received her B.Sc. in Biology from Ibaraki University, Japan, in 1982, followed by an M.Sc. in Biology from the same university in 1984. She earned her Ph.D. in Biophysics from Osaka University, Japan, in 1988. In 1987, she developed an in vitro actin-myosin motility assay system and demonstrated that a two-headed myosin structure is not essential for muscle contraction. In 1992, she joined Yanagida Biomotron Project, where she developed a single-molecule imaging system in 1995. In 2000, she established her own laboratory at Department of Molecular Physiology, Tokyo Metropolitan Institute of Medical Science. In 2001, she succeeded in visualizing DNA rotation during transcription by individual RNA polymerase molecules. In 2008, she was appointed as a professor at the Institute for Integrated Cell-Material Sciences (WPI-iCeMS), Kyoto University, where she launched projects on nanodiamond fluorescent probes and intracellular temperature measurement. In 2016, she moved to Institute for Protein Research at Osaka University, from which she retired in 2025. She is currently a specially appointed professor at Premium Research Institute for Human Metaverse Medicine (WPI-PRIMe), The University of Osaka. She received Inoue Research Award for Young Scientists in 1991 and JAUW-Morita Award for Science in 1999.

Abstract

Temperature and heat, both within and outside the body, play a fundamental role in sustaining biological functions and regulating metabolic processes. Our recent work has revealed that spontaneous intracellular heat generation is critically involved in the differentiation of neuronal cells. To better understand intracellular thermogenesis, a variety of fluorescence-based nanothermometers have been developed, including quantum dots, lanthanide complexes, polymers, and genetically engineered proteins. In this presentation, we introduce a temperature sensing method utilizing fluorescent nanodiamonds and highlight their exceptional thermal sensitivity, which remains largely unaffected by factors such as pH, ion concentration, viscosity, intermolecular interactions, and the presence of organic solvents. We also report on the measurement of intracellular thermal conductivity using diamond quantum sensors coated with heat-generating polymers. Contrary to the conventional assumption that intracellular thermal conductivity is equivalent to that of water, our findings demonstrate that it is approximately one-sixth as high. This discovery provides important new insights into intracellular heat diffusion and carries broad implications for fundamental biomedical research on cellular thermogenesis. Lastly, we present a novel fluorescent thermometer based on carbon quantum dots synthesized through a hydrothermal reaction of anthraquinone derivatives and citric acid—a technology we have recently developed.

CP-07-1

TBA

Yuya Seki

Keio University, Japan

CP-07-2

Thermalization and criticality on an analog-digital quantum simulator

Trond I. Andersen

Google Quantum AI, USA

Biography

Trond I. Andersen is a senior research scientist at Google Quantum AI, where he works on realizing new physical phenomena and beyond-classical applications on NISQ hardware. Trond received his B.S. in Physics at Massachusetts Institute of Technology, where he studied optoelectronic phenomena in graphene with Prof. Pablo Jarillo-Herrero. He then received his PhD in Mikhail Lukin's group at Harvard University, where he performed several studies of excitons in twisted 2D semiconductors, and also used nanoscale defects in diamond to probe electron-phonon dynamics in graphene. In his current work at Google, Trond is particularly focused on hybrid analog-digital quantum simulation, with the goal of using quantum hardware to gain new insights about both non-equilibrium phenomena and ground state properties in quantum magnets.

Abstract

Understanding how interacting particles approach thermal equilibrium is a major challenge of quantum simulators. Unlocking the full potential of such systems towards this goal requires flexible initial state preparation, precise time evolution and extensive probes for final state characterization. Here we present a quantum simulator comprising 69 superconducting qubits that supports both universal quantum gates and high-fidelity analogue evolution, with performance beyond the reach of classical simulation in cross-entropy benchmarking experiments. This hybrid platform features more versatile measurement capabilities compared with analogue-only simulators, which we leverage here to reveal a coarsening-induced breakdown of Kibble–Zurek scaling predictions in the XY model, as well as signatures of the classical Kosterlitz–Thouless phase transition. Moreover, the digital gates enable precise energy control, allowing us to study the effects of the eigenstate thermalization hypothesis in targeted parts of the eigenspectrum. We also demonstrate digital preparation of pairwise-entangled dimer states, and image the transport of energy and vorticity during subsequent thermalization in analogue evolution. These results establish the efficacy of superconducting analogue–digital quantum processors for preparing states across many-body spectra and unveiling their thermalization dynamics.

CP-07-3

Annealing Quantum Computation for Scientific Applications

Mark Johnson

D-Wave, Canada

Biography

Mark W. Johnson has been involved in the development and commercialization of technology for more than 25 years, and currently leads the development of quantum systems and technology at D-Wave. Mark joined D-Wave in 2005 as an experimental physicist and superconducting circuit design engineer to help develop, build, and deliver the world's first commercially available quantum computer. Since then he has continued to work with the D-Wave team to develop and release subsequent generations of quantum computers. Prior to joining D-Wave, Mark was a scientist with the Superconductive Electronics Organization at the Space Park facility of Northrop Grumman, formerly TRW, Inc., developing superconductive analog-to-digital converters and digital signal processors for communications applications. Mark holds a doctorate in physics from the University of Rochester.

Abstract

Technological advances in the capabilities of commercially available Annealing Quantum Computers have included both increasing qubit coherence time, as well as increasing the speed at which the Hamiltonian can be controlled. Beyond increasing the problem-solving power of these systems for large scale optimization problems, these advances have opened the door to a wide range of scientific quantum computing applications. These include quantum simulation of spin glass systems and geometrically frustrated magnets, including the first demonstration of Quantum Supremacy on a useful, real-world problem. On the scale of individual qubits, these advances have opened the door to a degree of quantum state preparation and manipulation not previously possible within the fabric of large-scale quantum annealing processors. I will review some of the possibilities in the context of the recently released Advantage2™ Annealing Quantum Computer.

JT-01
(CP+SE)-1

Future of Quantum Biology through Quantum Computing: Expectations and Practical Challenges

Wataru Mizukami

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

Biography

Wataru Mizukami is a Professor at the Center for Quantum Information and Quantum Biology, the University of Osaka, and leads the "Quantum Computing for Chemistry and Material Science" group there. He completed the doctoral program at the Graduate University for Advanced Studies in 2011, Ph.D. in Science. Former Marie Curie Research Fellow at the University of Bristol and Special Researcher in Basic Science at RIKEN. He moved to Osaka in 2019 and his main research focuses on the development and application of quantum algorithms for chemistry. He is also an advisor of QunaSys Inc.

Abstract

How can quantum computing change the way we understand biomolecules? Say, there has been increasing interest in applying quantum computers to drug discovery. However, it is important to recognize that current drug discovery problems are either classical in nature or, at best, weakly-correlated quantum problems, which may not be ideal for quantum computers to show their advantage. In this talk, I will begin by revisiting the key principle that quantum computers are effective for strongly correlated molecular problems, and from there introduce a long-term vision for quantum biology. Then, how far current quantum computing technology has come towards achieving this vision will be shared with presenting our research results. Specifically, recent computational results obtained using quantum computers at Osaka University and RIKEN will be introduced, alongside advancements in universal machine learning interatomic potentials towards integration with quantum computing.

JT-01 (CP+SE)-2

Experimental Evidence for Quantum Tunnelling of Protons in DNA Mutation

Johnjoe McFadden

Faculty of Health and Medical Sciences, University of Surrey, UK

Biography

Johnjoe McFadden studied Biochemistry at the University of London, did his PhD at Imperial College, University of London. His mainstream research is in the field of molecular genetics and systems biology, particularly of microbes that cause infectious diseases such as tuberculosis, antimicrobial resistance and vaccines. He has wide-ranging interests and wrote the popular science book about quantum biology, 'Quantum Evolution' published in 2000 and then 'Life on the Edge', published in 2014 with the physicist, Jim Al-Khalili. His quantum biology research is focused on investigating the role of quantum mechanics in mutation, photosynthesis and drug activation. He was the founding Director of the Leverhulme Quantum Biology Doctoral Training Centre at the University of Surrey and conducts research in quantum biology at this Centre.

Abstract

Mutation drives evolution and plays key roles in cancer, aging, and drug resistance. The idea that quantum mechanics contributes to spontaneous mutations dates back to Erwin Schrödinger's 1944 book *What is Life?*, in which he proposed that quantum tunnelling might shift atomic positions within genes, triggering mutations. Building on this, Per-Olov Löwdin suggested that proton tunnelling in DNA could produce rare tautomeric base pair forms, leading to replication errors. While this hypothesis remained largely theoretical, recent quantum chemical models have explored how bases might transition between canonical and tautomeric states via tunnelling. However, direct experimental evidence has been limited. In this study, we used primer extension analysis to compare mutation rates in ordinary water and deuterated water (D_2O). We observed significant kinetic isotope effects, supporting a role for proton tunnelling in spontaneous mutation.

JT-01 (CP+SE)-3

Quantum Technologies for Magnetic Resonance Spectroscopy, Imaging and Sensing in the Life Sciences

Martin B. Plenio

Institute of Theoretical Physics, Ulm University, Germany

Biography

The author earned his Diploma (1992) and PhD (1994) in Physics from the University of Göttingen. Following a Feodor Lynen Fellowship at Imperial College London (1995–1997) with Professor Sir Peter Knight FRS, he became Lecturer (1998) and later Full Professor of Quantum Physics (2003). In 2009, he joined Ulm University as an Alexander von Humboldt Professor. He has made pioneering contributions to entanglement theory, quantum technologies with atoms, ions, photons, and color centers in diamond, as well as quantum effects in biology. He is author of 440 papers with 71,000+ citations (h-index 124) and Clarivate Highly Cited Researcher. His awards include the IOP Maxwell Medal (2004), Royal Society Wolfson Research Merit Award (2006), Clifford Paterson Lecture, Max-Born Medal (2012), and two successive ERC Synergy Grants. He founded the Center for Quantum BioSciences, securing €23 million in funding, and co-founded NVision Imaging Technologies (2015, >110 employees) and QCDesign (2022, >15 employees). Of his mentees, 43 now hold permanent academic positions, including at Caltech, Oxford, UCL, and The Hebrew University.

Abstract

Nuclear Magnetic Resonance (NMR) is one of the most widely used spectroscopic techniques in biology and the life sciences, with applications ranging from chemical analysis and drug discovery to medical imaging. However, its utility is inherently limited by its low sensitivity. This limitation is rooted in the weak nuclear spin nuclear spin polarisation in thermal equilibrium - typically only a few parts per million - and the constraints of inductive signal detection.

I discuss how both of these limitations can be overcome using quantum technologies. Specifically, I will demonstrate how optically detected magnetic resonance, employing colour centers in diamond, offers a means for the detection of ESR and NMR signals in biological environments including cells. NMR signals can be collected with chemical shift resolution even at the nano- and micronscale. Furthermore, I discuss how quantum control can facilitate nuclear spin hyperpolarisation, resulting in signal increases of over 10,000-fold. These methods holds the potential to enable the metabolic profiling of single cells as well access to metabolic imaging for early treatment assessment in standard clinical MRI scanners.

CC-05-1

Migration to Post-Quantum Cryptography: Recent Trend and Challenges in the Financial Sector

Masashi Une

Institute for Monetary and Economic Studies, Bank of Japan, Japan

Biography

Dr. Masashi Une was born in Fukuyama, Japan, on October 23, 1971. He received the bachelor degree in social science from the University of Tsukuba in 1994. He joined the Bank of Japan in 1994. He also received the Ph.D. degree of engineering from Yokohama National University in 2003. He has been in charge of IT security research and management in the Bank of Japan for more than twenty years. His research interest includes IT security related to the financial services, e.g., cryptography, AI safety, open API security, blockchain, crypto assets, and biometric authentication. He has been studying these topics in collaboration with IT staff of Japanese financial institutions.

Abstract

The following security risk has globally gathered much attention: if a large-scale and practical quantum computer would be realized and maliciously operated, conventional cryptographic algorithms, such as RSA and Elliptic Curve Cryptography, could be efficiently broken with Shor’s factoring algorithm. One of practical countermeasures against this risk is to adopt the post-quantum cryptography (PQC) in IT systems instead of the vulnerable algorithms. The migration to PQC algorithms has an advantage of making use of the existing network infrastructure. However, it is not easy to complete the migration effectively. There are three challenges: (1) how to specify IT systems which implement the vulnerable algorithms, (2) how to establish a roadmap and an organization for the migration, and (3) how to deal with a risk of the future compromise of PQC algorithms. In the financial sector, G7 Cyber Expert Group released a statement which emphasized the importance of immediately starting to discuss the migration. In Japan, Financial Services Agency published a paper which summarized the discussion of the working group on PQC algorithms. By following and referring to these activities, it is desirable to discuss the migration appropriately.

CC-05-2

Towards a Global Quantum Cryptography Infrastructure

Taofiq Paraiso

Quantum Information Group, Toshiba Europe Cambridge Research Laboratory, UK

Biography

Dr. Taofiq Paraiso is a Team Leader at Toshiba Europe, Cambridge Research Lab, UK, where he is responsible for the development of photonic integrated circuits for quantum key distribution and quantum random number generation, as well as their system integration into practical chip-based QKD devices. Dr. Paraiso has over 15 years of academic and industrial research experience in the fields of quantum photonics, semiconductor physics, light-matter interactions, and nanofabrication. He previously held research positions at the California Institute of Technology and the Max-Planck Institute for the Science of Light, Germany. He received his PhD in Physics from the Swiss Federal Institute of Technology Lausanne (EPFL) in Switzerland.

Abstract

As our communication networks and the volume of sensitive information are ever expanding, there is a tangible need to enhance our cryptography infrastructure with a solution that provides long-term resilience against rising threats from quantum computing and, potentially, artificial intelligence. Quantum Key Distribution is one of the most promising candidates to address these goals, as it offers direct means of measuring the channel confidentiality during the communication. Strong of over two decades of technological development and field validation, QKD has become a mature technology, with products available through a growing number of vendors and the first commercial networks under deployment in various countries. On the route to global adoption of QKD, the practical deployment of a robust quantum communication infrastructure calls for innovative solutions in hardware scalability, transmission speed and range, network architecture, key management, and integration with our existing coherent optical communications networks. In this talk, I will present an overview of our approaches and efforts to tackle challenges across all these layers and propose some perspectives on potential future developments.

CC-05-3

Quantum Key Distribution Research and Development in NEC

Hiroki Kawahara

Advanced Network Research Laboratories, NEC Corporation, Japan

Biography

He received the B.E. and M.E. degrees in Electrical, Electronics, and Information Engineering from Osaka University, Osaka, Japan, in 2009 and 2011, respectively. In 2011, he joined Nippon Telegraph and Telephone Corporation, where he was engaged in the research and development of optical transport networks. From 2021 to 2023, he was with NTT Communications Corporation, working on the operation of terrestrial and submarine optical transport networks. He is currently with NEC Corporation, where his research focuses on quantum key distribution systems.

Abstract

Quantum key distribution (QKD) enables the generation and distribution of cryptographic keys with security based on the principles of quantum mechanics, making it a promising technology for mission-critical applications. NEC has been actively engaged in research and development aimed at the social implementation of QKD.

This presentation first outlines NEC's recent R&D activities on BB84 and continuous-variable (CV) QKD systems. To further accelerate the large-scale and cost-effective deployment of QKD networks, we, in collaboration with other partners, have successfully demonstrated the integration of QKD systems into live existing telecom fiber infrastructure. The details of this demonstration will be presented.

Acknowledgements

The work introduced in this presentation was partially supported by "Research and development for the construction of a global quantum cryptography network" (JPJ008957) in "R&D of ICT Priority Technology Project" (JPMI00316) of the Ministry of Internal Affairs and Communications (MIC), Japan.

JT-02
(CC+CP)-1

Simulating photons traveling through linear optical elements for more accurate models of quantum interconnects

Akihito Soeda

Principle of Informatics Research Division, National Institute of Informatics, Japan
Informatics Program, SOKENDAI, Japan
Graduate School of Science, The University of Tokyo, Japan

Biography

Akihito Soeda is an Associate Professor in the Principles of Informatics Research Division at the National Institute of Informatics, Tokyo. He is also a visiting researcher at the University of Tokyo. He earned his Ph.D. in Physics from the University of Tokyo, specializing in theoretical quantum information. His research includes theoretical studies of higher-order quantum operations and distributed algorithms to unlock scalable quantum networks and the future quantum internet. He is a Board Member of the Quantum Internet Task Force and serves on program committees for QCNC, IEEE QCE, and other international conferences. His current JST Moonshot project develops use-case driven performance metrics for quantum networks, integrating physics, information theory, and network engineering.

Abstract

Utility-scale quantum computation is likely to require a multicomputer architecture, where quantum computer nodes are connected by quantum interconnects. Photons are arguably a preferred choice of medium to facilitate the necessary classical and quantum information exchange between the nodes. Photon-based communication is not limited to quantum computation and would be mandatory for long-distance communication in quantum domains. The expected scale and accuracy requirements in achieving fault-tolerant quantum computation indicate that the manipulation of photons is done at sufficiently high accuracies and call for innovative system designs. Proper simulations would serve as effective tools. In this talk, we discuss how the simulations can be formulated. We model photons traveling through free space and interacting with linear optical elements. The optical elements are modeled as a collection of stationary qubits. We implement various types of linear optical elements and use to numerically demonstrate quantum experiments that highlight the quantum nature of light. These include relevant phenomena for quantum information processing, such as the bunching phenomenon of two photons and violation of the Clauser–Horne–Shimony–Holt inequality.

JT-02
(CC+CP)-2

Fast and Scalable Fault-Tolerant Quantum Computing with Neutral Atoms and Cavity-QED Interconnects

Shinichi Sunami

NanoQT, Japan

Biography

Shinichi Sunami is VP of Theory and Architecture at NanoQT. He earned his PhD at the University of Oxford in 2022 and then remained there as a Postdoctoral Researcher and Junior Research Fellow. He received Award for Excellence from University of Oxford in both 2022 and 2023 for his outstanding contribution to research, teaching and outreach.

Abstract

Optimized architectural design can transform a collection of emerging technologies into a robust and high-performance computational module exploiting the unique features of the underlying hardware. While significant optimization has been made over the past decade for superconducting qubits, corresponding architectural designs have not been widely available for rapidly emerging neutral-atom quantum computing technologies. In this talk, we introduce an optimized design that leverages the unique characteristics of neutral-atom systems: fast selective gates, flexible transversal gate operations, and parallel atom shuttling, which outperforms existing zoned and selective-gate only designs. Through careful system-level optimization spanning atomic physics considerations, logical gate design and instruction set architecture, we identify the regime where the neutral-atom systems can perform large-scale fault-tolerant quantum computing (FTQC) with comparable spacetime (qubit-second) overhead as the superconducting qubits operating lattice surgery, despite 100-1000 times slower physical-level operation speed [1].

We further discuss the potential for neutral-atom systems to scale by fast, high-fidelity photonic interconnects. We first describe the underlying hardware technology: nanophotonic cavity-QED based remote entanglement generation [2,3,4] with a proposal for generating Bell pairs at 400 kHz rate at 99.9% fidelity, including potential device imperfections and fluctuations, using our recent proposal for robust remote entanglement generation using cavity-assisted photon scattering [5]. This allows for an efficient, high-bandwidth multiprocessor FTQC operations through pipelined entanglement distillation factories [1,3].

This talk is based on our recent experimental and theoretical works, [1] arXiv:2506.18979 (2025), [2] arXiv:2506.06123 (2025), [3] PRX Quantum 6, 010101 (2025), [4] arXiv:2502.14859 (2025), and [5] arXiv:2507.01229 (2025).

JT-02
(CC+CP)-3

Toward Scalable Multicore Fault-Tolerant Quantum Computers using Quantum Multiplexing

Shin Nishio

Graduate School of Science and Technology, Keio University, Japan
Department of Physics and Astronomy, University College London, UK

Biography

Shin Nishio specializes in system software for quantum computing and quantum error correction codes. He started working in quantum information processing when he was in the undergraduate program under the supervision of Prof. Rodney Van Meter at Keio University. As an undergraduate, he worked with Prof. Takahiko Satoh and Dr. Atsushi Matsuo to design problems and judge submissions for the IBM Quantum Challenge in 2019, the first quantum programming competition hosted by IBM. Over 700 people participated in the challenge and enjoyed designing quantum algorithms for a toy graph theory problem. He earned his Ph.D. in informatics at SOKENDAI in alliance with National Institute of Informatics and Okinawa Institute of Science and Technology under the supervision of Prof. Kae Nemoto, where he conducted research on reduction of resource overheads for distributed fault-tolerant quantum computing. Currently Shin is a project assistant professor in Prof. Takahiko Satoh's Group at Keio University in Japan. He is also a research associate funded by Overseas Research Fellowships of JSPS in Prof. Dan Browne's Group at University College London in UK. He leads efforts to define the functions required for large-scale quantum computing systems and to address the challenges involved in their realization.

Abstract

Linking multiple quantum processors via a quantum interconnect is a promising approach to realizing large-scale, fault-tolerant quantum computation. Quantum multiplexing refers to encoding high-dimensional quantum information onto a single photon by exploiting multiple degrees of freedom or multiple components within a single degree of freedom. This technique is expected to enable more efficient quantum communication.

In this work, we consider the adoption of quantum multiplexing in an interconnected fault-tolerant quantum computing architecture. We analyze how such multiplexing affects the logical error rate of an error-corrected communication channel using surface codes and hypergraph product codes. While multiplexing can offer significant resource savings, it also converts photon-loss errors into correlated errors, which can degrade code performance. However, we demonstrate that this detrimental effect can be substantially mitigated by employing an appropriate strategy for assigning qubits to photons—making multiplexed communication viable with both higher throughput and improved fidelity. We also place our analysis in the context of recent developments in fault-tolerant quantum computation, highlighting how quantum multiplexing aligns with emerging architectural trends.

SE-06-1

Multi-ion clocks for compact clocks and sensors

Tanja E. Mehlstäubler

Physikalisch-Technische Bundesanstalt, Germany
Leibniz Universität Hannover, Germany

Biography

T.M. studied physics at the Ludwig-Maximilian Universität Würzburg and at the State University of New York at Stony Brook, USA, where she graduated with a Master's thesis on "Parity Violation in Francium Atoms".
After her doctoral thesis (with summa cum laude) on 'Novel Laser Cooling Methods for a Frequency Standard with Neutral Mg Atoms', she worked as a Postdoc on the atomic gravimeter at the LNE/SYRTE in Paris. The atomic gravimeter is now commercially available (at iXblue). T.M. then switched from quantum applications based on neutral atoms to trapped ions. In 2009, T.M. established the first Junior Research Group at PTB to demonstrate her novel approach of the multi-ion clock. In 2016 she completed her Habilitation at the Leibniz Universität Hannover.
Since 2018 she has been appointed Guest-Professor at Osaka University, Japan. In 2020, she became Full Professor at Leibniz Universität Hannover and Head of the Department „Quantum Clocks and Complex Systems" at PTB. She is elected member and speaker of the AMO-Review Board of the German Science Foundation, member of the Clusters of Excellence QuantumFrontiers (in the board) and PhoenixD.

Abstract

Trapped and laser-cooled ions allow for a high degree of control of atomic quantum systems. They are the basis for modern atomic clocks, quantum computers and quantum simulators. In our research we use ion Coulomb crystals, i.e. many-body systems with complex dynamics, for precision spectroscopy. Multi-ion clocks will not only improve the stability by exploiting the higher signal to noise of multiple ions or their uncertainty by allowing for sympathetic cooling of clock ions using a separate ion species but will be the basis for future entangled clocks and cascaded clocks.
This paves the way to novel optical frequency standards with ultra-high stability reaching 10^{-19} relative accuracy and stability, and for applications such as relativistic geodesy and quantum simulators in which complex dynamics becomes accessible with atomic resolution. We will report on the first multi-ion clock operation and frequency comparisons, obtaining a world-record in optical frequency comparisons and achieving a critical milestone for the redefinition of the second. In a series of follow-up clock campaigns the Coulomb crystal clock also proved repeatable frequency measurements in the low 10^{-18} regime over more than 3 years.

SE-06-2

Quantum-amplified global-phase spectroscopy on an optical clock transition

Leon Zaporski

Center for Ultracold Atoms, Massachusetts Institute of Technology, USA

Biography

I am a postdoc at MIT-Harvard Center for Ultracold Atoms, working on the Yb Clock experiment of Prof. Vladan Vuletić.

Abstract

Optical lattice clocks (OLCs) are at the forefront of precision metrology, operating near a standard quantum limit (SQL) set by quantum noise. Harnessing quantum entanglement offers a promising route to surpass this limit, yet there remain practical roadblocks concerning scalability and measurement resolution requirements. In this talk I will focus on a recent adaptation of the holonomic quantum-gate concept to the development of a novel Rabi-type "global-phase spectroscopy" (GPS) that utilizes the detuning-sensitive global Aharanov-Anandan phase. With this approach, our team was able to demonstrate quantum-amplified time-reversal spectroscopy in an OLC that achieved 2.4(7) dB metrological gain without subtracting the laser noise, and 4.0(8) dB improvement in laser noise sensitivity beyond the SQL. Our technique is not limited by measurement resolution, scales easily owing to the global nature of entangling interaction, and exhibits high resilience to typical experimental imperfections. We expect it to be broadly applicable to next-generation atomic clocks and other quantum sensors approaching the fundamental quantum precision limits.

(https://arxiv.org/abs/2504.01914)

SE-06-3

Contributions of NICT's Optical Lattice Clock to Local and International Timescales

Hidekazu Hachisu

Space-Time Standards Laboratory, NICT, Japan

Biography

Hidekazu Hachisu started his research career in the group of Professor Hidetoshi Katori at the University of Tokyo in 2006, where he studied electrodynamic trapping with an atom chip to manipulate spinless neutral atoms and tackled the blackbody radiation shift in optical lattice clocks based on mercury and strontium atoms. He joined NICT in 2010 and is now a senior researcher working on the research and development of strontium optical lattice clocks and their applications, such as steering Japan Standard Time and calibration of Coordinated Universal Time. He is a member of the Consultative Committee for Time and Frequency (CCTF) Working Group on Primary and Secondary Frequency Standards.

Abstract

Since 1967 the second, the SI unit of time, has been defined by a microwave transition of the cesium-133 isotope. Over the last two decades, optical frequency standards (OFSs), such as the optical ion clock and the optical lattice clock, have advanced rapidly and now surpass the cesium microwave standards in accuracy and stability. This has prompted the scientific community to discuss redefining the SI second to represent a single or multiple optical transitions. For this redefinition, contributions of OFS to local and international timescales have been set as an ancillary condition and mandatory criterion, respectively. NICT was the first to generate a real signal of a timescale based on an OFS, intermittently measuring the local timescale by a strontium optical lattice clock more than once a week. We generate Japan Standard Time (JST) with reference to the optically steered timescale since August 2021, now four years. NICT's optical lattice clock also contributes to calibrating the rate of Coordinated Universal Time (UTC), and I will show some of the results achieved so far.

PL-05-1

On the Nature of Quantum Algorithms

Isaac Chuang

Department of Physics, MIT, USA

Biography

Prof. Chuang is a pioneer in the field of quantum information science. His experimental realization of two, three, five, and seven quantum bit quantum computers using nuclear spins in molecules provided the first laboratory demonstrations of many important quantum algorithms, including Shor's quantum factoring algorithm. The error correction, algorithmic cooling, and entanglement manipulation techniques he developed provide new ways to obtain complete quantum control over light and matter, and lay a foundation for possible large-scale quantum information processing systems.

Abstract

What is the underlying reason why quantum algorithms running on quantum computers can solve certain problems faster than classical algorithms running on classical computers? I will describe how the underlying nature of almost all major quantum algorithms essentially relies on the physics of a two-level system – a single qubit. This picture brings together in a single unifying perspective Grover's quantum search algorithm, Shor's quantum factoring algorithm, and the quantum simulation algorithm of Feynman and Lloyd. This understanding also informs searches for new quantum algorithms.

PL-05-2

Superconducting quantum computing at the International Year of Quantum Science and Technology and the future

Yasunobu Nakamura

RIKEN Center for Quantum Computing, Japan,
Department of Applied Physics, Graduate School of Engineering, The University of Tokyo, Japan

Biography

Yasu Nakamura began 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 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 led his research team at RIKEN since 2014. He has been the founding Director of the RIKEN Center for Quantum Computing since 2021 and the Project Leader of the MEXT Q-LEAP Flagship project on Superconducting Quantum Computing since 2018.

Abstract

Superconductivity was discovered in 1911, even before the theory of quantum mechanics was formulated in 1925. The physics of superconducting qubits was conceived in 1980, even before quantum information science was widely acknowledged in the 1990s. From history, we learn how difficult it is to predict the progress of science and technology as well as the future of our lives. However, the past tells us that breakthroughs often occur at a level beyond our imagination.

Now, at the International Year of Quantum Science and Technology (IYQ2025), a quarter century after the first demonstration of coherent control of a superconducting qubit, superconducting quantum computers exist to our surprise (or not?). They are still small-scale, error-prone, and not yet drastically outperforming classical computers. Anyways, it is fantastic that hundreds of qubits are controlled coherently in a programmable manner.

There remain, not surprisingly, many challenges to be overcome before realizing a large-scale, fault-tolerant superconducting quantum computer, on which numerous groups worldwide are working actively. Control and readout of qubits must be fast and high-fidelity, and the overall scalability must be ensured from quantum processor units to packaging, wiring, cryogenics, control electronics, error correction, and software. Nevertheless, new ideas are emerging rapidly, and technology is evolving quickly.

PL-05-3

Engineering high quality qubits in silicon with atomic precision

Michelle Y. Simmons

Silicon Quantum Computing, Australia

Biography

Professor Michelle Simmons is the world's leading materials scientist, Founder and CEO of Silicon Quantum Computing (SQC).
Michelle is the pioneer of atomic electronics. She developed both the world's first single-atom transistor and the first integrated circuit made with atomic precision.
SQC manufactures the world's highest quality qubits with atomic precision engineering, in-house. This is the most viable path to a commercial scale quantum computer.

Abstract

The realisation of a large-scale error corrected quantum computer relies on our ability to reproducibly manufacture qubits that are fast, highly coherent, controllable and stable. The promise of achieving this in a highly manufacturable platform such as silicon requires a deep understanding of the materials issues that impact device operation. In this talk I will demonstrate how we engineer every aspect of the processor using atom qubits in silicon for fast, controllable exchange coupling [1], fast, high fidelity qubit initialisation and read-out [2]; low noise all epitaxial gates for highly stable qubits [3,4]; and efficient, high fidelity qubit control [5,6] leading to the demonstration of the highest fidelity Grover's algorithm to date [7].
I will also discuss our latest results in quantum analogue processors. Here I will present an atomically engineered quantum feature generator in which we use quantum states to increase the accuracy of classical machine learning [8]. I will also show our latest results in analogue simulation [9,10] demonstrating the uniqueness of the atom in silicon system.

[1] Y. He, S.K. Gorman, D. Keith, L. Kranz, J.G. Keizer, and M.Y. Simmons, "A fast (ns) two-qubit gate between phosphorus donor electrons in silicon", Nature 571, 371 (2019)
[2] D. Keith, M. G. House, M. B. Donnelly, T. F. Watson, B. Weber, M. Y. Simmons, "Microsecond Spin Qubit Readout with a Strong-Response Single Electron Transistor",
Physical Review X 9, 041003 (2019); D. Keith, S. K. Gorman, L. Kranz, Y. He, J. G. Keizer, M. A. Broome, M. Y. Simmons, "Benchmarking high fidelity single-shot readout of semiconductor qubits", New Journal of Physics 21, 063011 (2019).
[3] L. Kranz S. K. Gorman B. Thorgrimsson Y. He D. Keith J. G. Keizer M. Y. Simmons, "Exploiting a Single-Crystal Environment to Minimize the Charge Noise on Qubits in Silicon", Advanced Materials 32, 2003361 (2020).
[4] M. Koch, J.G. Keizer, P. Pakkiam, D. Keith, M.G. House, E. Peretz, and M.Y. Simmons, "Spin read-out in atomic qubits in an all-epitaxial three-dimensional transistor", Nature Nanotechnology 14, 137 (2019 – with cover article).
[5] L. Fricke, S.J. Hile, L. Kranz, Y. Chung, Y. He, P. Pakkiam, J.G. Keizer, M.G. House and M.Y. Simmons, "Coherent spin control of a precision placed donor bound electron qubit in silicon", Nature Communications 12, 3323 (2021).
[6] J. Reiner, Y. Chung, C. Lehner S.H. Misha, S. Monir, D. Poulos, K. Charde, L. Kranz, B. Thorgrimsson, P. Macha, D. Keith, Y-L. Hsueh, R. Rahman, J.G. Keizer, S.K. Gorman, M.Y. Simmons, "Control of multiple nuclear spin quantum registers", Nature Nanotechnology 19, 584 (2024).
[7] I. Thorvaldson, D. Poulos, C. M. Moehle, S. H. Misha, H. Edlbauer, J. Reiner, H. Geng, B. Voisin, M. T. Jones, M. B. Donnelly, L. F. Pe˜na, C. D. Hill, C. R. Myers, J. G. Keizer, Y. Chung, S. K. Gorman, L. Kranz, and M. Y. Simmons, "Grover's algorithm in a four-qubit silicon processor above the fault-tolerant threshold", Nature Nanotechnology 20,472 (2025).
[8] S. A. Sutherland, M. Donnelly, J.G. Keizer, C.R. Myers, B. Thorgrimsson, Y. Chung, S.K. Gorman and M. Y. Simmons, "Experimental quantum enhanced machine learning using quantum many body systems", paper in review (2024).
[9] M. Kiczynski, S.K. Gorman, H. Geng, M.B. Donnelly, Y. Chung, Y. He, J.G. Keizer and
M.Y. Simmons, "Engineering topological states in atom-based semiconductor quantum dots", Nature 606, 694-699 (2022).
[10] M. B. Donnelly, Y. Chung, R. Garreis, S. Plugge, D. Pye, M. Kiczynski, M. M. Munia, S. Sutherland, B.Voisin, L. Kranz, Y.L. Hsueh, A.M. Saffat-Ee Huq, C. M. Moehle, C. R. Myers, R. Rahman, J.G. Keizer, S.K. Gorman, and M.Y. Simmons, "Large-scale analogue quantum simulation using precision atom-based quantum dot arrays", paper in review (2024)

AE-1

Quantum Computer Art: The Aesthetics of the Imperceptible and the Poetics of Multiplicity

Akihiro Kubota

Tama Art University, Japan

Biography

Akihiro Kubota, Dr. Eng. Professor, Art & Media Course, Department of Information Design, Tama Art University, Japan.
Earned a doctoral degree from the Graduate School of Engineering, Department of Naval Architecture, The University of Tokyo.
Recipient of the Award of Distinction in the Hybrid Art category at Prix Ars Electronica 2015 for the world's first art satellite, ARTSAT1: INVADER. Also received the 66th Minister of Education Award for Fine Arts (Media Arts Division) in recognition of the ARTSAT Project.
Publications include Design for Distant Others (BNN, Inc., 2017) and Principles of Media Art (Film Art, Inc., 2018; author and co-editor), among others.

Abstract

In this session, I will introduce the Quantum Computer Art (QCA) project, which explores new forms of artistic expression using actual quantum computers. The project makes use of a superconducting quantum computer developed by the Center for Quantum Information and Quantum Biology (QIQB), The University of Osaka. By programming quantum states directly on chips cooled to near absolute zero, I seek to treat not only their intended behavior but also their inherent physical errors as aesthetic material, reinterpreting them as elements of a novel artistic language.
Specifically, I propose two conceptual frameworks to bridge the gap between imperceptible quantum states and tangible physical entities: Quantum Information Aesthetics (QIA) and Quantum Chip Bitmap (QCB). QIA extends Max Bense's information aesthetics by integrating it with the principles of quantum information theory. QCB, meanwhile, is a method for generating pixel art directly on a quantum chip by manipulating its quantum gates, thus enabling the creation of visual works grounded in the material reality of quantum computation.

PL-06-1

"Machine Learning Physics" --- an emergent new arena of research unifying AI and quantum physics

Koji Hashimoto

Department of physics, Kyoto University, Japan

Biography

Professor Koji Hashimoto is a leading theoretical physicist specializing in string theory, quantum gravity, and the interface between machine learning and fundamental physics. He earned his Ph.D. in Physics from Kyoto University in 2000 and has held research positions at the University of California, Santa Barbara; the University of Tokyo and RIKEN. In 2012 he was appointed as a full professor at Osaka University, and since 2021, he has been a professor at the Graduate School of Science, Kyoto University. Professor Hashimoto's research encompasses string theory, holographic principle, and the application of deep learning to theoretical physics. His contribution includes analyses of quantum chaos using out-of-time-order correlators, quantum computational complexity and black holes, and neural networks representing quantum gravity spacetimes. He has authored several influential books, including "D-branes" (Springer, 2012) and "Deep Learning and Physics" (Springer, 2021). As a director he leads the MEXT "Machine Learning Physics" initiative, aiming to integrate AI methodologies with theoretical physics. In addition to his academic work, Professor Hashimoto has contributed to science communication by novels and essays, public lectures, art performance, musical collaboration, and supervising the physics in the film "Shin Ultraman" and the subtitles for "Oppenheimer". His interdisciplinary approach continues to influence both scientific and public understanding of physics.

Abstract

Machine learning and physics have long been deeply intertwined, and there have been eras when their relationship came to the forefront. Even in today’s revolutionary AI development, physics has played a significant role—for example, in diffusion models. From a physics standpoint as well, an integrative perspective across various specialized domains is provided by innovative new mathematical frameworks, and machine learning serves as one such framework. Launched in fiscal year 2022, the MEXT Scientific Transformation Area Research (A) initiative “Foundation of Machine Learning Physics” was established to forge a new interdisciplinary field merging machine learning and quantum physics in Japan. Now in its fourth year, it has produced a wide range of research outcomes and functions as a central hub where many researchers gather. In this talk, I will introduce the goals of this initiative, illustrating them with specific research examples, and discuss the future relationship between machine learning and quantum physics. The research examples include quantum simulations accelerated by machine learning methods in particle physics, computational physics and condensed matter physics, as well as novel approaches to AI architectures such as quantum interpretation of diffusion models and gravitational symmetries within neural networks.

PL-06-2

Make Optical Lattice Clocks Compact and Useful for Real-world Applications

Hidetoshi Katori

Department of Applied Physics, The University of Tokyo, Japan
Space-Time Engineering Research Team, RIKEN, Japan

Biography

Hidetoshi Katori is a Professor at the Department of Applied Physics, Graduate School of Engineering, the University of Tokyo, and Team Director at RIKEN, where he leads the Space-Time Engineering Research Team. He received his Doctor of Engineering from the University of Tokyo in 1994. He proposed and demonstrated the optical lattice clock, which has enabled significant advances in precision measurements and fundamental physics. His contributions have been recognized by the Breakthrough Prize in Fundamental Physics, the Micius Quantum Prize, and the Japan Academy Prize. He is a member of the Japan Academy.

Abstract

An "optical lattice clock," proposed in 2001, benefits from low quantum-projection noise by simultaneously interrogating many atoms trapped in an optical lattice. Approximately a thousand atoms trapped in the optical lattice enable measuring frequencies with a precision of 10^{-18} in an average time of a few hours. This superb stability is especially beneficial for chronometric leveling, which determines a centimeter-level height difference between clocks located at remote sites by measuring the gravitational redshift.

We overview the progress of optical lattice clocks and address recent topics to explore real-world applications of the 18-digit-accurate clocks, including 1) compact optical lattice clocks with a volume of 250 litter developed in collaboration with industry partners, 2) chronometric leveling with transportable clocks over 500 km apart, and 3) our challenge to further improve the clock stability by developing a "longitudinal spectroscopy" that allows continuous interrogation of the clock transition to improve the clock stability. We look ahead to the role of future clocks when networks of high-precision clocks are implemented in society.

This work received support from JST-Mirai Program Grant Number JPMJMI18A1, Japan.

PL-06-3

The Age of Computation is yet to Come

Artur Ekert

OIST, Japan
CQT, National University of Singapore, Singapore
University of Oxford, UK.

Biography

Artur Ekert is one of the pioneers of quantum information science. His invention of entanglement-based quantum cryptography has linked the foundational concepts of quantum theory with the study of secure communication. This breakthrough has sparked a surge in global research efforts and continues to inspire new research directions. Beyond his notable discovery that Bell's inequalities can be used to detect eavesdropping, Ekert has made several seminal contributions to both the theoretical and experimental aspects of quantum communication and computation. His expertise has proven invaluable to various companies and government agencies, with whom he has actively collaborated and provided counsel. Outside academia, Ekert is a passionate scuba diving instructor and pilot.

Abstract

The theory of classical universal computation was laid down in 1936, it was implemented within a decade, became commercial within another decade, and dominated the world's economy half a century later. The unavoidable step to the quantum level promises entirely new modes of computation that do not have classical analogues. At present it is not clear when, how and even whether fully-fledged quantum computers will eventually be built; but notwithstanding this, the quantum theory of computation already plays a much more fundamental role in shaping our world-view than its classical predecessor ever did. But what if the theory is eventually refuted—if some deeper limitation foils the attempt to build a scalable quantum computer? I would be thrilled to see that happen. Such an outcome is by far the most desired one. Not only would it lead to a revision of our fundamental knowledge about physics, we would expect it to provide even more fascinating types of computation. For if something stops quantum mechanics, we shall expect to have an exciting new whatever-stops-quantum-mechanics theory, followed by exciting new whatever-stops-quantum-computers computers. From this perspective it appears as though the age of computation has not yet even begun!

OP-1

Promoting Application of Advanced Quantum Technologies to Social Challenges — Toward Future Quantum Society —

Tetsuomi Sogawa

Science and Core Technology Laboratory Group, NTT, Inc., Japan

Biography

He received his B.S., M.S., and Ph.D. degrees in electrical engineering from the University of Tokyo in 1986, 1988, and 1991, respectively. In 1991, he joined NTT Basic Research Laboratories (NTT-BRL). From 1999 to 2000, he was a guest scientist at the Paul Drude Institute in Berlin, Germany, where he studied acoustic spin manipulation in semiconductor quantum structures. Between 2004 and 2006, he worked at the Council for Science and Technology Policy in the Cabinet Office of Japan. After serving as Director of NTT-BRL starting in 2013, he was appointed as Director of the NTT Science and Core Technology Laboratory Group in 2018. Since 2014, he has also served as a visiting professor at the Institute of Industrial Science, the University of Tokyo. In 2023, he became Program Director of "Promoting the Application of Advanced Quantum Technologies to Social Challenges", under the Cross-ministerial Strategic Innovation Promotion Program (SIP), led by the Cabinet Office of Japan. He is a Fellow of the Japan Society of Applied Physics.

Abstract

The Cross-ministerial Strategic Innovation Promotion Program (SIP), led by Japan's Cabinet Office, drives research and development to address critical societal challenges—ranging from fundamental research to practical implementation. Now in its third phase (2023–2027), SIP3 comprises 14 pioneering initiatives. Among them is Promoting the Application of Advanced Quantum Technologies to Social Challenges, also known as SIP3 Quantum. With an annual budget of approximately $20 million, SIP3 Quantum aims to translate quantum technologies into real-world applications by integrating quantum and classical systems. The program consists of four interconnected sub-programs: quantum computing, quantum security and networks, quantum sensing, and an innovation creation platform. SIP3 Quantum is fostering international collaboration, strengthening ties with North America and the European Union, including through the Japan-EU Digital Partnership. These partnerships are helping to advance quantum technologies through global cooperation and shared innovation. Ultimately, SIP3 Quantum envisions a future society where quantum technologies drive economic growth, promote harmony between people and the environment, and enhance quality of life.

SP-01-1

Securing Global Networks in the Quantum Era

Chune Yang Lum

SpeQtral, Singapore

Biography

Chune Yang LUM is co-founder and Chief Executive Officer of SpeQtral.
He is responsible for the strategic growth of SpeQtral globally and is focused on helping governments and enterprises around the world to secure and future-proof their communication infrastructures for the quantum era. Before co-founding SpeQtral in 2018, Lum held leadership positions in industry and business development at the National University of Singapore (NUS), the Centre for Quantum Technologies and SES, a global satellite telecommunication services provider. With over 20 years of quantum, space and telecommunications experience under his belt, Mr. Lum brings a unique blend of technical and business experience across the quantum and space sectors and is playing an active role in realizing quantum safe communications in Singapore and beyond.

Abstract

Quantum technologies are advancing at an accelerating pace in the past few years, with governments and private enterprises making significant investments to progress the technologies and business proposition. Global communications are at risk of being compromised, and the timescale to implement quantum-safe communication technologies at a global scale is uncertain. While there are many on-going initiatives to deploy metropolitan-scale quantum-safe networks, there is insufficient effort in coordinating intercontinental space-based quantum key distribution (QKD) with local networks. In this talk, I will provide an overview of the various satellite QKD initiatives, particularly SpeQtral's activities to advance technologies and integration in this domain. International collaboration is critical in accelerating the adoption and deployment of quantum-safe networks, as an end-to-end solution for end-users would necessarily require contribution and coordination from multiple technology providers, vendors, satellite operators and telcos. Everyone in the international community will stand to benefit from a global quantum-secure communication infrastructure.

SP-01-2

Quantum secure cloud technology for establishing highly confidential data centers

Mikio Fujiwara

Quantum ICT Collaboration Center, National Institute of Information and Communications Technology, Japan

Biography

Mikio Fujiwara received B.S. and M.S. degrees in electrical engineering and at Ph.D. degree in physics from Nagoya University, Nagoya, Japan, in 1990, 1992, and 2002, respectively. He has been involved in R&D activities at NICT (previously called CRL, Ministry of Posts and Telecommunications of Japan) since 1992. His main research interests include entangled photon pair sources, single photon detection technology, quantum key distribution (QKD), satellite QKD systems, and QKD network.

Abstract

The development of quantum computers is being vigorously pursued in many countries around the world. Some roadmaps predict the emergence of error-tolerant quantum computers around 2030. Once quantum computers become reality, there is a high possibility that the public key cryptography (e.g. RSA) currently widely used on the Internet will be decrypted. Considering the risk of so-called harvest attacks, it is necessary to use public key cryptography with quantum-resistant for data that requires confidentiality for an extremely long time. Quantum Key Distribution (QKD) technology has information-theoretic security, and by combining it with Vernam's one time pad encryption (OTP) , secure communication without the risk of eavesdropping will be possible regardless of what kind of computer appears in the future. However, in QKD links, the transmission medium is a single photon, so the transmission distance is limited by the dark count rates of the single photon detectors, and the distribution length is limited around 100 km level for commercially available products. In addition, the key generation rate deteriorates in proportion to the loss of transmission, so it deteriorates exponentially with the fiber transmission distance. Aiming to expand the service area of QKD and increase the number of users, a key relay based on a "trusted node" can be implemented to share a secure key between any two points in the QKD network. Proof of Concepts (POCs) of secure communication networks are being conducted in various countries around the world. National Institute of Information and Communications Technology (NICT) has established a secret sharing system on the QKD network and further applied the secure calculation function of Shamir's secret sharing protocol, enabling not only transmission and storage, but also restoration and confirmation of data integrity by information-theoretically secure personal authentication using a single password. In addition, with the aim of improving throughput, we have also developed a secret sharing storage based on exclusive OR (XOR) and implemented a secure calculation function based on a "trusted server" and have successfully demonstrated distributed backup of genome data and secure calculation for genome analysis. We have named this network the Quantum secure cloud and are conducting research and development for realizing a secure data center. We will introduce the partial reconstruction function, which we believe to be an advantage of XOR-based secret sharing and show technologies that can contribute to protecting personal information, such as statistical calculations from sensitive information. By using these technologies, we are trying to establish a highly secure data center.

SP-01-3

Applications for Quantum Secure Cloud

Shinya Murai

QKD Business Promotion Dept., ICT Solutions Division, Toshiba Digital Solutions Corporation, Japan

Biography

Shinya Murai is a Senior Fellow at Toshiba Digital Solutions Corporation, where he leads the technical development and product planning of Quantum Key Distribution. Since joining Toshiba, he has been engaged in research and development of network systems and applications. In 2015, he led a project to demonstrate the transmission of genome analysis data using a quantum cryptography communication system. Since 2017, he has been promoting the launch of a quantum key distribution business.

Abstract

The research and development of a new concept of quantum system called Quantum Secure Cloud, along with its practical application, are being promoted. Quantum Secure Cloud is a cloud platform that enables secure data sharing and storage by combining information-theoretically secure cryptographic communication using quantum key distribution and one-time pad with information-theoretically secure secret sharing technology. In addition, state-of-the-art computers, including advanced quantum computers, will be deployed in this cloud, making it possible not only to safely store highly confidential data but also to utilize those data using cutting-edge computing technology.

For example, the target data of this cloud platform includes data that has been stored in on-premise environments due to high confidentiality and has been restricted from cross-referencing and utilization by multiple organizations. This cloud platform is expected to attract more users to quantum technology. In the medical field, for instance, storing genomic information, electronic medical record data, and research data can facilitate cross-referencing by multiple medical institutions. Additionally, analyzing this information using advanced computing machines can significantly contribute to medical research, diagnosis, and drug discovery.

This presentation will describe new applications that utilize quantum technology created by Quantum Secure Cloud.

SP-02-1

Towards Quantum-Accelerated Supercomputing - A Europe-Japan Perspective

Juha Vartiainen

IQM Quantum Computers, Finland

Biography

Dr. Juha Vartiainen is the Co-Founder and Chief Global Affairs Officer of IQM Quantum Computers, a leading European company specializing in superconducting quantum computers. He holds a PhD in quantum computing from the Helsinki University of Technology, where he studied under the supervision of Japanese professor Mikio Nakahara from 2001 to 2005. With a strong background in quantum physics, Dr. Vartiainen has played a central role in advancing Europe's quantum ecosystem through strategic partnerships, international expansion, and technology diplomacy.

He is also a dedicated advocate for international standardization in quantum technologies. He has served as an advisor to national standardization committees through the Finnish Standards Association (SFS), contributing to Finland's voice in ISO and IEC working groups on ICT and quantum topics, and actively participating in European efforts to promote interoperability, trust, and scalability in the emerging quantum industry.

Dr. Vartiainen frequently represents Finland in global quantum dialogues and has contributed to shaping national and EU-level quantum strategies. His work bridges deep-tech innovation and public policy, helping to build frameworks that support industrialization, resilient supply chains, and the sustainable global development of quantum computing.

Abstract

Quantum computing is rapidly emerging as a transformative force across science and industry. While current systems are still at an early stage, the integration of quantum algorithms with classical high-performance computing (HPC) is opening new frontiers in solving complex problems — from quantum chemistry and materials discovery to artificial intelligence and beyond.

This presentation introduces joint efforts between Europe and Japan to develop hybrid HPC+QC platforms, benchmark their performance, and establish standardised, scalable infrastructure. We highlight the Q-Neko project — a flagship EU–Japan collaboration that brings together leading research institutions and industrial partners from both regions.

Focusing on shared use cases, integrated software stacks, coordinated roadmaps, and researcher mobility, Q-Neko aims to lay the groundwork for quantum-accelerated supercomputing. Drawing from practical examples of work already advanced in Europe, the talk will also explore the strategic importance of policy coordination, robust cross-border supply chains, and international standardisation — essential for building trust and ensuring interoperability between Europe and Japan.

Through this collaboration, Europe and Japan are well-positioned to jointly lead the transition to the next generation of high-performance computing — *HPC 3.0* — where tightly integrated clusters of CPUs, GPUs, and QPUs enable breakthroughs once thought unattainable.

SP-02-2

System operation technology for the quantum computer 'A' testbed

Shinichi Yorozu

RIKEN Center for Quantum Computing, Japan

Biography

Shinichi Yorozu received his Ph. D in Applied Physics from the University Tokyo in 1993. He joined the Fundamental Research Laboratories, NEC Corporation as a researcher in 1993. He was responsible for the study of superconducting devices, circuits and systems. Subsequently he was responsible for research and management for quantum technology, nanotechnology and materials at NEC Tsukuba Laboratories. In 2019, he joined RIKEN Center for Emergent Matter Science. Since 2021, he has been a deputy director of RIKEN Center for Quantum Computing. He is currently responsible for all aspects of the center managing, research and management of superconducting quantum computer, and managing the Quantum innovation hubs in Japan as headquarters.

Abstract

Quantum computers have been made publicly available through cloud services and are actively used. System operation technology is essential for the use of quantum computers. It is still in the early stages, and further development is necessary. RIKEN has been operating a superconducting quantum computer "A." Users connect to "A" via the cloud for using the quantum computer by a software development kit for programming. We are developing software development kits, middleware, and system monitoring technology. In this talk, we will report on the configuration and system operation of superconducting quantum computer "A" as well as efforts toward social implementation.

The works were supported by Cross-ministerial Strategic Innovation Promotion Program (SIP), 'Research theme A-1b: Building and operation of a domestically developed quantum computer testbed environment' (funding agency: QST), Quantum Leap Flagship Program (MEXT Q-LEAP) Grant No. JPMXS0118068682.

SP-02-3

Quantum Circuit Generation with Transformer-Based Generative AI

Shunya Minami

Global Research and Development Center for Business by Quantum-AI Technology, Japan
National Institute of Advanced Industrial Science and Technology, Japan

Biography

Shunya MINAMI is a researcher at the Global Research and Development Center for Business by Quantum-AI Technology, National Institute of Advanced Industrial Science and Technology (AIST), Japan. After obtaining his doctorate in Statistics, he conducted AI-driven materials science at the Institute of Statistical Mathematics. Since 2023, he has been engaged in research focusing on quantum-AI technologies, particularly applying AI to accelerate quantum innovation.

Abstract

Quantum computing is entering a new phase with the advent of logical quantum processors, holding promise for solving complex problems beyond classical capabilities. Nevertheless, applying quantum algorithms to practical problems remains challenging. In this talk, we introduce conditional-GQE, a context-aware quantum circuit generation method leveraging Transformer-based generative AI. Specifically focusing on combinatorial optimization problems, we have developed a quantum circuit generator capable of producing circuits tailored to the input problem, termed the Generative Quantum Combinatorial Optimization (GQCO) model. GQCO features an encoder-decoder Transformer architecture that integrates Graph Neural Networks. We present a successful training strategy and demonstrate that GQCO achieves nearly perfect accuracy in generating quantum circuits comprising up to 10 qubits. Our approach provides a flexible framework capable of incorporating inductive biases and constraints arising from quantum devices. Moreover, the conceptual workflow described in this study can be extended beyond combinatorial optimization to any task formulated for quantum computing, such as molecular ground-state searches, quantum machine learning, and solving partial differential equations. We therefore view GQE-based quantum circuit generation as a logical next step following variational quantum algorithms.

SP-03-1

Next-Gen Computing – Bits, Qubits, and Neurons Unite

Heike Riel

IBM, Switzerland

Biography

Dr. Heike Riel is IBM Fellow, Head of the Science of Quantum & Information Technology department, and Lead of IBM Research Quantum Europe & Africa. The mission of the team is to create the future of computing by achieving scientific and technological breakthroughs in Quantum Computing and Technologies, bits and neurons and explore new computing paradigms.

She received the master's in physics from the Friedrich-Alexander University of Erlangen-Nürnberg (D) and the PhD in physics from University of Bayreuth (D) and an MBA from Henley Business College (UK). She is elected President of the German Physical Society (DPG) for 2026-2028.

Dr. Heike Riel has received several prestigious honors and awards, e.g., elected member of the Leopoldina – German National Academy of Sciences and the Swiss Academy of Engineering Sciences; she was awarded the APS David Adler Lectureship Award in the Field of Materials Physics, the Applied Physics Award of the Swiss Physical Society, and the 2022 IEEE Andrew S. Grove Award. She was honored as Fellow of the American Physical Society, and with an honorary doctorate by Lund University. In February 2022 she was elected to the National Academy of Engineering and in 2023 to acatech, the National Academy of Science and Engineering Germany.

Abstract

For over seven decades, semiconductor innovation has been the foundation of technological progress, continuously advancing the performance of classical computing. Today, this evolution is driven by breakthroughs in materials, chip architectures, advanced packaging, and photonics integration—co-optimized to meet the demands of increasingly complex workloads. A major catalyst in this transformation is artificial intelligence (AI), with compute requirements for large-scale training models doubling approximately every six months. This exponential growth, coupled with rising energy demands, has led us to develop novel AI-specific processors like approximate computing and analog in-memory computing designed for greater efficiency and performance.

Concurrently, quantum computing is emerging as a transformative new paradigm aiming to solve relevant problems intractable to classical computers. Quantum processing units (QPUs) have seen rapid advancements across the full technology stack—from hardware and software to integration with classical systems, error mitigation and correction, algorithms and applications. To rapidly enhance system performance—including qubit count, operational fidelity, and processing speed—advancements are required across the entire quantum computing stack. A modular architecture, combined with robust error correction algorithms, paves the way for building a highly scalable and fault-tolerant quantum computer. The goal is to realize a system with 200 logical qubits capable of executing 100 million quantum operations by 2029. This presentation will provide an overview of the key challenges, recent technological progress, and the roadmap guiding this ambitious development for advancing bits, neurons and qubits and unite them to build the future of computing.

SP-03-2

Quantum Universe: A Platform of Education for Creating Quantum Community

Masayuki Ohzeki

Graduate School of Information Sciences, Tohoku University, Japan
Sigma-i Co., Ltd., Japan
Department of Physics, Institute of Science Tokyo, Japan
Research and Education Institute for Semiconductors and Informatics, Kumamoto University, Japan

Biography

Masayuki Ohzeki received his Ph.D. in Physics from the Tokyo Institute of Technology in 2008. After a postdoctoral position at the same institution, he became an Assistant Professor at Kyoto University in 2010 and a Project Researcher at Sapienza University of Rome in 2011. He joined Tohoku University in 2016 as an Associate Professor and was promoted to Professor at the Graduate School of Information Sciences in 2021, and subsequently named a Distinguished Researcher in 2022. Since October 2024, he has been a Professor at Institute of Science Tokyo on a cross-appointment. In 2019, he founded Sigma-i Co., Ltd. to bridge academia and industry in quantum computing. His research in statistical mechanics and quantum annealing has earned him numerous accolades, including the MEXT Young Scientists' Prize (2016), the Funai Academic Award (2019), and the KDDI Award (2023). His current focus is on developing quantum computing talent and fostering a vibrant quantum community through innovative educational platforms.

Abstract

This presentation introduces Quantum Universe, an innovative educational platform designed to foster a robust quantum community. At its core is a world-first initiative: a series of live-streamed, interactive classes broadcast publicly on YouTube, providing guided learning experiences. We will detail the implementation of numerous talent development events under the Quantum Universe banner and showcase practical applications of quantum computing in Japanese industry. A key feature of this presentation will be the introduction of projects and works created by the participants themselves. The curriculum is designed to cultivate talent proficient in quantum annealing, a technology with its origins in Japan. Furthermore, embracing a 'learning by doing' philosophy, the platform encourages challenges in gate-based quantum computing. We will elaborate on how Quantum Universe offers an accessible pathway for a diverse audience, from high school students to working professionals, to delve into quantum computing, irrespective of their prior educational background or professional experience, thereby democratizing quantum education and innovation.

SP-03-3

Challenges in the Development of the Quantum Workforce

Shinya Ogata

Digital Technology Division, SKILLUP NeXt, Ltd., Japan

Biography

I currently hold the position of Chief Technology Officer (CTO) at SKILLUP NeXt, Ltd. I founded the company in 2018, which was then known as SKILLUP AI, Ltd. Concurrently, I am the Leader of the Human Resource Development Working Group at Q-STAR.

Abstract

Quantum technology is a foundational technology crucial for Japan's future industrial competitiveness, yet the cultivation of expert talent in this field has become a pressing challenge. This presentation will examine concrete strategies to address this issue.

First, we will report the findings from surveys and interviews conducted with domestic companies. This will clarify the ideal talent profile genuinely sought by industry, the existing gap between industrial needs and university education, and the realities and barriers of in-house talent development.

Based on this analysis, we will propose a forward-looking strategy for Japan's quantum talent development. We will particularly discuss the importance of and specific measures for establishing a system to encourage participation from individuals with diverse backgrounds, expanding practical educational programs tied to industry needs, and creating a sustainable development ecosystem through robust collaboration between industry, academia, and government.

SP-04-1

Nanoscale Quantum Sensors for Ultra-Sensitive Body Fluid Diagnostics: Toward a Quantum Liquid Biopsy Platform

Ryuji Igarashi

Institute for Quantum Life Science (iQLS), National Institutes for Quantum Science and Technology (QST), Japan

Biography

Ryuji Igarashi received his Ph.D. in Engineering from the Department of Molecular Engineering, Graduate School of Engineering, Kyoto University in March 2012. He conducted postdoctoral research as a CREST researcher under Prof. Masahiro Shirakawa and later served as a PRESTO researcher in the JST program “Single Cell Analysis”. He joined the National Institutes for Quantum Science and Technology (QST), where he has held various leadership roles including Senior Researcher and PRESTO researcher in the JST program “Quantum Bio”. In April 2019, he was appointed Group Leader of the Institute for Quantum Life Science at QST, a position he continues to hold to the present. In January 2024, he was also appointed Professor at the School of Life Science and Technology, then known as Tokyo Institute of Technology (renamed Tokyo Institute of Science in October 2024). Since 2008, he has consistently conducted research on biological measurements using nanodiamond Nitrogen-vacancy (NV) centers. His work includes the development of innovative and ultra-sensitive diagnostic technologies by integrating quantum technology and life science.

Abstract

NV centers in diamond exhibit an elegant quantum-mechanical conjugation between fluorescence and spin states in their room-temperature-stable triplet electrons, enabling highly sensitive quantum sensing. By embedding NV centers in nanodiamonds with sizes down to 5 nm, these sensors achieve nanoscale spatial resolution for detecting physical and chemical parameters such as temperature, magnetic fields, and free radicals—even under physiological conditions. We have conceived and developed quantum sensing techniques not only for measuring such parameters, including intracellular pH, but also for enabling single-molecule analysis of three-dimensional molecular structural dynamics.

A quantum liquid biopsy platform has been constructed based on the Selective Imaging Protocol (SIP), originally devised by the author in 2009 and reported in 2012 (Igarashi *et al., Nano Lett.* 2012). This platform enables background-free, modulated detection of target-specific fluorescence signals from functionalized nanodiamond sensors in complex biofluids. It is applicable to a wide range of disease biomarkers, including phosphorylated tau associated with Alzheimer’s disease. By integrating these sensors with immunoassay formats, we demonstrate sandwich assays with a sensitivity enhancement of two to three orders of magnitude compared to conventional ELISA. This approach offers a powerful pathway for non-invasive, rapid, and cost-effective early disease diagnostics using quantum-enhanced readout in biological fluids.

SP-04-2

Application of Dissolution Dynamic Nuclear Polarization using the Triplet Electrons in Pentacene

Makoto Negoro

Institute for Quantum Life Science, National Institutes for Quantum Science and Technology, Japan
Center for Quantum Information and Quantum Biology, The University of Osaka, Japan

Biography

With a Ph.D. in Science from Osaka University, Negoro serves as the Deputy Director and Professor at the Center for Quantum Information and Quantum Biology (QIQB) at Osaka University. Additionally, he holds the position of cross-appointed researcher at the National Institutes for Quantum Science and Technology in Japan. He co-founded a quantum software startup, Qunasys, Inc. He serves as CSO of a quantum controller startup, QuEL, Inc.

Abstract

Dissolution dynamic nuclear polarization (DNP) has a wide range of important applications, including real-time monitoring of chemical reactions, drug discovery, metabolic imaging, and evaluation of cancer therapies. In conventional DNP, thermally polarized electrons are used as polarizing agents. To achieve a high polarization level of around 30%, the process is conducted at liquid helium temperatures, making the apparatus large and expensive.

In 2014, we successfully achieved room-temperature hyperpolarization of 34% in a solid sample using DNP with photoexcited triplet electron spins instead of thermally polarized electrons—a method known as Triplet-DNP [1]. We have conducted dissolution Triplet-DNP [2], where a solid sample hyperpolarized by Triplet-DNP is transferred to a superconducting magnet and dissolved by injecting an aqueous solvent. Dissolution Triplet-DNP has enabled the analysis of ligand-protein interactions and drug inhibition [3]. We have also obtained a hyperpolarized image of a mouse. We have extensively studied sample preparation methods to expand the range of applicable molecular species [4], ultimetely reaching a diagnostic drug used in cancer evaluations.

[1] Proc. Natl. Acad. Sci. in U.S.A. 2014, 111, 7527–7530.
[2] J. Magn. Reson. 2019, 309, 106623.
[3] J. Phys. Chem. Lett. 2023, 14, 6241–6247.
[4] J. Am. Chem. Soc. 2024, 146, 14539–14545.

SP-04-3

SiC-based quantum sensors for automobile application

Katsuhiro KUTSUKI[1], Kosuke TAHARA[1], Shin-ichi TAMURA[1], Haruko TOYAMA[1], Jotaro J. NAKANE[1],Yuichi YAMAZAKI[2], Takeshi OHSHIMA[2,3]

[1] *Toyota Central R&D Labs., Inc., Japan,* [2] *National Institutes for Quantum Science and Technology, Japan,* [3] *Tohoku University, Japan*

Biography

Katsuhiro KUTSUKI received the B.E., M.E., and Ph.D. degrees in advanced science and biotechnology at Osaka University, Osaka, Japan, in 2006, 2008 and 2011, respectively. In 2011, he was with the Power Devices Laboratory, Toyota Central R&D Labs., Inc., Aichi, Japan, where he engaged in the research on SiC MOS devices. Since 2022, he has been involved in the research on SiC-based quantum sensors. He is a member of the IEEE electron devices society and the Japan Society of Applied Physics.

Abstract

As the electrification of automobiles progresses rapidly to reduce the environmental impact, highly efficient power conversion is required to reduce the energy loss during driving. Due to its high breakdown voltage, SiC-based diodes and transistors have been desired to replace the conventional power-conversion devices, such as Si-based insulated gate bipolar transistors (IGBTs). To implement SiC devices in automobiles, ensuring long-term reliability is essential. In addition to careful screening inspections, it is quite significant to detect early signs of failure. Considering that conventional current sensors cannot capture the signs, it is necessary to detect very weak signals by state-of-the-art technologies. We therefore started developing a SiC quantum sensor to monitor the inside of SiC devices. Silicon vacancy (V_{Si}) in 4H-SiC is one of the most promising color centers because of the room-temperature operation and well-established fabrication manner [1]. We demonstrated the detection of magnetic fields by optically detected magnetic resonance (ODMR) using V_{Si}. However, the long-standing challenge of V_{Si} is a low ODMR contrast from S=3/2 system. In this study, we proposed simultaneous driving of the two microwave transitions in the four-level manifold, which turns each defect into a pair of "duplex qubits," recycling population that would otherwise generate background fluorescence. The dual-tone approach doubles photoluminescence contrast and halves the room-temperature AC-magnetometry detection limit compared to simplex operation [2]. This advance pave the way for the onboard monitoring of electronic devices.

Acknowledgements

This work was performed for a research theme "Environment development for practical use of solid-state quantum sensors: towards social implementation" in Council for Science, Technology and Innovation (CSTI), Cross ministerial

Strategic Innovation Promotion Program (SIP), "Promoting application of advanced quantum technologies to social challenges" (Funding agency: QST). We thank Hidekazu Tsuchida for the epitaxial growth of SiC.

[1] M. Widmann et al., Nature Materials 14, 164 (2015).

[2] K. Tahara et al., npj Quantum Information 11, 58 (2025).

MS-01-1

Quantum Error Correction Below the Surface Code Threshold

Volodymyr Sivak

Google Quantum AI, USA

Biography

Volodymyr Sivak is a senior research scientist at Google Quantum AI, working in the areas of quantum error correction, model-free quantum control, and system optimization. Volodymyr obtained his PhD at Yale University in the group of Michel Devoret, specializing in experiments with superconducting quantum circuits.

Abstract

Quantum error correction provides a path to reach practical quantum computing by combining multiple physical qubits into a logical qubit. In this work, we present two surface code memories operating below threshold: a distance-7 code and a distance-5 code integrated with a real-time decoder. The logical error rate of our larger quantum memory is suppressed by a factor of $\Lambda = 2.14 \pm 0.02$ when increasing the code distance by two, culminating in a 101-qubit distance-7 code with 0.143% ± 0.003% error per cycle of error correction. This logical memory is also beyond break-even, exceeding its best physical qubit's lifetime by a factor of 2.4 ± 0.3. We maintain below-threshold performance when decoding in real time, achieving an average decoder latency of 63 μs at distance-5 up to a million cycles, with a cycle time of 1.1 μs. To probe the limits of our error-correction performance, we run repetition codes up to distance-29 and find that logical performance is limited by rare correlated error events occurring approximately once every hour, or 3×10^9 cycles. Our results present device performance that, if scaled, could realize the operational requirements of large scale fault-tolerant quantum algorithms.

MS-01-2

Research and Development of Theory and Software for Fault-tolerant Quantum Computers

Masato Koashi

Graduate School of Engineering, The University of Tokyo, Japan

Biography

Masato Koashi is a professor and the head of Research Institute for Photon Science and Laser Technology at the University of Tokyo. After he was awarded PhD at the Univ. of Tokyo in 1995 for experimental studies on quantum optics, he started theoretical research in the field of quantum information at the NTT Basic Research Laboratories. He continued the research in this field while he moved to the Graduate Univ. for Advanced Studies (SOKENDAI), Osaka University, and the Univ. of Tokyo. His research has covered a wide range of topics in quantum information theory, and the notable contribution includes fundamental studies on quantification of quantum information, security proofs for various important protocols of quantum key distribution (QKD), discovery of a QKD protocol built on a new principle, and new ideas on quantum error correcting codes and fault tolerant quantum computation. Since 2020, he has been appointed to a Project Manager in the Moonshot Goal 6 Program.

Abstract

In this presentation, I will report on the progress and the achievements of the Theory and Software Project, which is in its fifth year since it started. The Project is made up of many prominent theory groups in Japan, and centers around the construction of a “cross-layer co-design model,” which is a model of a fault-tolerant quantum computer encompassing all the hardware/software technical layers ranging from design and control of qubits, quantum error correcting codes, fault tolerant architecture to proceed with computational steps, and compilers, to various applications chosen as benchmarks. The model enables the estimation of performance and resource costs of a large-scale quantum computer under various designs and conditions. Our model, while it is still under development, has already been able to help identify prominent issues in realizing a large-scale quantum computer, and we have found cross-layer solutions to many of them. Alongside this endeavor, the participants of the Project in each layer have also steadily developed various approaches toward reduction in hardware requirements for realizing a fault-tolerant quantum computer. They cover many grounds, such as improving the mainstream methods, pioneering new possibilities, and deepening the fundamental understandings.

MS-01-3

Development of Scalable Highly Integrated Quantum Bit Error Correction System (QUBECS)

Kazutoshi Kobayashi

Department of Electronics, Kyoto Institute of Technology, Japan

Biography

Kazutoshi Kobayashi received his B.E., M.E. and Ph. D. in Electronic Engineering from Kyoto University, Japan in 1991, 1993, 1999, respectively. Starting as an Assistant Professor in 1993, he was promoted to an Associate Professor in the Graduate School of Informatics, Kyoto University in 2001, and stayed in that position until 2009. For two years during this time, he acted as an Associate Professor of VLSI Design and Education Center (VDEC) at the University of Tokyo. Since 2009, he has been a Professor at Kyoto Institute of Technology.

While in the past he focused on reconfigurable architecture utilizing device variations, his current research interest is in improving the reliability (Soft Errors, Bias Temperature Instability and Plasma Induced Damage) of current and future VLSIs. He started a research project related to gate drivers for GaN and SiC transistors since 2013. In 2022, he was nominated for one of the project managers of Moonshot Goal 6.

He was the recipient of the IEICE best paper award in 2009, the IRPS best poster award in 2013, the ICICDT best paper award in 2019 and the IEICE Electronics Society award in 2021.

Abstract

QUBECS aims to realize an agile error correction system for a wide variety of qubits, superconducting qubits, neutral atoms, and so on, and to realize a small and low-power qubit controller for superconducting qubits. The Moonshot Goal 6 by 2050 will target the realization of a large-scale and fault-tolerant general-purpose quantum computer. In this research and development project, we will realize an error correction system and a qubit controller that can handle up to 1 million qubits by combining a communication network between upper-level medium-sized qubits and top-level qubit hardware.

Item 1: Backend for error correction: Research and develop a backend system for error correction which is scalable to the number of Qubits.

Item 2: Advanced Qubit Control Frontend: The performance improvement and the size reduction of the existing frontend by utilizing digital signal processing and SoCs

Item 3: Scalable Classical-Quantum Interface by Photonic/Cryo-CMOS: Integrated Circuits Achieving scalable classical-quantum interface with photonic/CMOS integrated circuits operating in extremely low-temperature environment.

Item 4: Cryo CMOS ASICs for Frontend/backend: Frontend/backend power and area reduction through ASIC/SoC, and miniaturization of quantum-bit controllers.

Item 5: Frontend Analog RF LSI at Room Temperature: To develop key functional blocks of the frontend analog RF LSI using advanced CMOS process technologies. The evaluation results of TEG and identified issues will guide the proposal of a design guideline for CMOS integration.

MS-02-1

Toward Large-Scale Integration of Superconducting Quantum Circuits

Tsuyoshi Yamamoto

Secure System Platform Research Laboratories, NEC Corporation, Japan

Biography

Tsuyoshi Yamamoto received Ph.D. degree in applied physics from the University of Tokyo, Tokyo, Japan in 2001. In his thesis, he studied the crystal structure and physical properties of misfit-layered (Bi,Pb)-Sr-Co-O system. In 2001, he joined NEC Corporation, Tsukuba, Japan, where he has been engaged in research on superconducting quantum circuits. From 2009 to 2010, he had been a visiting researcher at University of California, Santa Barbara, where he worked on superconducting phase qubits at Prof. John Martinis Lab. He has been a Visiting Associate Professor at University of Tsukuba since 2014, a Visiting Professor at Tokyo University of Science since 2020, and a Joint Appointed Fellow at Global Research and Development Center for Business by Quantum-AI technology (G-QuAT), the National Institute of Advanced Industrial Science and Technology (AIST) since 2025. Currently, he is one of the project managers of Moonshot Research & Development program Goal 6 from Japan Science and Technology Agency (JST), leading a project, “Development of Integration Technologies for Superconducting Quantum Circuits”.

Abstract

Despite many recent successful achievements in superconducting quantum computer consisting of about a hundred qubits, it is not straightforward to further scale up the system to the level that it can perform some useful tasks. For example, the number of coaxial cables, which is larger than one per a qubit in the current system, must be drastically reduced considering the limitation of inner space and cooling power of a dilution refrigerator. In our Moonshot project, we aim to develop break-through technologies which solve those bottlenecks hindering the large-scale integration in superconducting quantum circuits. In the presentation, I will talk about some of our achievements. We have developed multi-chip stacked module, which we envision to use as a quantum version of a system in package. We have also developed standard cell libraries for single-flux quantum circuits for the operation at 10 mK, and thus can be integrated into the package in the future. I will also introduce our superconducting quantum computer using the dilution refrigerator developed in our project, which will be released on the cloud at the Osaka Expo.

This work was supported by JST Moonshot R & D Program under Grant JPMJMS2067.

MS-03-1

Large-scale and high-coherence fault-tolerant quantum computer with dynamical atom arrays

Kenji Ohmori

Institute for Molecular Science (IMS), National Institutes of Natural Sciences, Japan

Biography

Kenji Ohmori is a Chair Professor at the Institute for Molecular Science (IMS), National Institutes of Natural Sciences, Japan. After receiving his Ph.D. from The University of Tokyo in 1992, he was a Research Associate and an Associate Professor at Tohoku University. In 2003 he was appointed a Full Professor at IMS. Professor Ohmori is currently leading large-scale / long-term national projects on the development of ultrafast quantum simulators and quantum computers generously supported by the MEXT and Cabinet Office of the government of Japan. He has been celebrated with many honors. Highlights include the Japan Academy Medal (2007), Fellow of the American Physical Society (2009), Humboldt Research Award from the government of Germany (2012), Commendation for Science and Technology by the Minister of MEXT (2018), and the Medal with Purple Ribbon from His Majesty the Emperor of Japan for his achievements on quantum physics. The Medal with Purple Ribbon is awarded for inventions and discoveries in science and technology, and for outstanding achievements in the fields of science, sports, art and culture.

Abstract

Neutral-atom quantum computers use the arrays of ultracold atoms assembled with optical tweezers, in which each single atom serves as a high-quality qubit, whereas the whole system operates at room temperatures. Our moonshot project uses rubidium (Rb) atoms as qubits at IMS and has various core competences including ultrafast laser technologies that allows for an ultrafast two-qubit gate operating in nanoseconds, faster than any other two-qubit gates with neutral atoms by two orders of magnitude [1]. We have also been developing underlying technologies that would improve the fidelity of this ultrafast gate, such as a stable gate-operation laser and an automated system for ultraprecise initialization of many qubits [2-3]. Our project is also developing different systems with ytterbium (Yb) qubits at Kyoto University and strontium (Sr) qubits at RIKEN, where a wide range of technological developments are underway by taking advantage of the property of each atomic species [4-5].

In another direction of our R&D, we are currently developing a full-stack quantum computer at IMS with Rb atoms. This would be Japan's first full-stack quantum computer with neutral-atoms, scheduled to start operating in this year 2025.

References

[1] Y. Chew et al., Nat. Photonics. 16, 724 (2022).
[2] T. P. Mahesh et al., Opt. Lett. 50, 403 (2025).
[3] Y. T. Chew et al., Phys. Rev. A 110, 053518 (2024).
[4] Y. Nakamura et al., Phys. Rev. X 14, 041062 (2024).
[5] T. Kusano et al., Phys. Rev. Research 7, L022045 (2025).

MS-03-2

Nanofiber Cavity Quantum Electrodynamics Systems for Distributed Quantum Computing

Takao Aoki

Department of Applied Physics, Waseda University, Japan

RIKEN Center for Quantum Computing, RIKEN, Japan

Biography

Prof. Takao Aoki is Professor at Department of Applied Physics, Waseda University in Japan, Team Director at Nanophotonic Cavity Quantum Electrodynamics Team, RIKEN Center for Quantum Computing, RIKEN, Japan, and the Chief Scientific Officer at the quantum hardware startup Nanofiber Quantum Technologies, Inc. He earned BEng, MEng, and PhD in Department of Applied Physics, School of Engineering, The University of Tokyo. His research focuses on quantum technologies based on cavity quantum electrodynamics with optical nanofibers and laser-cooled atoms.

Abstract

Distributed quantum computing, which connects many quantum processing units (QPUs) with small to moderate numbers of qubits into a large-scale quantum network, is a promising approach to realize the large-scale quantum systems required for fault-tolerant universal quantum computing.

Cavity quantum electrodynamics (QED) systems can serve as a platform for such distributed quantum computers, provided that multiple atoms can be strongly coupled to cavities in an individually addressable manner and that these units can be interconnected with minimal losses. We have been developing nanofiber-based cavity QED systems that fulfill these requirements.

In this talk, we will present our experimental work on: a nanofiber cavity QED system with a single trapped atom in the strong coupling regime [1]; the demonstration of coupled-cavity QED, where two nanofiber cavity QED systems are coherently connected in an all-fiber configuration [2,3]; the development of high-finesse nanofiber cavities to achieve high cooperativity [4–6]; and recent progress toward realizing distributed quantum computing with nanofiber cavity QED systems.

References
[1] S. Kato and T. Aoki, Phys. Rev. Lett. 115, 093603 (2015).
[2] S. Kato et al., Nature Communications 10, 1038 (2019).
[3] D. White et al., Phys. Rev. Lett. 122, 253603 (2019).
[4] S. K. Ruddell et al., Opt. Lett. 45, 4875 (2020).
[5] S. Kato and T. Aoki, Opt. Lett. 47, 5000 (2022).
[6] S. Horikawa et al., Rev. Sci. Instrum. 95, 073103 (2024).

MS-04-1

Fault-tolerant Quantum Computing with Photonically Interconnected Ion Traps

Hiroki Takahashi

Experimental Quantum Information Physics Unit, Okinawa Institute of Science and Technology, Japan

Biography

Obtained Ph.D in applied physics at the University of Tokyo in 2009. From 2009 to 2018, a postdoctoral researcher at University of Sussex in the UK. From 2010 to 2014, a JST PRESTO researcher. From 2018 to 2019, a project research associate at RCAST, the University of Tokyo. From 2019 to 2020, a project associate professor at Osaka University. Since 2020, an assistant professor and a PI at Okinawa Institute of Science and Technology.

Abstract

In this talk, I will report the efforts and progress made in the ion trap project in the Moonshot Goal 6 towards fault-tolerant quantum computing with photonically interconnected ion traps. Trapped ions are the leading candidate amongst various quantum computing platforms. Robust qubits with long trapping and coherence times can be obtained in the internal states of trapped ions. The strong Coulomb interaction between ions is facilitated to achieve high-fidelity two qubit gates. The outstanding challenge in the ion trap quantum computing is the scalability of the platform to a large qubit count. There have been two distinct approaches for the scalability: quantum CCD and quantum photonic interconnects. The former is concerned with the interconnection between independent ion traps on a single chip with micro-fabricated electrodes and shuttling of the ions. While micro-fabricated ion traps and ion shuttling are also investigated in our project, we have been mainly focusing on the latter approach: quantum photonic interconnects. Efficient quantum photonic interconnects can be achieved if the ions are coupled to optical micro-cavities. One of the main research topics in our project is to incorporate a micro-cavity in a linear ion trap. This has been pursued in the ion trap community over the decades but has not been achieved yet. In our project, a 3D ion trap suitable for micro-cavity integration was designed, fabricated and tested. Fiber-based Fabry-Perot cavities have been also established. I will also report on other research topics in the project such as quantum logic gates using microwaves, photonic waveguide integration and Rydberg atom-ion interaction amongst others.

MS-05-1

Development of Semicondutor Qubit Systems

Seigo Tarucha

Center for Emergent Matter Science and Quantum Computing, RIKEN, Japan

Biography

Seigo Tarucha received the B. E. and M. S. degrees in applied physics from the University of Tokyo in 1976 and 1978, respectively. He joined NTT Basic Research degree in applied physics from the University of Tokyo in 1986. In 1998 he moved to the University of Tokyo as a professor in the Department of Physics and then to the Department of Applied Physics in 2005. In March of 2019 he retired from the University of Tokyo and since then he has been fully affiliated to RIKEN Center for Emergent Matter Science (CEMS). He has been running a Quantum Functional System research laboratory in CEMS since 2013 and also working as a CEMS deputy director since 2018. He was a guest scientist in Max-Planck-Institute (Stuttgart) in 1986 and 1987 and in Delft University in 1995. He is currently working on physics and technology of spin-based quantum computing and topological quantum computing. He received Japan IBM award in 1998, Kubo Ryogo award, The Quantum Devices award in 1998, Nishina award in 2002, National medal with purple ribbon in 2004, Leo Esaki Award in 2007, Achievement award of Japan Applied Physics Society in 2018, and Fujiwara Award in 2023. He is a fellow of Japan Applied Physics Society and IOP.

Abstract

In the Moonshot program, we are developing the technological foundation to implement silicon qubit systems by 2030, aiming to realize a large-scale, error-corrected quantum computer. I will review our recent progress. Our project consists of four work packages (WPs): In WP1 we have achieved >99% readout fidelity, 99.5% two-qubit gate fidelity, and demonstrated the highest fidelity (>99.99%) in a five-qubit silicon device with simultaneous multi-qubit operations. We have also implemented advanced signal wiring technology. In WP2 we have derived optimal conditions for qubit transmission through simulations and confirmed the effectiveness of adiabatic operation. In WP3 we are optimizing a new epitaxial growth system to improve Si/SiGe quality and advancing interface control to enhance valley splitting. Notably, we have successfully observed large valley splitting using qubit devices. In WP4 we have conducted preparatory experiments on novel quantum circuits, achieving electron wave packet velocity control and long-distance transport, indicating the high potential of the proposed quantum circuit architecture.

MS-05-2

Large-scale Silicon Quantum Computer

Hiroyuki Mizuno

Research & Development Group, Hitachi, Ltd., Tokyo, Japan

Biography

Hiroyuki Mizuno received his M.S. degree (Semiconductor Physics) and Dr.Eng. degree (Integrated Circuits) from Osaka University, Japan, in 1993 and 2001, respectively. He joined Hitachi, Ltd. in 1993, where he has led research and development in high-speed, low-power semiconductor circuits for SRAMs and microprocessors (SuperH). He is recognized as a pioneer in quantum-inspired computing, particularly for the work on CMOS Annealing. From 2002 to 2003, he was a visiting scholar at the Department of Computer Science, Stanford University. Since 2020, he has been serving as Project Manager for the “Large-Scale Silicon Quantum Computer Project,” part of the Moonshot R&D Program, a flagship initiative led by the Cabinet Office. He has also been chairing the Q-STAR Subcommittee on “Promotion of SDGs with Quantum Technology” since 2021. He is currently a Corporate Chief Researcher at Hitachi. He is a Fellow of the IEEE and a member of the ACM.

Abstract

The progress of the four R&D themes of this project will be described. Theme 1 (Quantum computing system) advanced two-qubit operations using a 4x4 qubit array, including both vertical and horizontal couplings. The CCD method improving coherence time by more than two orders of magnitude was developed. We also advanced a quantum operating system with automated qubit control. In support of FTQC, we proposed a shuttling-qubit QEC architecture and established a full-hierarchy simulation environment that reflects device characteristics, enabling the definition of specifications for a silicon FTQC system. Theme 2 (Multi-chip cryogenic packaging technology) developed cryogenic packaging technologies that integrate qubit and interface chips and include heat-dissipation structures. Cryogenic ADC technology for 100-mK environment was completed, and prototype chips were produced and evaluated for feedback control of waveform and temperature. Theme 3 (Hot silicon qubits) evaluated silicon qubit operations at ~1 K. Benchmarks for electron and hole spin systems were advanced. Progress was also made in packaging techniques compatible with cryogenic circuits. In theme 4 (Quantum computing in small qubit systems), high-fidelity two-qubit operations were demonstrated in compact experimental circuits. It extends to more complex gates, including successful pseudo-control of fluctuation correlations. These works are supported by JST Moonshot R&D Grant No. JPMJMS2065.

R&D theme		PIs	R&D challenge	
1	Quantum computing system	Hitachi/ Hiroyuki Mizuno	1 2 3	2D qubit arrays Cryogenic LSI systems for qubit control and readout System architecture
2	Multi-chip cryogenic packaging technology	Kobe Univ./ Makoto Nagata	4 5	Cryogenic multi-chip implementation Environmental noise monitoring
3	Hot silicon qubits	Science Tokyo/ Tetsuo Kodera	6	High temperature operation of silicon qubits
4	Quantum computing in small qubit systems	U. Tokyo/ Jun Yoneda RIKEN/ Takashi Nakajima	7 8	Compatibility of qubit arrays and basic qubit operations Verification of quantum controllability qubits

MS-06-1

Optical Quantum Computers with Quantum Teleportation

Akira Furusawa

Department of Applied Physics, School of Engineering, The University of Tokyo, Japan
RIKEN Center for quantum computing, Japan
OptQC Corporation, Japan

Biography

Akira Furusawa received his MS degree in applied physics and Ph.D. degree in physical chemistry both from The University of Tokyo, Japan, in 1986 and 1991, respectively. His research interests cover the area of nonlinear optics, quantum optics, and quantum information science. He is currently Professor of Applied Physics, School of Engineering, The University of Tokyo, the Deputy Director of RIKEN Center for Quantum Computing, and Co-founder and Director of OptQC Corporation, which is a startup company for optical quantum computers. Professor Furusawa has authored more than 100 papers in leading technical journals and conferences, which include the first realization of unconditional quantum teleportation in 1998 at California Institute of Technology as a visiting scientist at Professor Jeff Kimble's lab. He received the Ryogo Kubo Memorial Award in 2006, the JSPS prize in 2007, the Japan Academy Medal in 2007, the International Quantum Communication Award in 2008, the Palacky University Medal in 2011, the Toray Science and Technology prize in 2015, and the Medal with purple ribbon in 2016. He is a member of the Physical Society of Japan, the Japanese Society of Applied Physics, and OPTICA.

Abstract

We invented the scheme of teleportation-based quantum computing in 2013. In this scheme, we can multiplex quantum information in the time domain and we can build a large-scale optical quantum computer only with four squeezers, five beam splitters, and two optical delay lines.

For universal quantum computing with this scheme, we need a nonlinear measurement and we invented the efficient way. We recently succeeded in the realization.

Our tentative goal is to build a super quantum computer with 100GHz clock frequency and hundred cores, which can solve any problems faster than conventional computers without efficient quantum algorithms. Toward this goal we started to combine our optical quantum computer with optical communication 5G technologies.

Our ultimate goal should be the realization of all-optical quantum computer with 10THz clock frequency. Toward this goal we already succeeded in the realization of all-optical feedforward.

For the realization of fault-tolerance with our optical quantum computers, we use Gottesman-Kitaev-Preskill (GKP) qubits. We recently succeeded in the generation and invented an efficient way for the generation.

We built a real machine of optical quantum computer in Riken and put it on the cloud. We will work on a neural network and Shor's algorithm with the real machine.

MS-07-1

Development of Quantum Interfaces for Building Quantum Computer Networks

Hideo Kosaka

Quantum Information Research Center, YOKOHAMA National University, Japan
Institute of Advanced Sciences, YOKOHAMA National University, Japan
Department of Physics, Graduate School of Engineering Science, YOKOHAMA National University, Japan

Biography

He is the Director of the Quantum Information Research Center (QIC: https://qic.ynu.ac.jp/en/) and a Professor at Yokohama National University (YNU: https://kosaka-lab.ynu.ac.jp/en/). He is also a Research Fellow of the Institute of Industrial Science, the University of Tokyo. After graduating from Kyoto University, he worked at NEC and then became an associate professor at Tohoku University and then a full professor at Yokohama National University. He is a Project Manager of the Moonshot Program (Goal 6) titled "Realization of a fault-tolerant universal quantum computer" established by the Japan Cabinet Office, managing the project titled "Development of Quantum Interfaces for Building Quantum Computer Networks" (https://moonshot.ynu.ac.jp/en/index.html). He is also a leader of the QKD Program titled "Research and Development for Building a Global Quantum Cryptography Communication Network" funded by the Ministry of Internal Affairs and Communications (MIC), leading the project titled "the development of Quantum Repeater Networks" (https://qurep.ynu.ac.jp/english/members/index.html) and Quantum Internet project also by MIC.

Abstract

Diamond is a promising platform for both quantum computation and communication. Our challenge is to build a quantum interface or quantum transducer to scale up quantum computers by connecting superconducting qubits via an optical fiber mediated by a color center in a diamond-based opto-mechanical crystal resonator [1-4]. This would also enable the quantum repeater network to be scaled up towards the realization of the quantum Internet [5–8].

Acknowledgements

This work was supported by a Japan Science and Technology Agency (JST) Moonshot R&D grant (JPMJMS2062), a JSTCREST grant (JPMJCR1773), the Ministry of Internal Affairs and Communications R&D of ICT Priority Technology Project (JPMI00316), and the Japan Society for the Promotion of Science (JSPS) Grants-in-Aid for Scientific Research (20H05661, 20K20441, 23KJ0983). This work was partially supported by Japan Science and Technology Agency (JST) as part of Adopting Sustainable Partnerships for Innovative Research Ecosystem (ASPIRE), Grant Number JPMJAPxxxx.

References

[1] H. Kurokawa, M. Yamamoto, Y. Sekiguchi, and H. Kosaka, "Remote Entanglement of Superconducting Qubits via Solid-State Spin Quantum Memories", Phys. Rev. Applied, 18, 064039 (2022).

[2] B. Kim, H. Kurokawa, K. Sakai, K. Koshino, H. Kosaka, and M. Nomura, Phys. Rev. Applied, 20, 044037 (2023).

[3] H. Kurokawa, K. Wakamatsu, S. Nakazato, T. Makino, H. Kato, Y. Sekiguchi and H. Kosaka, "Coherent electric field control of orbital state of a neutral nitrogen-vacancy center", Nature Communications 15, 4039 (2024).

[4] H. Kurokawa, S. Nakazato, T. Makino, H. Kato, S. Onoda, Y. Sekiguchi, and H. Kosaka, "Quantum Orbital-State Control of a Neutral Nitrogen-Vacancy Center at Millikelvin Temperatures", Phys. Rev. Lett. (2025) in printing.

[5] Kazuya Tsurumoto, Ryota Kuroiwa, Hiroki Kano, Yuhei Sekiguchi, and Hideo Kosaka, "Quantum teleportation-based state transfer of photon polarization into a carbon spin in diamond", Communications Physics 2, 74 (2019).

[6] Y. Sekiguchi, Y. Yasui, K. Tsurumoto, Y. Koga, R. Reyes, and H. Kosaka, "Geometric entanglement of a photon and spin qubits in diamond", Communications Physics 4, 264 (2021).

[7] T. Nakazato, R. Reyes, N. Imaike, K. Matsuda, K. Tsurumoto, Y. Sekiguchi, and H. Kosaka, "Quantum error correction of spin quantum memories in diamond under a zero magnetic field", Communications Physics 5, 102 (2022).

[8] Yuhei Sekiguchi, Kazuki Matsushita, Yoshiki Kawasaki, and Hideo Kosaka, "Optically addressable universal holonomic quantum gates on diamond spins", Nature Photonics 16, 662 (2022).

MS-07-2

Quantum Cyberspace with Networked Quantum Computer

Takashi Yamamoto

Center for Quantum Information and Quantum Biology, Japan
Graduate School of Engineering Science, The University of Osaka, Japan

Biography

Takashi Yamamoto serves as a Deputy Director of the Center for Quantum Information and Quantum Biology Research (QIQB) and is a Professor in the Graduate School of Engineering Science at Osaka University. He received Ph. D from The Graduate University for Advanced Studies (SOKEN) Japan in 2003. After one year as a postdoc in SOKEN, he moved to Osaka University in 2004. In 2018, He was promoted to full Professor. His research interest is theoretical and experimental aspects of various topics in quantum optics and quantum information processing. He received the 20th Inoue Research Award for Young Scientists (2004), the 3rd Young Scientist Award of Japan Physical Society (2009), and The Young Scientists' Prize of The Commendation for Science and Technology by MEXT (2014). From 2020, he has served as a project manager (PM) of Moonshot goal 6.

Abstract

Our R&D project is focused on developing quantum network technologies for interconnecting quantum computers at small and medium scales. This foundational work aims to pave the way for the realization of a fault-tolerant universal quantum computer. Simultaneously, we are conducting research to enable the implementation of distributed quantum computing by networking. Based on current technology, the hardware candidates for quantum computers include superconducting, optical, atom/ion, and semiconductor physical systems. By connecting smaller quantum computers created in these physical systems, we plan to build a large-scale networked quantum computer and implement the quantum protocols.

Our project is structured around four primary research pillars:

[1] Atom networking technology.
[2] Photon networking technology.
[3] Semiconductor networking technology.
[4] Superconducting networking technology.

It's worth noting that the 'atom networking technology' pillar also involves the development of a superconducting photon detector, which is a crucial component commonly used in quantum networking.

As the project manager (PM) of this project, I will present research progresses of each of these research topics, starting from the end of 2020.

MS-07-3

Scalable and Robust Integrated Quantum Communication System

Shota Nagayama

Graduate School of Media Design, Keio University, Japan

Biography

Ph.D. in Media and Governance from Keio University in 2017.
He joined mercari R4D as a Senior Researcher in 2018.
Since 2022, he concurrently served as a Project Associate Professor at Graduate School of Media and Governance, Keio University.
Since April 2025, Associate Professor at Graduate School of Media Design, Keio University.
He also serves as the Director of Quantum Internet Task Force, a Board Member of WIDE Project, a Project Manager for a JST Moonshot Goal 6 R&D project on Scalable and Robust Integrated Quantum Communication System.

Abstract

Our project aims to build a universal testbed for quantum communication networks—essential infrastructure for realizing large-scale, distributed quantum computers.
These quantum networks will allow multiple quantum computers to work together, enabling complex computations beyond the reach of a single device.
To achieve this, we are developing core communication technologies and integrating both hardware and software into a functional prototype network.
This testbed will demonstrate the basic principles and communication protocols of a quantum interconnect.

In this presentation, we will share the current status of the testbed development in Japan, positioned within the broader context of international efforts in quantum network research.
We will also introduce “Q-Fly,” a system design invented during the project, which serves as a flexible and extensible architecture for quantum interconnection.

Q-Fly enables scalable deployment of quantum nodes and links by abstracting the complexity of underlying quantum hardware.
Finally, we will present a future vision of quantum interconnects based on Q-Fly, where heterogeneous quantum systems can be efficiently connected and coordinated, paving the way toward a robust and scalable quantum networks.

QuEL, Inc.

High-Density Qubit Controller

QuEL-3

Supporting over 1000-qubit system with Direct Digital Synthesis technology

Key Specifications

General

# of ports	12 outputs & 2 inputs
Connectors	SMA
Dimension	440 x 780 x 41 mm^3
Height	1U
Power Consumption	430 W

Outputs

Frequency range	0.5 GHz - 8.5 GHz
Sample rate	20 GSa/s
Bandwidth	4 GHz
Resolution	16 bit
Max output power	10 dBm
Noise floor	<-153 dBc/H
Phase Noise	<-120 dBc/Hz (@ 8 GHz, 10 kHz offset)

Inputs

Frequency range	0.5 GHz - 8.5 GHz
Sample rate	20 GSa/s
Bandwidth	2 GHz
Resolution	12 bit
Max input power	-25 dBm

QuEL, Inc. QuEL is a startup from the University of Osaka, developing qubit controllers.
QuEL has a strong track record in large-scale quantum computing systems, supporting Riken RQC's superconducting qubit systems (64-qubit system developed in 2023 and 144-qubit system developed in 2025). Additionally, QuEL also contributes to R&D of a variety of qubits, including neutral atoms, trapped ions, and silicon quantum dots.
QuEL is a team of quantum computer researchers, hardware engineer, and software engineers. Please feel free to contact us if you have any requests or questions about qubit controllers.

https://quel-inc.com | info@quel-inc.com


SHIMADZU
Excellence in Science
「空を自由に飛べないか」。
「身体の中を写真に撮れないか」。
みなさまが思い描く夢を
叶えることができれば、世界は変わる。
人々に新しい幸福を届けることができる。
夢はいつも、未来の始まりでした。
「できるとすれば島津」。
その期待に応えるために私たちは科学技術を進化させ、
数々の夢、イノベーションの誕生に立ち会うことができました。
創業から150年。
あなたの夢に夢中になり
島津はいま、ここにある。
さぁ、次の夢へ。未来へ。
私たちは進化しつづけていきます。
今日はまだ、
未来の途中だ。
2025
世界中のパートナーとともに
食肉に替わる培養肉や
がん細胞だけを破壊する
光免疫療法の開発に貢献
1961
世界初遠隔式X線
テレビジョン
システムの
販売開始
1877
初代 島津源蔵
民間初の有人軽気球の
飛揚に成功
1897
蓄電池の
製造に成功
2020
アルツハイマー病の
予測を目指す質量分析計の
医療機器承認を取得
1956
日本初の
ガスクロマトグラフ
製品化に成功
2002
田中耕一
ノーベル化学賞受賞
1896
二代 島津源蔵
X線写真の撮影に成功
150 Years of Innovation
150周年記念
サイト公開中
150 YEARS ANNIVERSARY
株式会社 島津製作所　Shimadzu Corporation

LQUOM

Quantum Communication

Realizing a Quantum Society

Long-distance quantum communication leading quantum internet technology

With the quantum repeater currently under development, we aim to implement quantum internet on the global optical fiber network.

LQUOM technology enables long-distance quantum communication

Quantum memory

Storing and Reproducing Quantum States

Quantum Frequency Conversion

Converting wavelength of a photons to another to be coupled with a quantum memory.

Frequency Stabilization

Matching the frequencies of remote photon sources and memories.

Narrow Linewidth Entangled Photon Source

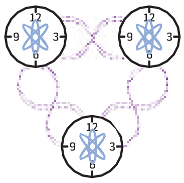
Compatible with a quantum memory and telecommunication wavelength

Applications Brought by Quantum Communication

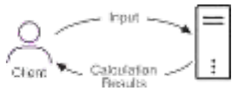
Quantum Cryptography

Distributed Quantum Computation

World Clock



Blind Quantum Computation



LQUOM

Quantum Communication

LQUOM is a deep-tech startup originating from Yokohama National University, possessing essential technologies for building a quantum internet such as entangled photon source, quantum memory, wavelength conversion, and frequency stabilization.

LQUOM, Inc.

79-5 Tokiwadai, Hodogaya-ku, Yokohama-shi, Kanagawa 240-0067

7-7 Shin-kawasaki, Saiwai-ku, Kawasaki-shi, Kanagawa 212-0032

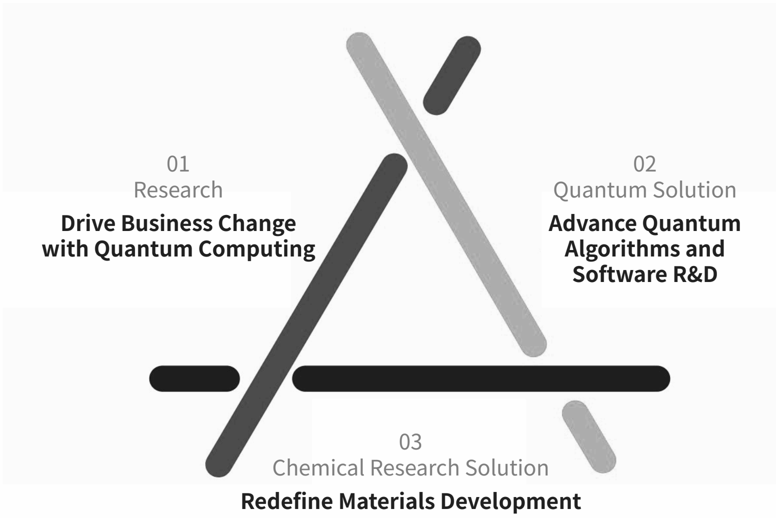
contact@lquom.com

Related Links

QUNASYS

Maximize The Power Of Quantum Computing

Expanding application frontiers and building practical foundations, QunaSys turns quantum computing into new industrial value —tackling real-world industry challenges, driving breakthrough innovations, and shaping the future through its power.

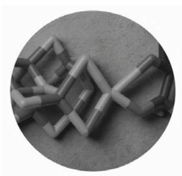


WHAT WE OFFER

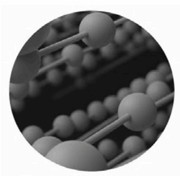
01 | Research

Accelerating Business Transformation with Quantum Computing

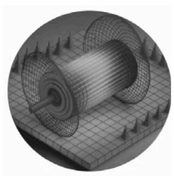
We are committed to driving the industrial adoption of quantum technologies as a powerful force for solving society's key challenges.



Chemical Simulation



Condensed Matter Simulation

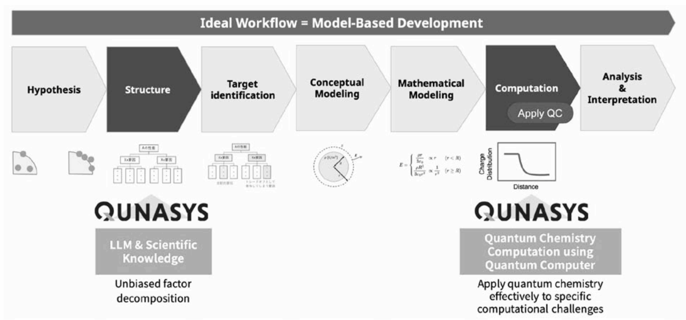


Computer-Aided Engineering

03 | Chemical Research Solution

Transforming the Way We Develop Materials

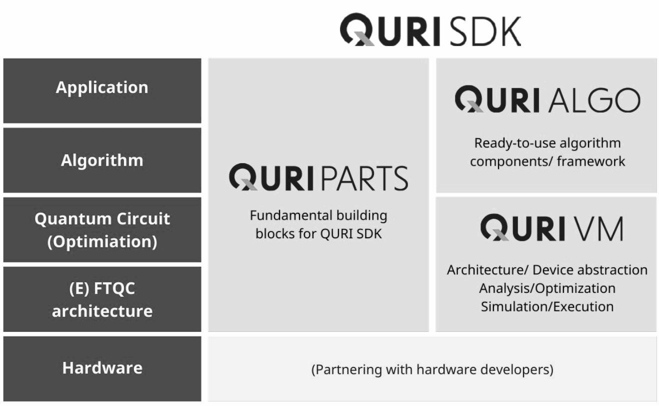
We help you build a computation-ready environment and seamlessly integrate computational chemistry into your workflow.
Step away from intuition-based trial-and-error — and move toward data-driven innovation.



02 | Quantum Solution

Opening the Door to Quantum Computing

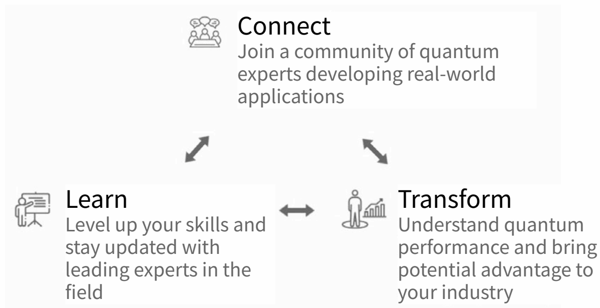
We are building a complete software stack — from low-level architecture to high-level applications — to help more users unlock the full potential of quantum computing.



QPARC

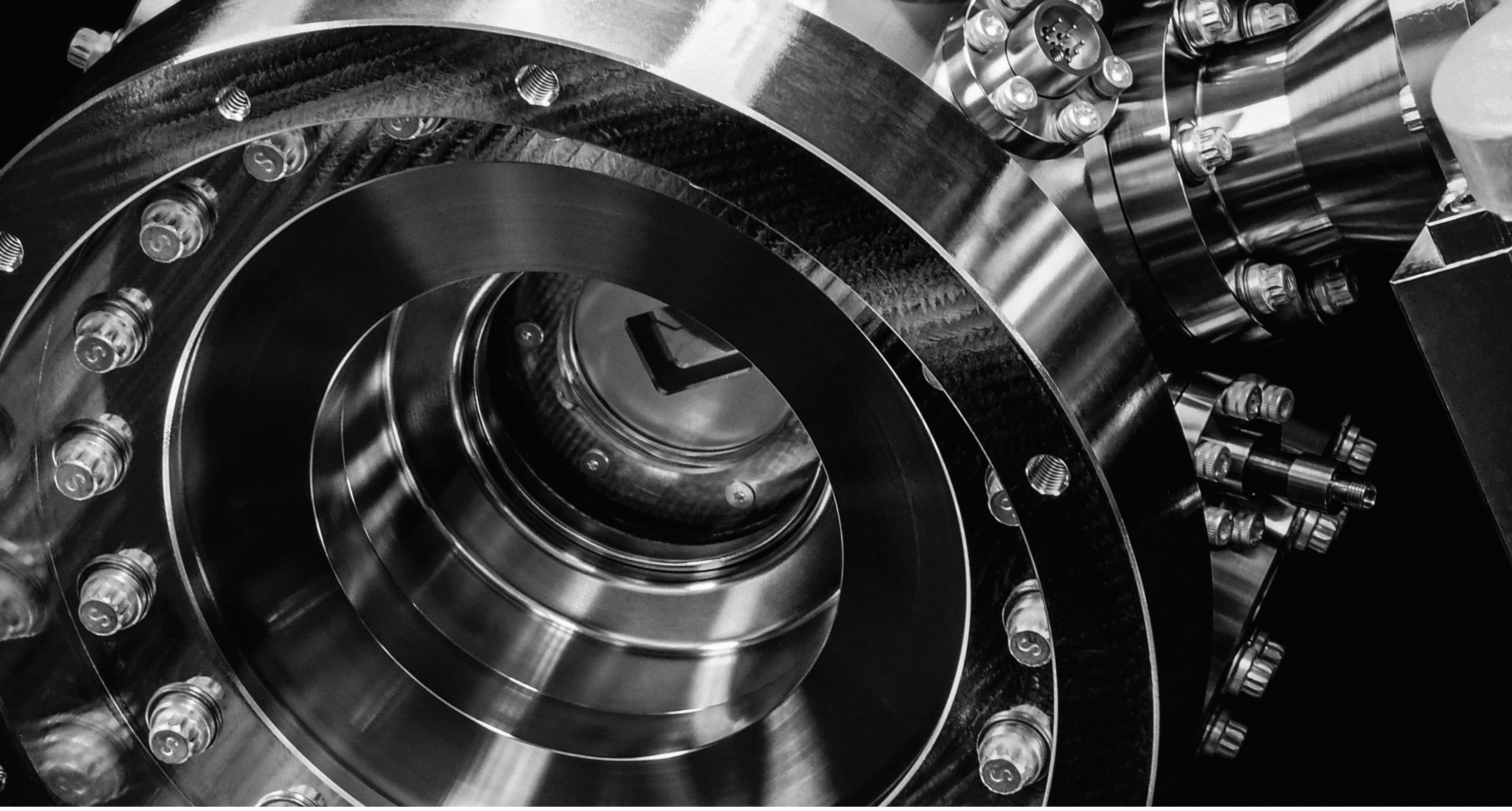
Growing the Quantum Ecosystem

QPARC is a community that brings together industry and academia to exchange insights, explore possibilities, and drive real-world implementation of quantum computing.



Contact us: **info@qunasys.com**

https://qunasys.com/en/



Where Limits End and
Possibilities Dawn

QUANTINUUM
HELIOS

A next-generation Quantinuum System, **Helios**, continues the evolution of system performance and provides premier quantum computing capabilities, including world-leading two-qubit gate fidelity of 99.95% with all-to-all connectivity.

Empowering users to solve classically intractable problems and explore the hybrid classical-quantum application space, Helios will be available as a Hardware-as-a-Service (HaaS) offering featuring onsite deployment, as well as cloud access in 2025.

96
physical qubits

99.95%
two-qubit gate fidelity

Faster circuit time
with new chip design

Lower resources
required per qubit

Helios is available now for pre-order →

Scan the QR code for more information

QUANTINUUM

Q-STAR

Quantum STrategic industry Alliance for Revolution

About Q-STAR

Established in Japan in September 2021, Q-STAR (Quantum STrategic industry Alliance for Revolution) unites startups, SMEs, large corporations, and academic institutions to forge new industries and business opportunities through quantum technology. Q-STAR actively seeks global collaborations across sectors to collectively advance the field.

Toward Global Leadership in the Future Quantum Industry

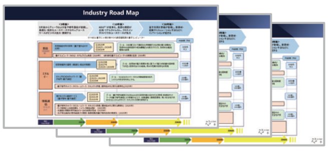
Q-STAR contributes to establish Japan's leadership with three strategies.

Use Cases

Vendor and user companies collaborate to discuss and validate use cases.

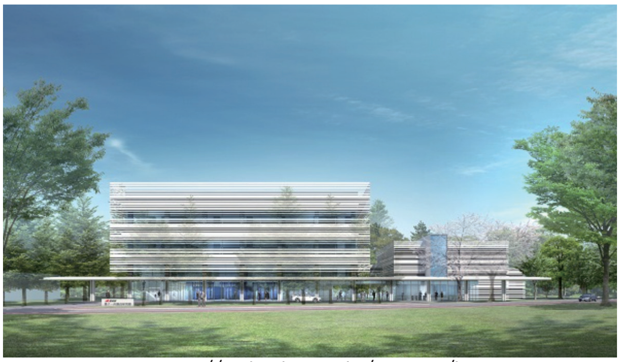
A wide range of use case discussions

Selected use cases from the discussions were incorporated into the industry roadmap.



Test Beds

Working toward early social implementation by demonstrating use cases in a real-world environment through collaboration on a testbed with G-QuAT.



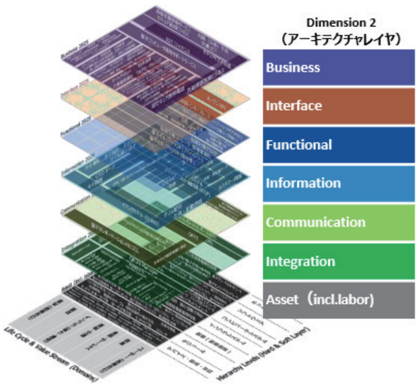
Source: https://unit.aist.go.jp/g-quat/index.html

Standardization

Frameworks that connect technology to business.

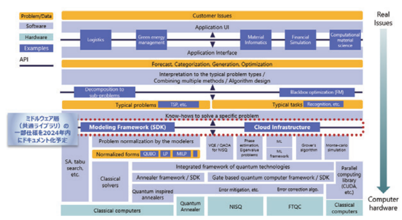
Q-RAMI

- Overview of the entire pathway toward social implementation
- Shared understanding among stakeholders



Software Stack Diagram

- Exploring quantum solutions to societal challenges
- Identifying potential use cases



Contact

Q-STAR(The Quantum STrategic Industry Alliance for Revolution)

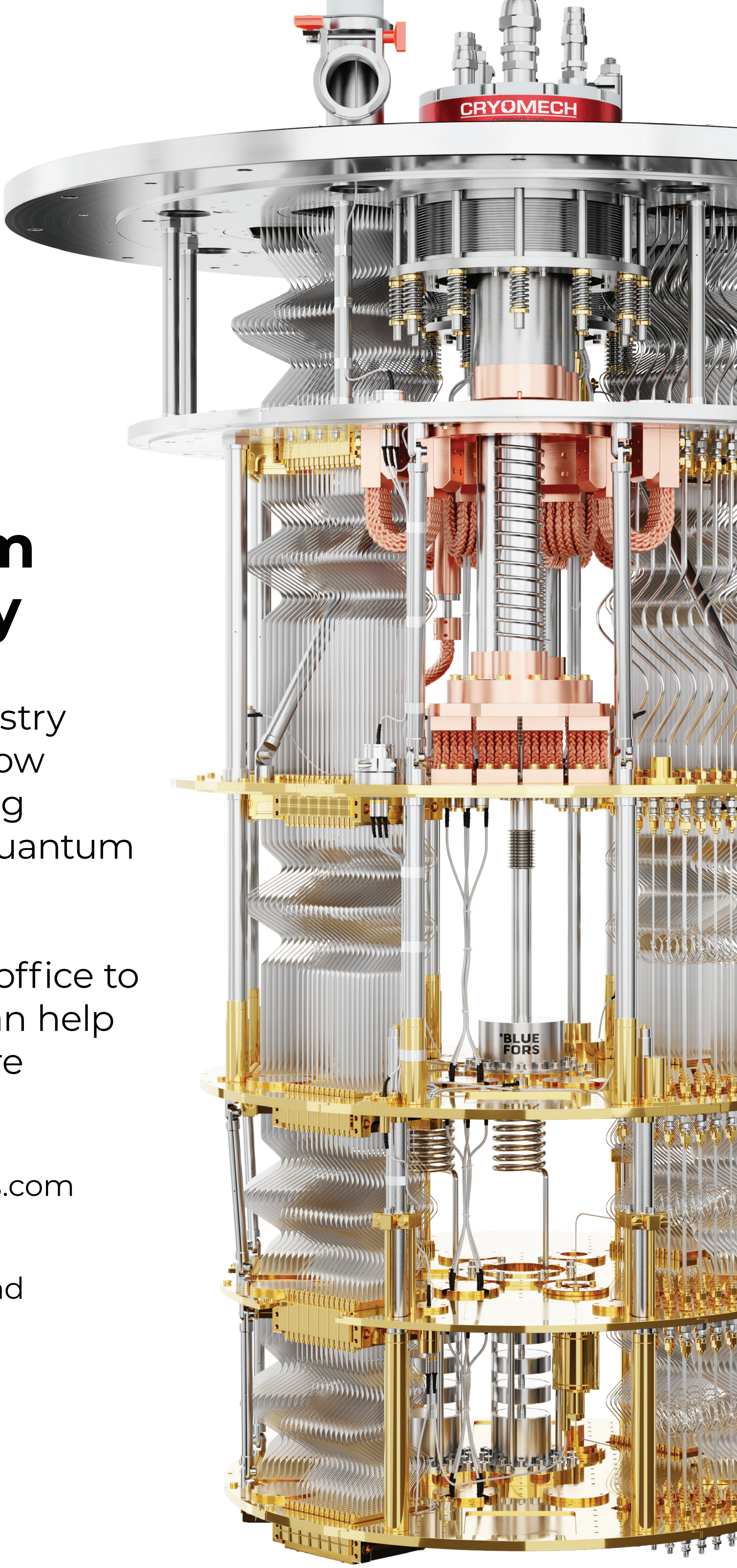
Office within Vision Bridge , LLC

Shin-Kagurazaka Building 2F, 43 Tansumachi, Shinjuku-ku Tokyo 162-0833, Japan

TEL: 03-5229-6883 FAX: 03-5229-6889

Mail : info.qstar@supportoffice.jp HP(JP) : https://qstar.jp/ HP(EN): https://qstar.jp/en

HP(EN) LinkedIn



CRYOMECH
BLUE FORS