Q-LEAP

Quantum Leap Flagship Program

Q-LEAP

Quantum science and technology (photonics and quantum technology) is an area that is sure to bring change to the economies and society of the future. It is already positioned as a vital platform technology from a security standpoint. When Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) drafted the "New Promotional Policy for Quantum Science and Technology (Photonics and Quantum Technology)" in August 2017, it positioned three areas as particularly important aspects of quantum science and technology: Quantum Information Technology, Quantum Metrology and Sensing, and Next Generation Laser. Based on this stance, in 2018 MEXT launched the Photonics and Quantum Leap Flagship Program (Q-LEAP) and moved forcefully to advance it toward eventual application in society.

To run the program, Q-LEAP appointed program directors (PDs) for each technological area. With the PDs managing research and development in their respective areas, network-type research bases were formed for each of the three following technological areas. In each technological area, a flagship project and basic foundation research are being carried out.

1) Quantum Information Technology (mainly involving quantum simulators and quantum computers)
2) Quantum Metrology and Sensing
3) Next Generation Laser

In addition, to enhance the development of human resources who will lead the next generation of quantum technology, Q-LEAP established:

4) Human Resources Development Program

Q-LEAP is moving forward with the development of a wide variety of common educational programs and programs that leverage the unique characteristics of each educational institution.

Quantum Information Technology

Program Directors
ITOH Kohei
- President, Keio University

Project Overview

With sights set on developing general-purpose quantum computers that can impact society and the economy for the better, research is proceeding in a wide assortment of areas: hardware research quantum software and algorithms and theoretical research on quantum software, focusing on architecture. We are pursuing R&D with clear goals for applications in society, including realization of Japan's first quantum computer.

Quantum Metrology & Sensing

Program Directors
ARAKAWA Yasuhiko
- Specially Appointed Professor, Institute for Nano Quantum Information Electronics, The University of Tokyo

Project Overview

In this area we're working to develop Quantum Metrology and Sensing technologies whose sensitivity, precision and spatial resolution surpass those of conventional technologies, using quantum-mechanical effects and focusing on solid quantum sensors. To implement this technology in society in the near future, we're assessing the R&D phases of each technology, clarifying the roadmap to implementation and pursuing an integrated program of research from basic research to development research.

Next Generation Laser

Program Directors
KONDO Kiminori
- Director, Department of Quantum Applied Photonics, Kansai Institute for Photon Science, National Institutes for Quantum Science and Technology (QST)

Project Overview

Laser technology is used widely in an array of industries, including ICT, material processing, healthcare and many more. It has taken on growing importance in recent years as an elemental technology supporting quantum technology. In this area, the laser technologies in which we are especially pursuing R&D are laser manufacturing and ultrashort-pulsed laser. By coordinating these two fields, we aim to achieve processing with levels of precision surpassing anything available today.

Human Resources Development Program

Program Directors
ITOH Kohei
- President, Keio University

Project Overview

The field of quantum technology is developing rapidly, and the international competition in this space is intensifying. To further accelerate R&D in this field and its applications in society, Japan needs "quantum talents". We are therefore working in this domain to develop educational programs for people in all walks of life, from youth to people in higher education and training for industrial positions, to ensure continuous strengthening of understanding at each level.

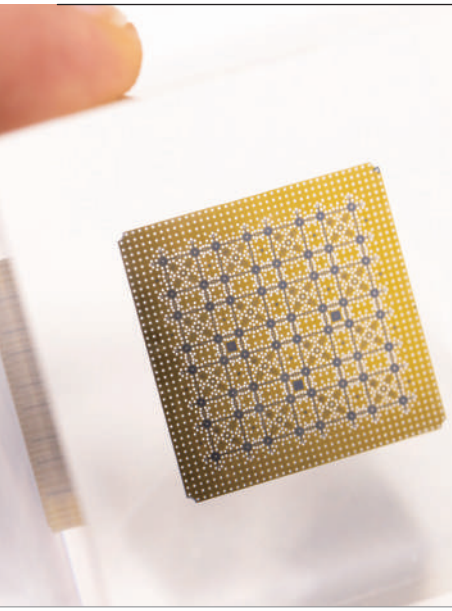
Quantum Information Technology

Flagship Project

Research and development of superconducting quantum computers

Quantum Information Technology Flagship

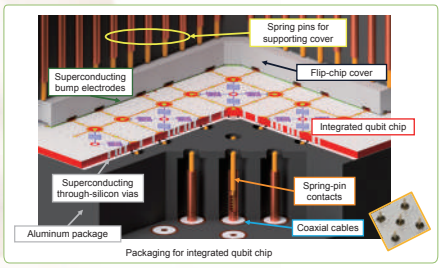
❝ Building a superconducting quantum computer through close coordination among hardware, middleware and software R&Ds ❞



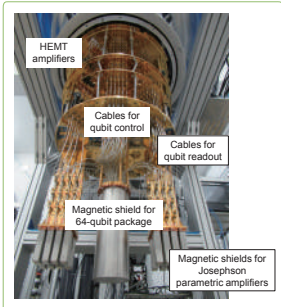
GOAL

Improving the operation and performance of home-built superconducting quantum computers as a quantum computing platform

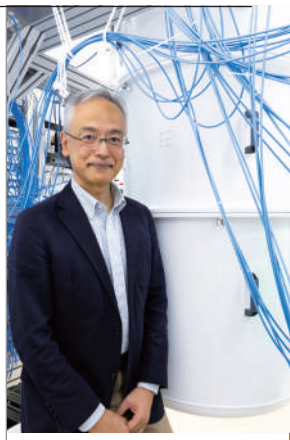
As part of the effort to develop a quantum computer, we are raising the precision of control and readout of quantum-bit (qubit) integrated circuits, improving the performance of the entire system from quantum processor units to peripheral electronics.



Packaging for integrated qubit chip



64-qubit quantum computer system



Project Leader

NAKAMURA Yasunobu

Director, RIKEN Center for Quantum Computing

Development of quantum software by intelligent quantum system design and its applications

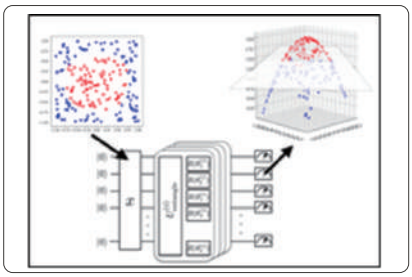
Quantum Information Technology Flagship (Quantum AI)

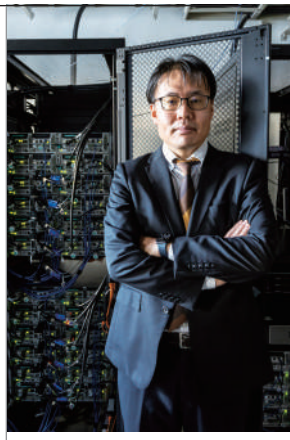
❝ Exploring applications for quantum computers in finance and mathematical data science, as well as in material sciences such as materials and chemistry ❞

GOAL

Proposing and applying new approaches to put quantum computers to effective use.

Current quantum computers have limitations in function and performance. We're exploring more effective ways of using quantum computers and pioneering practical solutions for large-scale quantum computers.





Project Leader

FUJII Keisuke

Deputy Director, Professor, Center for Quantum Information and Quantum Biology (QIQB), Osaka Univ.

Basic Foundation Research

Project Name	Project Leader
Development of cold-atom based quantum simulators by optical control with precisions on the attosecond temporal and nanometer spatial scales and their applications to quantum computing	OHMORI Kenji Professor and Department Chair, Institute for Molecular Science, National Institutes of Natural Sciences
Multi-degree-of-freedom complex quantum simulator using cooled ions	TOYODA Kenji Professor, Center for Quantum Information and Quantum Biology (QIQB), International Advanced Research Institute (IARI), Osaka Univ.
Architecture and applications for small to large scale quantum computation	NEMOTO Kae Professor, Okinawa Institute of Science and Technology Graduate University Specially Appointed Professor, Principles of Informatics Research Division,National Institute of Informatics
Large scale integration of silicon qubits to realize quantum computer	MORI Takahiro Group Leader, Device Technology Research Institute,National Institute of Advanced Industrial Science and Technology
Quantum software	YAMAMOTO Naoki Professor, Faculty of Science and Technology, Keio University

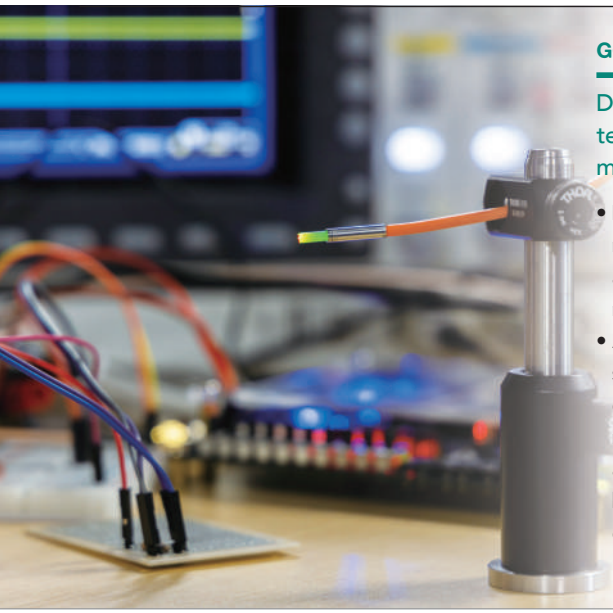
Quantum Metrology & Sensing

Flagship Project

Development of innovative sensor systems by highly sophisticated control of solid quantum sensors

Quantum Metrology & Sensing Flagship

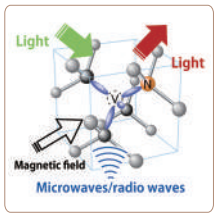
“ Collaboration among the layers of basic technologies, sensor-system technologies and prototypes application technologies to develop innovative solid quantum sensors ”

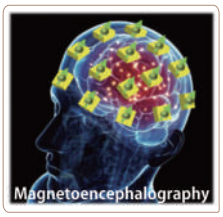


GOAL

Demonstration of simultaneous measurement of current and temperature in EV batteries and pursuit of high sensitivity for magnetoencephalography

- Development of hierarchical biometric measurement technologies for magnetic imaging of cells and nerve tissues, magnetocardiography and magnetoencephalography of small animals and magnetoencephalography of humans
- Achievement of small prototypes for dynamic simultaneous measurement of current and temperature in batteries and power devices





Project Leader

HATANO Mutsuko

Executive Vice President / Professor, School of Engineering, Institute of Science Tokyo

Innovations in Medicine and Life Sciences through Development of Quantum Life Technology

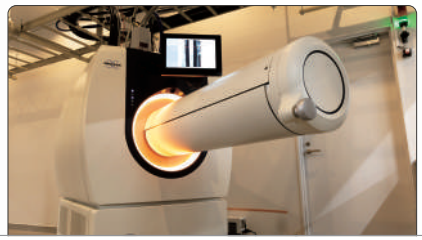
Quantum Metrology & Sensing Flagship (Quantum Life Science)

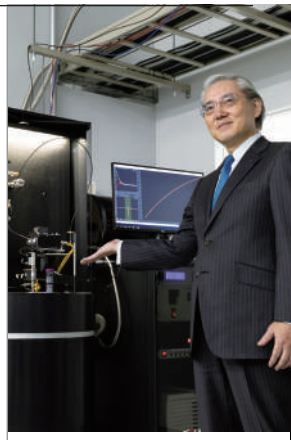
“ Leading the world with innovation in medicine and life sciences and creation of social innovation, establishing quantum life technology ”

GOAL

Development of quantum life technologies such as nanoscale quantum biosensors and hypersensitive MRI/NMR, and their applications in medicine and life sciences

We are aiming to bring breakthroughs in neuroscience, immunology, cancer science, regenerative medicine, cell biology, and drug discovery science, while elucidating quantum effects in biological phenomena and paving the way for technological development that mimics superior biological functions.





Project Leader

BABA Yoshinobu

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

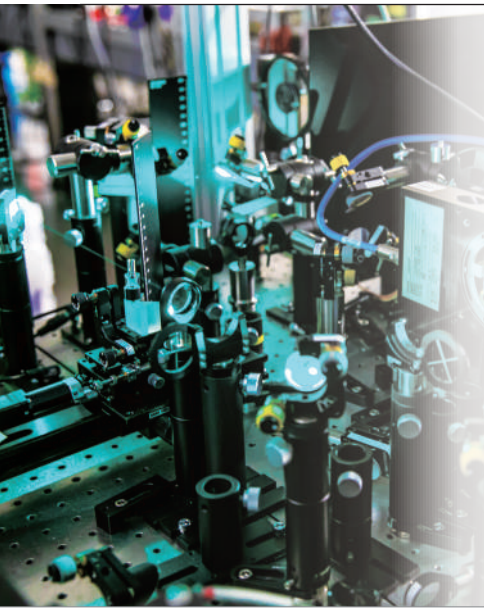
Basic Foundation Research

Project Name	Project Leader
Establishment of earthquake early alert methods using high-sensitivity gravity gradiometer	ANDO Masaki Professor, Graduate School of Science, The University of Tokyo
Development of photon-number-resolving quantum nano-photonics	EDAMATSU Keiichi Professor, Research Institute of Electrical Communication,Tohoku University
Development of quantum atomic magnetometer with dual quantum noise squeezing	SHIBATA Kosuke Visiting researcher, Physics Division,Department of Science,Gakushuin University
Development of Spectroscopic techniques based on cutting-edge quantum optics toward elucidating functions of complex molecular systems	SHIMIZU Ryosuke Professor, Graduate School of Informatics and Engineering, The University of Electro-Communications
Research on quantum Sensing devices using quantum entangled photons	TAKEUCHI Shigeki Professor, Graduate School of Engineering, Kyoto University
Material science of complex defects for highly-sensitive quantum sensors	TERAJI Tokuyuki Group leader, Research Center for Electronic and optical Materials, National Institute for Materials Science (NIMS)
Development of next generation high-performance inertial quantum sensors	NAKAGAWA Ken'ichi Professor, Institute for Laser Science, The University of Electro-Communications

Advanced Laser Innovation Center (ALICe)
Science and theory enabling intelligent laser manufacturing (STELLA)

Next Generation Laser Flagship (STELLA)

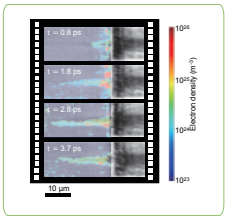
“ Driving CPS laser manufacturing - the key to realizing a supersmart society - powered by artificial intelligence (AI) and advanced physical modeling ”

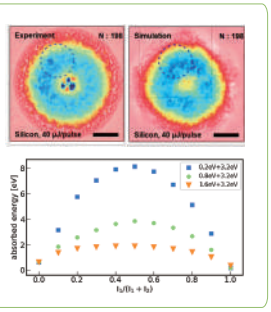


GOAL

Leveraging Japan’s strengths to implement CPS in laser manufacturing, general manufacturing and society at large

We will demonstrate proof of concept for CPS laser manufacturing through the integration of AI and advanced physical modeling. Furthermore, we will advance interdisciplinary, industry-academia collaborative foundational research with photon science as a central theme, cultivating outstanding talent that will lead the next generation and establish new academic strengths for Japan.



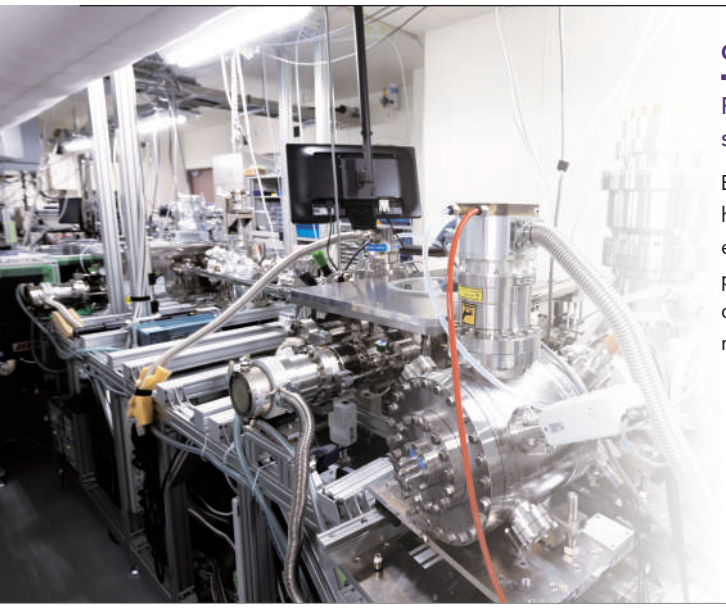


Project Leader
ISHIKAWA Kenichi
Professor, The University of Tokyo

Advanced Laser Innovation Center (ALICe)
Attosecond lasers for next frontiers in science and technology (ATTO)

Next Generation Laser Flagship (ATTO)

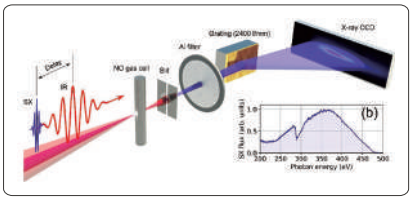
“ We’re conducting frontier research to develop attosecond light sources and observe ultrafast phenomena using attosecond light pulses. ”



GOAL

Formation of an R&D platform to drive attosecond science and technology

By developing attosecond pulse light sources with high repetition and high intensity, along with leading-edge measurement technologies, we aim to elucidate phenomena in the attosecond domain. We are also constructing advanced measurement systems for the material-science, biology and medical fields.



Project Leader
YAMANOUCHI Kaoru
Director
Institute for Attosecond Laser Facility
Project Professor
Emeritus Professor

Basic Foundation Research

Project Name	Project Leader
Developing guidelines on materials strengthening and toughening based on mechanism of atomic scale damaging under ultrashort pulsed laser processing	SANO Tomokazu Professor, Graduate School of Engineering, Osaka University
Operando measurements with advanced beams to study the mechanism of fine structure formation	HASHIDA Masaki Researcher, Institute for Chemical Research, Kyoto University Professor, Research Institute of Science and Technology, Tokai University
Development of attosecond light functions of strongly correlated quantum materials	IWAI Shinichiro Professor, Graduate School of Science, Tohoku University
Research on basic technologies for a highrepetition attosecond pulse source driven by a free electron laser	HAJIMA Ryoichi Director, Dept. of Advanced Photon Research Kansai Institute for Photon Science National Institutes for Quantum Science and Technology (QST)

Human Resources Development Program

Human Resources Development Program
Common core program

Project Leader
NEMOTO Kae
Director, Global Research Center for Quantum Information Science
Specially Appointed Professor
National Institute of Informatics

Quantum Academy of Science and Technology
https://qacademy.jp/

Common core program

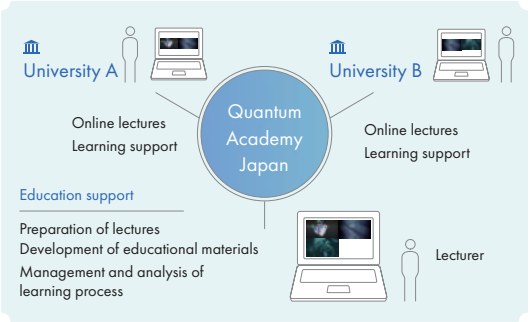
Development of the Standard Program for Quantum Science and Technology

"Establishing the standard education system for quantum science and technology."

GOAL

We aim to establish the standard online education system based on the Japanese inter-university structure.

Create and distribute the high standard educational materials for quantum science and technology.
Develop the online system to support both educators and learners.



Original subprogram

Project Name	Project Leader
Fostering qantum natives through practical research and development	OHZEKI Masayuki Professor, Graduate School of Information Sciences, Tohoku University
Quantum education for future technologies	NOGUCHI Atsushi Associate Professor, Graduate School of Arts and Sciences, University of Tokyo
A hands-on program for fostering quantum-based thinkers among emerging engineers in various disciplines	KISHIMOTO Tetsuo Associate Professor, Graduate School of Informatics and Engineering, The University of Electro-Communications

Quantum-technology literacy program

Project Name	Project Leader
Quantum transformation research into commercializing innovator human resource development	CHE Heewon CEO, JellyWare Inc.

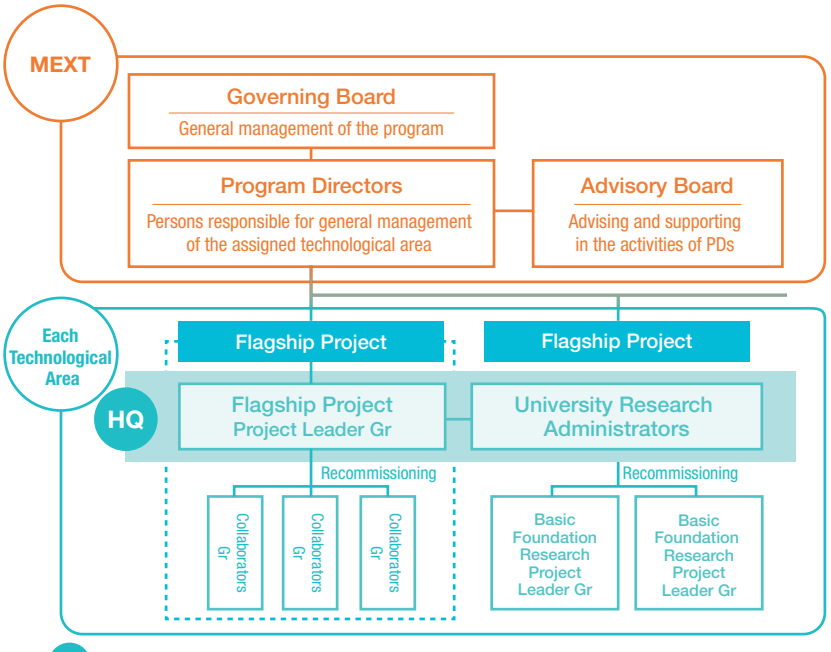
Ecosystem creation program

Project Name	Project Leader
Establishing an ecosystem for quantum talent development	YAN Tennin Co-Founder & CEO, QunaSys Inc.

Operation/Implementation Structure of Q-LEAP

A governing board is established within MEXT to manage progress in R&D and run various programs.

A framework for the operation and implementation of Q-LEAP is established, with focus on research management in each area, comprehensive liaison between industry and academia, research promotion and so on. For example, the PDs, who have authority over budget allocation and other responsibilities, perform detailed progress management (R&D management in the style of the Cross-ministerial Strategic Innovation Promotion Program).

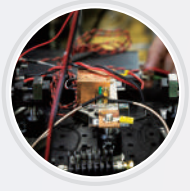


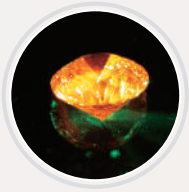
HQ Headquarters for implementation of R&D. Performs tasks such as planning and coordination.

Q-LEAP

Quantum Leap
Flagship Program

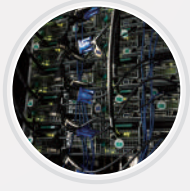


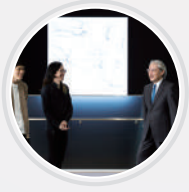







MEXT
MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

Ministry of Education, Culture, Sports, Science and Technology
Research Promotion Bureau　Basic and Generic Research Division
Office for Quantum Science and Technology

JST

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Quantum Leap Flagship Program (Q-LEAP)

https://www.jst.go.jp/stpp/q-leap/en/index.html

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