Press Dossier

Exploring and Making Quantum Technology
Finnish Presidency - Quantum Flagship Event

October 17-18, 2019
Helsinki, Finland

Index

Europe's vision for Quantum Technologies

In October of 2018, Europe witnessed the start of a new and promising initiative known as the **Quantum Flagship.** This initiative is one of the most ambitious programs put into motion by the European Union with a 1b€ budget funded by the European Commission.

This **10-year long initiative** will support large-scale and long-term research and innovation projects that will have the main goal of transferring quantum physics research from the lab to the market by means of commercial applications.

The **first quantum revolution** allowed scientists and engineers to understand and predict physical processes at the nanoscale level. Now, the **second quantum revolution** is currently unfolding; a revolution that is leading to the engineering of quantum systems that could transform today's technological landscape. These systems, based on quantum physics laws and principles, use photons, electrons, atoms, and molecules as tools, to develop devices that are much more secure, faster, sensitive and that have higher capacities, among other many advantages.

Thus, in this new technological era, Europe is in full motion to bring disruptive quantum technologies to the scientific and technology arenas and to our society in general. This will enable new commercial opportunities that address global challenges, provide strategic capabilities for security, and seed yet unimagined applications for the future. All this with the vision of boosting Europe's intellectual and industrial power and infrastructures to position the region as a worldwide knowledge-based industry and technology leader in this field.

In pursuing this, Europe will build a network of **Quantum Technologies programs** that will foster an ecosystem capable of delivering the knowledge, technologies and open research infrastructures and testbeds necessary for the development of a world-leading knowledge-based industry. Examples of these commitments are the Quantum Flagship as well as the recently launched **OpenQKD testbed project**, which will pave the way for the construction and deployment a **secure Pan-European Quantum Communication Infrastructure**. This infrastructure will become the backbone of the **Quantum Internet**, a secure network that connects quantum computers, simulators and sensors via quantum nodes, which will be used for distributing sensitive data, information and resources securely over the region and worldwide.

As Jürgen Mlynek, Chair of the Quantum Flagship Strategic Advisory Board, expresses, "Europe is striving to take a leading role in the second quantum revolution currently unfolding worldwide. Considering the efforts mounted around the globe though, it will not be possible to remain at the forefront without the continent-wide support that has carried the European Quantum Flagship so far. This is why I am particularly looking forward to these meetings where the community at large can come together and exchange ideas about the present and future of quantum technologies."

Exploring and Making Quantum Technology

Quantum Flagship Presidency Event

On October 17-18th of 2019, renowned representatives, experts and stakeholders within the quantum technologies field are gathering in Helsinki to participate in the "Exploring and Making Quantum Technology" event, aimed to discuss the current landscape and future of the quantum technologies ecosystem in Europe.

Organised by the Finnish Presidency, Aalto University, VTT Technical Research Centre of Finland, the Academy of Finland, the Quantum Flagship, and supported by the European Commission, this two-day event will be a great opportunity for the scientific community, industry representatives as well as policymakers to come together to view the current status and progress of quantum technologies within Europe and define the next steps and strategic goals for the advancement of these technologies in the region.

Agenda of the Event

October 17

Moderator: Tommaso Calarco, Chair of the Quantum Community Network
Venue: Paasitorni

12:00	Registration (light lunch will be served)

Opening

13:00	Welcome **Heikki Mannila**, President of the Academy of Finland
13:15	Progress in Quantum Technologies: What is the Future of Quantum Technologies beyond the Flagship Initiative? **Khalil Rouhana**, Deputy Director-General for Communications Networks, Content and Technology, European Commission
13:45	The European Quantum Flagship: Where do we stand today? **Jürgen Mlynek**, Chair of the Quantum Flagship Strategic Advisory Board

Future of quantum technologies in Europe

14:10	Quantum Technology Finland: Exploring Pathways to the Future **Jukka Pekola** and **Sabrina Maniscalco**, Aalto University and University of Turku
14:30	Technology Keynote **Antti Vasara**, President & CEO, Technical Research Centre of Finland (VTT)
14:50	Industry Keynote: Shaping the quantum future from Europe **Jan Goetz**, CEO, IQM
15:10	Aligning national, regional and European QT Public Policies **Sylwia Kostka**, National Science Centre, Poland; QuantERA Programme Coordinator
15:30	Coffee Break & Group Picture
16:00	Panel Discussion: Establishing a European Infrastructure for Quantum Technologies Moderator: Sabrina Maniscalco, Professor of Theoretical Physics at University of Turku **Khalil Rouhana**, Deputy Director General, DG Connect (European Comission) **Ambassador Milos Koterec**, Innovation Counsellor at the Slovakia embassy in Helsinki (Slovakia) **Freeke Heijman** - Special Advisor to the Minister on Quantum Technologies (The Netherlands) **Herbert Zeisel** – Director, Research for Digital Transformation (Germany) **Michael Wiesmüller** - Head of Department, Key Enabling Technologies for Industrial Innovations (Austria) **Antti Vasara**, President & CEO, Technical Research Centre of Finland (VTT) (Finland)
17:15	Closing Remarks
17:30	Transportations to Dipoli, from Paasitorni (there will be no organized return transportation to Paasitorni)
18:00	Welcome Reception at Dipoli (includes cocktails & QT exhibition) **Ilkka Niemelä**, President of Aalto University Inauguration of QT exhibition
20:00	End of Reception

EXPLORING AND MAKING QUANTUM TECHNOLOGY

European Quantum Flagship Event
October 17-18 2019

October 18

Venue: Aalto University, Dipoli, Otakaari 24, Espoo

Implementing the European Quantum Flagship
Moderator: Markus Wilkens, Coordinator of the Quantum Flagship Coordination and Support Action

9:00 Welcome
Jürgen Mlynek, Chair of the Quantum Flagship Strategic Advisory Board

9:10 Setting the Scene
Rob Thew, Chair of the Quantum Flagship Strategic Research Agenda Working Group

9:30 Panel Discussion: International Cooperation in Quantum Technology
Moderator: Philippe Chomaz, Executive Scientific Director at CEA

- **Jaya Baloo** - Vice Chair of the Quantum Flagship Strategic Advisory Board and Chief Information Security Officer (CISO) for Avast, Czechia
- **Jake Taylor** - Assistant Director for Quantum Information Science at White House Office of Science and Technology Policy, USA
- **Kenji Ohmori** - Vice Chair and Head of Expert Members, Committee for Quantum Science and Technology Policy, MEXT, Japan
- **Gustav Kalbe** - Head of the High Performance Computing and Quantum Technology unit from the European Commission

10:30 Coffee Break & Group Picture

11:00 Community Feedback Session - Cross Cutting Topic I: Infrastructures
Garrelt Alberts, Roadmap Leader at QuTech

12:00 Community Feedback Session - Cross Cutting Topic II: Engineering
Rogier Verberk, Director Semiconductor Equipment at TNO and Chair of the Quantum Flagship Innovation Working Group

13:00 Lunch Break

14:00 The EPO support for innovation in Quantum Technologies
Nigel Clarke and **Maria Oliete Ballester** - European Patent Office (EPO)

14:20 Community Feedback Session - Cross Cutting Topic III: Education
Chiara Macchiavello, Associate Professor of the University Di Pavia and Chair of the Quantum Flagship Education Working Group

15:20 Closing Remarks
EC representative

15:40 End

Organizing Entities

About the Quantum Flagship

The Quantum Flagship was launched in 2018 as one of the largest and most ambitious research initiatives of the European Union. With a budget of at least €1 billion and a duration of 10 years, the flagship brings together research institutions, academia, industry, enterprises, and policy makers, in a joint and collaborative initiative on an unprecedented scale. The main objective of the flagship is to consolidate and expand European scientific leadership and excellence in this research area as well as to transfer quantum physics research from the lab to the market by means of commercial applications and disruptive technologies. With over 2000 researchers from academia and industry currently involved in this initiative, it aims to create the next generation of disruptive technologies that will impact Europe's society, placing the region as a worldwide knowledge-based industry and technological leader in this field.

website, Twitter, Linkedin

About VTT

VTT is a visionary research, development and innovation partner. We drive sustainable growth and tackle the biggest global challenges of our time and turn them into growth opportunities. We go beyond the obvious to help the society and companies to grow through technological innovations. We have over 75 years of experience of top-level research and science-based results. VTT´s turnover and other operating income is 268 M€.

VTT is at the sweet spot where innovation and business come together.

VTT – beyond the obvious. Twitter @VTTFinland, Facebook, LinkedIn, YouTube and Instagram. For photos and videos, please visit Image Bank

About Aalto University

Aalto University is a community of bold thinkers where science and art meet technology and business. We are committed to identifying and solving grand societal challenges and building an innovative future. Aalto University has six schools with 12 000 students and 400 professors. Our campus is in Espoo, Finland.

Twitter @AaltoUniversity, Facebook, LinkedIn, YouTube and Instagram. For photos and videos, please visit material bank.

About The Academy of Finland

The Academy of Finland's mission is to fund high-quality scientific research, provide expertise in science and science policy, and strengthen the position of science and research. We are an agency within the administrative branch of the Finnish Ministry of Education, Science and Culture.

We work to contribute to the renewal, diversification and increasing internationalisation of Finnish research. Our activities cover the full spectrum of scientific disciplines.

We support and facilitate researcher training and research careers, internationalisation and the utilisation of research results. We are also keen to emphasise the importance of research impact and breakthrough research. We therefore encourage researchers to submit boundary-crossing applications that involve risks but also offer promise and potential for scientifically significant breakthroughs.

In 2019, our funding for research amounts to 458 million euros. Each year, our funding contributes to some 2,700 people's work (FTEs) at universities and research institutes.

Part of our funds come from proceeds of Finland's national gaming company Veikkaus. In 2019, these proceeds account for 70.7 million euros of our total funding for scientific research.

Invited Speakers and Moderators

Heikki Mannila

President of the Academy of Finland

Heikki Mannila (born 1960) is a Finnish computer scientist, the president of the Academy of Finland – the Finnish Research Council.

Mannila earned his Ph.D. in 1985 from the University of Helsinki and for many years he was a professor at the University of Helsinki. He has also worked at Max Planck Institute, Microsoft Research, Nokia Research Centre, and Aalto University (formerly Helsinki University of Technology). His research concentrated on algorithmic data analysis and data mining. From 2004 to 2008 he was Academy Professor. He became Vice President for academic affairs at Aalto University in 2009, and was appointed by the Finnish government as president of the Academy of Finland for a term lasting from 2012 to 2017. The appointment was renewed for the period 2017–2022.

Khalil Rouhana

Deputy Director-General in DG CONNECT, European Commission

Khalil Rouhana is the Deputy Director-General in DG CONNECT (Communications Networks, Content & Technology) since 1/12/2016. His responsibilities include the policies for digital economy and society and notably for research, innovation and industrial strategies, digital solution for societal challenges and governments as well as cybersecurity. Before that he was Director for “Digital Industry” in DG CONNECT supporting the competitiveness of core digital sectors in Europe and the digitisation of all industrial sectors of the economy. In his previous experiences in the Commission, he was the Director for “Digital content & Cognitive systems”, the Head of Unit in charge of ICT research and Innovation strategy, and started as a project officer in the ESPRIT programme in the areas of High Performance Computing and Future and Emerging technologies.

Before joining the Commission in 1992, he was for 5 years the director of an institute and school of engineering (Grande Ecole) in France. He started his career as research and development engineer for the aeronautics industry, worked for the French University in Beirut and created also his own engineering company. He has a master degree in electrical and electronic engineering from “Ecole Supérieure d’Electricité” (Supelec, France).

Jürgen Mlynek

Professor of Experimental Physics, Humboldt-Universität zu Berlin, Chair of the Strategic Advisory Board of the Quantum Flagship

Jürgen Mlynek is Chair of Strategic Advisory Board of the Quantum Flagship, continuing the work he started at the helm of the High-Level Steering Committee, the initiative's founding expert group in 2016. He obtained his PhD in physics in 1979 and habilitated in 1984, after which he became a Heisenberg fellow of the German Research Foundation (DFG) and served as assistant professor at ETH Zurich. He became a full professor for experimental physics at University of Konstanz in 1990 and at Humboldt University of Berlin in 2000.

From 1996 to 2001, he served as vice president of the German Research Foundation and between 2000 and 2005, president of the Humboldt University of Berlin. In 2005, Mlynek switched to the Helmholtz Association of German Research Centres, Germany's largest science organization, and became president for two terms until 2015.

Throughout his scientific career, Mlynek has worked in the field of experimental quantum optics, atomic physics and surface physics and has published more than 200 papers. He has received numerous awards for his work both as a researcher and a science manager, among them the Leibniz Prize of the German Research Foundation and the Order of Merit of the Federal Republic of Germany.

Ilkka Niemelä

President of Aalto University

Aalto University

Professor Ilkka Niemelä started as President of Aalto University on 1 July 2017.

Ilkka Niemelä received his doctorate in computer science from Helsinki University of Technology in 1993. He was appointed as Professor of Computer Science at Helsinki University of Technology in 2000. Professor Niemelä's previous positions include Head of Laboratory for Theoretical Computer Science 2000-2007, Chair of the Degree Program of Computer Science and Engineering 2008-2010, Dean of Aalto University School of Science 2011-2012, and Deputy President of Aalto University 2012-2014. Ilkka Niemeläwas Provost at Aalto University in 2014-2017 prior to his appointment as President.

President Niemelä's research interests include automated reasoning and constraint programming, knowledge representation, computational complexity, configuration, computer aided verification and testing. At Aalto University he is heading the computational logic group and is one of the Principal Investigators of the Finnish Center of Excellence in Computational Inference Research (COIN).

Ilkka Niemelä is a Fellow of the European Association for Artificial Intelligence and has served, for example, as the Editor-in-Chief of Theory and Practice of Logic Programming.

Jukka Pekola

Professor, Quantum Physics, Aalto University

Jukka Pekola is Professor in Quantum Physics at Aalto University. He is the director of the national Quantum Technology Finland Centre of Excellence, and the scientific leader of the national OtaNano research infrastructure, critical for the Quantum Technologies research in Finland.

Professor Pekola's work on the thermal conductivity of nanostructures has set new standards in the field. His experimental studies between classical and quantum physics are unique on a world scale. The micro and nanoscale thermometers and refrigerators he has developed are cutting-edge achievements in nanophysics.

Sabrina Maniscalco

Professor of Theoretical Physics at University of Turku

Sabrina Maniscalco is an Italian researcher in quantum physics and technology. She obtained her MSc (specialization in Theoretical Physics) in 1999 and her PhD from the University of Palermo in 2004. Between 2011 and 2014, she was Professor at Heriot-Watt University in Scotland. Maniscalco joined the Quantum Physics Research Group at the University of Turku after time as a post-doc researcher in Bulgaria and South Africa.

Since 2014, Maniscalco has been Professor of Theoretical Physics and Director of the Theoretical Physics Laboratory at the University of Turku, and Adjunct Professor at Aalto University and Vice Director of the Center of Excellence in Quantum Technology. In 2017 she received the Väisälä Prize.

Antti Vasara

President & CEO, Technical Research Centre of Finland (VTT)

Antti Vasara is the President & CEO of VTT Ltd since 2015. VTT is a visionary research, development and innovation partner with over 2000 people and turnover exceeding 250 MEUR.He is president of EARTO (European Association of Research and Technology Organisations)and chairman of the board of Palta (Finnish Service Sector Employers).

In addition, he is a nonexecutive director of Elisa Oyj (largest communications operator in Finland) and a board member at EK (Finnish Confederation of Industries). He has served on several high-level groups on industrial and innovation policy of the European Commission in addition to several groups in Finland on artificial intelligence and research policy. Previously, he has worked in the private industry for close to 25 years at Nokia, Tieto, SmartTrust and McKinsey & Company. Earlier in his career, he was a researcher in optical communications with 20+ peer reviewed articles and one international patent.

Vasara holds a Doctor of Science (Technology) degree from Aalto University in Finland.

Jan Goetz

CEO, IQM

Jan Goetz is a quantum physicist and CEO of IQM. His strong experience in superconducting circuits is partly based on his past research in QCD Labs at Aalto University and in Walther-Meissner-Institute at Technical University of Munich campus. Jan is globally connected and has a strong drive to develop the future of quantum technologies.

Jan received his PhD on superconducting quantum circuits in 2017 from TU Munich and continued as a Postdoc in Helsinki at Aalto University. He received a prestigious Marie Curie Fellowship from the European Union, and thinks Helsinki is a great hub for quantum computing.

Tommaso Calarco

Chair of the Quantum Community Network and Director of the Institute for Quantum Control of the Peter Grünberg Institute at Forschungszentrum Jülich

Tommaso Calarco has pioneered the application of quantum optimal control methods to quantum computation and to many-body quantum systems. Currently the Director of the Institute for Quantum Control of the Peter Grünberg Institute at Forschungszentrum Jülich, Tommaso received his PhD at the University of Ferrara and started to work as a postdoc in the group of P. Zoller at the University of Innsbruck. He was appointed as a Senior Researcher at the BEC Centre in Trento in 2004 and as a Professor for Physics at the University of Ulm in 2007, where he then became Director of the Institute for Complex Quantum Systems and of the Centre for Integrated Quantum Science and Technology.

He has authored in 2016 the Quantum Manifesto, which initiated the European Commission's Quantum Flagship initiative, and is currently the Chairman of one of the Flagship's Governing Bodies: The Quantum Community Network.

Markus Wilkens

Coordinator of the Quantum Flagship Coordination office and Senior Technology Consultant at VDI Technologiezentrum GmbH

Markus Wilkens is heading the European Quantum Flagship Coordination Office since April 2019. He has more than 15 years of experience in setting up and implementing community-driven strategy processes and public-private funding initiatives in deep technology sectors. As Head of Operations of the European Technology Platform Photonic21, he was responsible for establishing a public investment partnership of 700 million euros between European industry, research institutions and the European Commission for the Horizon 2020 research framework programme.

He has been an invited expert on various EU Commission advisory boards, including the Key Enabling Technology (KET) and Digital Innovation Hubs (DIH) initiatives. He previously worked as a technology consultant for Bayerische Landesbank, Munich, in investment banking and private equity. Markus is a graduate biologist and studied at the Free University of Berlin and Stanford University, USA.

Rob Thew

Chair of the Quantum Flagship Strategic Research Agenda Working Group and Group Leader at Université de Genève

Rob Thew is a senior researcher at the University of Geneva and chair of the Strategic Research Agenda Work Group. He studied at the University of Queensland in Australia, completing his honours under the supervision of Gerard Milburn and Bill Munro. He then worked with Michael Nielsen and Andrew White before completing his PhD at the University of Geneva, Switzerland, in the group of Nicolas Gisin and Hugo Zbinden.

Rob Thew is an expert in quantum communication, spanning fundamental to applied topics and more recently working in quantum sensing in bio and molecular systems. He has been involved in European projects since FP5 and is currently one of the group leaders in the Quantum Technologies group at the University of Geneva and is involved in the QFlag project.

Philippe Chomaz

Coordinator of the Applications and Market Working Group and Executive Scientific Director at CEA

Philippe CHOMAZ, former student of Ecole Normale Superieure (Paris), has been CNRS researcher at Orsay, visiting scientist at Berkeley and CEA researcher at Caen. He next served as deputy director of GANIL (Large Heavy Ion National Accelerator) and director of CEA-Irfu (Institute of Research into the Fundamental Laws of the Universe) at Saclay.

Since 2016, he is the executive Scientific Director of CEA fundamental research division (50 laboratories and 6270 staff). He published about 200 papers in nuclear, quantum and statistical physics and gave over 100 invited talks, as well as radio and television interviews. He has been President of SFP nuclear physics division, of European Center ECT, of the Physics committee in the French research agency, of the large laboratories at CERN and Secretary of the last CERN European Strategy.

Chiara Macchiavello

Coordinator of the Quantum Flagship Education Working Group and Associate Professor Università di Pavia

Chiara Macchiavello received her PhD in 1995 from the University of Pavia. She then spent two years at the University of Oxford with a Marie Curie postdoctoral position. In 1998 she became research assistant at the University of Pavia, where she is now Professor of the Physics of Quantum Computation.

She has made relevant contributions in various aspects of theoretical quantum information science, including pioneer work in quantum error correction and quantum algorithms, quantum privacy amplification and quantum cloning. For her work she was awarded a prestigious prize from Accademia Nazionale dei Lincei in 2006.

Rogier Verberk

Coordinator of the Quantum Flagship Innovation Working Group and Director Semiconductor Equipment at TNO

Rogier Verberk holds a PhD in experimental physics from Leiden University (2005), where he investigated the behaviour of individual CdS nanoparticles by means of optical spectroscopy. He started at TNO in 2005 as scientist but switched within a few years to project management and became one of TNO's 3 principal project managers, focusing on equipment development for the semiconductor industry, especially EUV lithography. He is (co-) author of several papers and patents in the field of molecular contamination control.

In 2013 TNO and the Technical University of Delft initiated QuTech, a joint research centre for the development of quantum computing and quantum internet. Verberk played a key role in the development of QuTech, its governance, and TNO's contributions to it. For three years he worked at QuTech where he was responsible for the technology developments in support of quantum physics research, contacts with industrial partners, and initiated the first developments for scalable quantum technologies.

Since July 2016 he is Director of semiconductor equipment, optical instrumentation for bio-medical applications, Industry 4.0, and quantum technologies at TNO; responsible for strategy, business development as well as the relevant technology roadmaps. Verberk is member of the Dutch National Semiconductor Equipment roadmap team, AENEAS, core team of the Dutch National Agenda on Quantum Technologies, and chairs the Innovation Working Group of the European Quantum Technologies Flagship.

Garrelt Alberts

Roadmap Leader at QuTech

Garrelt Alberts obtained his MSc degree in Physics and his Propaedeutic degree in Dutch Law at the University of Utrecht in 1998. He finished his PDeng in Mechanical Engineering at the Twente University on Computational Mechanics in 2001. Since then, Garrelt has been working at TNO in Delft.

He started as a Research Engineer at the Heat Transfer and Fluid Dynamics department, specialized in multiphase flow and fluid structure interaction. In 2007 he became a Project Manager and was responsible for several product-development projects and research programs for the Oil and Gas industry. In 2009 he became department manager of the Heat Transfer and Fluid Dynamics department, managing a group of 60 professionals.

Since the 1st of January 2017, he is QuTech's Shared Development roadmap leader. In that role he is responsible for managing TNO's engineering activities within QuTech.

Sylwia Kostka

National Science Centre, Poland; QuantERA Programme Coordinator

Programme Coordinator of the QuantERA ERA-NET in Quantum Technologies www.quantera.eu, world's largest network of Research Funding Organisations in Quantum Technologies from 27 countries, cofunded by the European Commission.

Sylwia develops strategic multilateral cooperation programmes at the National Science Centre, Poland, governmental research funding agency, where she works since its establishment in 2011. Her main areas of interest are research funding policies in the EU Member States, widening participation and effectiveness of international programmes. She holds Executive Master of Business Administration (MBA) from Cracow University of Technology, MA in International Cooperation and European Studies from the Jagiellonian University and MA in Development Cooperation Policy and Management from the SWPS University.

Nigel Clarke

Head of the Patent Information Research at European Patent Office (EPO)

Nigel Clarke has a Bachelor's degree in physical chemistry and a PhD in neutron science. After an R&D career in materials science and instrumentation, with the UK Atomic Energy Authority and the Ministry of Defence, Nigel joined the EPO in The Hague as a patent examiner, going on to become an IT project manager. He moved to international co-operation at the EPO Vienna, as co-ordinator of the PATLIB programme. This was followed by research into the patent information market.

For many years responsible for Espacenet and the EP Register, Nigel is now in charge of patent information research projects. Recent research topics include CAR T-cell immunotherapy and Blockchain. He has many years' experience of presenting patent information to the user community worldwide.

María Oliete Ballester

Programme Manager at European Patent Office (EPO)
Judicial Training & Future Emerging Technologies (FET) Projects

María Oliete Ballester is programme manager of Future Emerging Technologies (FET) projects and judicial training at the European Patent Academy of the EPO.

She is a lawyer with postgraduate studies in IP. She has formerly worked as a lawyer, legal advisor at the Institute of Professional Representatives before the EPO (epi) and researcher in the IP field at the Max Planck Institute for Innovation and Competition and the Ludwig Maximilians Universität (LMU).

Establishing a European Infrastructure for Quantum Technologies - Policy Panel Discussion Speakers

Khalil Rouhana

Deputy Director-General in DG CONNECT, European Commission

Khalil Rouhana is the Deputy Director-General in DG CONNECT (Communications Networks, Content & Technology) since 1/12/2016. His responsibilities include the policies for digital economy and society and notably for research, innovation and industrial strategies, digital solution for societal challenges and governments as well as cybersecurity. Before that he was Director for "Digital Industry" in DG CONNECT supporting the competitiveness of core digital sectors in Europe and the digitisation of all industrial sectors of the economy. In his previous experiences in the Commission, he was the Director for "Digital content & Cognitive systems", the Head of Unit in charge of ICT research and Innovation strategy, and started as a project officer in the ESPRIT programme in the areas of High Performance Computing and Future and Emerging technologies.

Before joining the Commission in 1992, he was for 5 years the director of an institute and school of engineering (Grande Ecole) in France. He started his career as research and development engineer for the aeronautics industry, worked for the French University in Beirut and created also his own engineering company. He has a master degree in electrical and electronic engineering from "Ecole Supérieure d'Electricité" (Supelec, France).

Ambassador Milos Koterec

Innovation Counsellor at the Slovakia Embassy in Helsinki - Slovakia

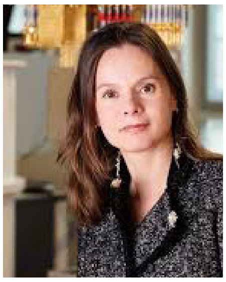
Miloš Koterec is a career diplomat from Slovakia. He was sent to the Permanent Mission of Slovakia to the U.N. from '95-'99. He then went on to work at the Permanent Mission to NATO for Slovakia in 2001. In 2005 he was elected as an MEP for Slovakia.

In 2009 he was appointed as the Permanent Representative to the U.N. for Slovakia. He has received the Gold Polish Army Medal in 2012.

Miloš Koterec is now serving as president of the economic and social council of the United nations, he became president on the tenth of January 2012 after serving as senior Vice-president of the council in 2011.

Freeke Heijman

Special Advisor to the Minister on Quantum Technologies - The Netherlands



Freeke Heijman is director strategic development at QuTech and special advisor to the Minister on Quantum Technologies. In this context she is responsible for the national policy and investments in QuTech, new international partnerships such as the flagship and development of the QuTech ecosystem. She is a 50-50 liaison between the Ministry and the QuTech Center.

She has extensive experience in space and innovation policy including in the role of head of unit. She graduated at the TU Delft Policy Analysis and Systems Engineering department in 1999 and started her career at KPN Research.

Paul Indelicato

Senior Researcher at CNRS and Research Advisor of the Conference of University President - France

Paul Indelicato is senior researcher at the French National Center for Scientific Research (CNRS) and Research advisor of the President of the Conference of University Presidents (CPU). At CPU he covers all aspects of research in universities, and in particular Open Science, Research Integrity, and small and emerging disciplines.

Paul Indelicato has been Deputy Director of the Office of Thierry Mandon, Minister for Higher-Education, Research and Innovation (MESRI) and his Senior Research advisor. During that time, he was in particular in charge of organizing the French participation to the Quantum Technology Flagship. He represented the Minister in the Quantum events in Amsterdam and in Malta. He was also in charge to setup the French Research Integrity organization. He also represented the Minister at the White House Artic Science Ministerial in 2017.

Before that he was vice-president for Research and Innovation of University Pierre and Marie Curie (now Sorbonne University) and Director of the Kastler Brossel laboratory, a laboratory very well known internationally for quantum physics research on cold atoms, quantum optics and tests of fundamental physics by doing high-precision measurements on atoms.

Paul Indelicato research work is in fundamental physics, both experimental and theoretical. On the experimental side he does accelerator-based experiments on highly-charged ions and exotic atoms, and x-ray metrology of highly-charged ions. He has performed experiments at most facilities in the US, Europe and Japan. He also works on the effect of gravitation on antimatter at CERN. On the theory side, he does quantum-electrodynamics calculation and study the relativistic many body problem. His work is carried out at the Kastler Brossel Laboratory in Paris. Paul Indelicato is also part of the Extreme Matter Institute of the Helmholtz association.

Herbert Zeisel

Deputy Director General “Research for Digital Transformation and Innovation” at the Federal Ministry of Education and Research (BMBF) - Germany

Herbert Zeisel is currently Deputy Director General “Research for Digital Transformation and Innovation” at the Federal Ministry of Education and Research (BMBF). His responsibilities include the Research and Innovation strategies in the fields of Artificial Intelligence and Software, Microelectronics, Cybersecurity and Communication, Quantum technologies, Human Machine Interfaces (Robotics) as well as innovations in Industrie 4.0, Autonomous Driving, and High Performance Computing.

He holds a diploma as “Diplom-Ingenieur (Uni)” and a PhD from the Friedrich-Alexander-University in Erlangen-Nuremberg in the field of Chemical Engineering. In 1988, he joined the “Federal Ministry for Research and Technology” (BMFT, later BMBF) acting as Project Officer and from 1994 as Head of Unit in different ICT-Fields (Microsystems and Sensors, Microelectronics, Internet and Services, Software, IT Operations, Information Management). From 2002 to 2010 he was Director for “Information and Communication Technologies” (ICT) at the German Aerospace Agency (DLR-PT). He represented Germany as head of delegation in several European and international committees. 2012 to 2014 Zeisel headed the division for Nanotechnology, New Materials and Batteries at the BMBF before he became Director for Key Technologies.

Antti Vasara

President & CEO, Technical Research Centre of Finland (VTT) - Finland

Antti Vasara is the President & CEO of VTT Ltd since 2015. VTT is a visionary research, development and innovation partner with over 2000 people and turnover exceeding 250 MEUR.He is president of EARTO (European Association of Research and Technology Organisations)and chairman of the board of Palta (Finnish Service Sector Employers).

In addition, he is a nonexecutive director of Elisa Oyj (largest communications operator in Finland) and a board member at EK (Finnish Confederation of Industries). He has served on several high-level groups on industrial and innovation policy of the European Commission in addition to several groups in Finland on artificial intelligence and research policy. Previously, he has worked in the private industry for close to 25 years at Nokia, Tieto, SmartTrust and McKinsey & Company. Earlier in his career, he was a researcher in optical communications with 20+ peer reviewed articles and one international patent.

Vasara holds a Doctor of Science (Technology) degree from Aalto University in Finland.

Michael Wiesmüller

Head of Department / Key Enabling Technologies for Industrial Innovation: ICT, Manufacturing and Nanotechnologies (III/i5), Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT) - Austria

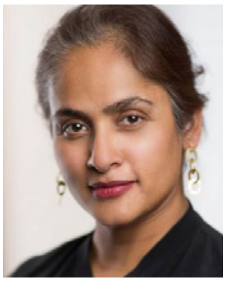
Initially stemming from the humanities and holding a degree in philosophy of science, working several years as scientists in the Humanities and as Management Consultant with A.T. Kearney he joined the Federal Ministry of Transport, Innovation and Technology (BMVIT) in late nineties. He is currently Head of Department for Key enabling Technologies for Industrial Innovation. Main responsibility of this department covers the design of Innovation Policies for High-Tech-Industries, national R&D strategies and programs in these domains, and all areas of International R&D Policy and Coordination.

Among others, Michael Wiesmüller acted as Austrian Delegate to the European ICT-Program, as Governance Board Member of the JTI's ECSEL and as Director of the EUREKA Clusters ITEA 3 and CATRENE and Austrian Lead Delegate to the Key Enabling Technologies. He represents Austria in various Mirror-Groups of European Technology Platforms and in several European Policy Coordination Initiatives. Recent Initiatives initiated within his department include Industry 4.0 Pilot Factories, Silicon Austria Labs, AI-Strategy Austria and the lighthouse projects Data Market Austria.

Speakers of the Panel Discussion: International Cooperation in Quantum Technology

Jaya Baloo

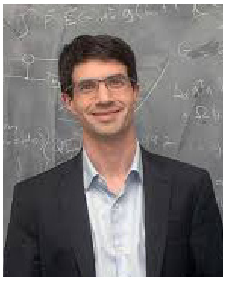
Vice Chair of the Quantum Flagship Strategic Advisory Board and Chief Information Security Officer (CISO) for Avast, Czechia



Jaya Baloo has been working internationally in Information Security for nearly 20 years. In the last few years, she has been named CISO of the year, top 100 CISOs globally, and top 100 Global Security Influencers. Her focus has been on secure network architecture where her work has ranged in areas from Lawful Interception, VoIP & Mobile Security, to designing national MPLS infrastructures, ISP architecture, as well as Quantum Communications networks. She has worked for numerous telecom providers, Verizon and France Telecom among others, and currently works for KPN Telecom in the Netherlands where she is the Chief Information Security Officer (CISO). A faculty member of Singularity university and a member of various infosec boards, she is always inspired about how much more there is to learn. As of October 1st, 2019, she will become the Chief Information Security Officer (CISO) for Avast, Czechia

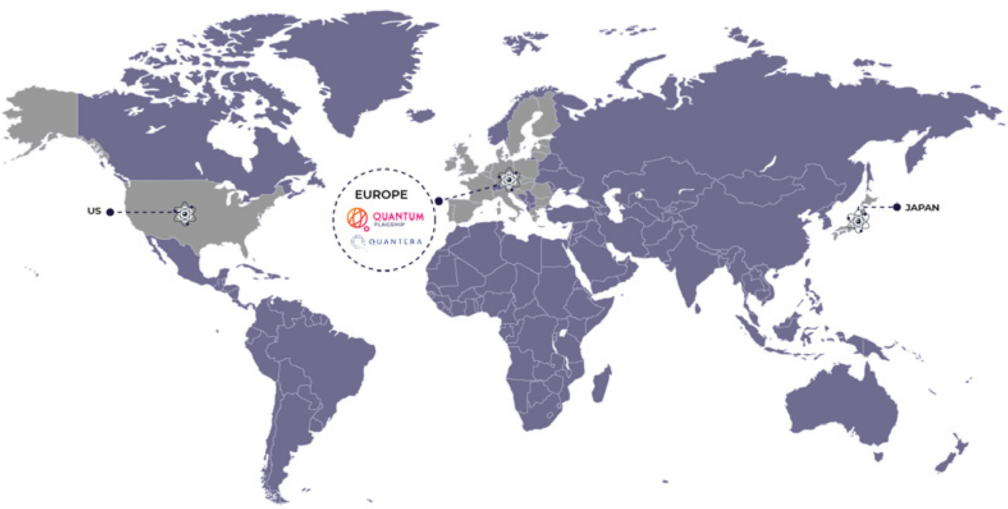
Jake Taylor

Assistant Director for Quantum Information Science at the White House Office of Science and Technology Policy, USA; and Interim Director, National Quantum Coordination Office, USA



Jake Taylor joined the White House Office of Science and Technology Policy in December 2017 to help lead the U.S. effort to advance American leadership in quantum information science. While at OSTP, he has overseen the passage of the National Quantum Initiative Act, signed into law on December 21, 2018; helped create the U.S. national strategy for quantum information science published in September, 2018; launched two National Science and Technology Council subcommittees to coordinate quantum-related research and development across the United States; and formed the National Quantum Coordination Office under OSTP's leadership.

While not on detail to OSTP, Taylor is a NIST Fellow at the National Institute of Standards and Technology (NIST), co-director of the Joint Center for Quantum Information and Computer Science (>http://quics.umd.edu<) at the University of Maryland, and a Joint Quantum Institute (>http://jqi.umd.edu<) Fellow. His research group investigates the fundamental limits of quantum devices for computation and communication. He received an AB in Astronomy & Astrophysics and Physics at Harvard in 2000 and then spent a year as a Luce Scholar at the University of Tokyo. Taylor returned to Harvard for his PhD in the group of Mikhail Lukin in 2006, exploring approaches to quantum computing and fault tolerance using spins in quantum dots. He went on to a Pappalardo Fellowship at MIT, working in both the Condensed Matter Theory group and the Center for Theoretical Physics, and during that time co-invented diamond-based magnetometry. In 2009 Taylor joined the Joint Quantum Institute and NIST, and in 2014 started the Joint Center for Quantum Information and Computer Science. He is a Fellow of the American Physical Society, and recipient of the Newcomb Cleveland Prize of the AAAS, the Samuel J. Heyman Service to American "Call to Service" medal, the Silver Medal of the Commerce Department, the Presidential Early Career Award for Science and Engineering, and the IUPAP C15 Young Scientist prize. He can be found on twitter @quantum_jake



Kenji Ohmori

Vice Chair and Head of Expert Members, Committee for Quantum Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan; Professor and Chairman, Institute for Molecular Science, National Institutes of Natural Sciences, Japan

Kenji Ohmori is a Japanese physicist and chemist from the National Institutes of Natural Sciences, Japan (NIMS), Institute for Molecular Science (IMS).

Kenji Ohmori has succeeded in designing and visualizing spatiotemporal images given by the interference of matter waves of atoms in a molecule with picometer and femtosecond resolution. The precision of this processing is the highest to date, higher than that of the current nanotechnology by three orders of magnitudes. This ultrahigh-precision processing has been implemented with the temporal oscillations of laser electric fields engineered with attosecond precision and imprinted on the matter waves of atoms and electrons in a molecule.

He has utilized this technique to develop a molecular computer in which a single 0.3-nanometer-size molecule can calculate 1000 times faster than the current fastest supercomputer. He has also developed an ultrafast quantum simulator that can simulate non-equilibrium dynamics of quantum many-body systems in one nanosecond, introducing a novel concept where he has combined his ultrafast coherent control with attosecond precision and ultracold atoms cooled down to temperatures close to absolute zero.

He has been honored with many prizes including the Japan Academy Medal (2007), JSPS Prize (2007), is a Fellow of the American Physical Society (2009), and has received the Humboldt Research Award (2012), Hiroshi Takuma Memorial Prize (2017) and Commendation by the Minister of MEXT (2018).

Gustav Kalbe

Head of the High Performance Computing and Quantum Technology unit European Commission

Gustav Kalbe is German, born in Belgium. From 1986 to 1990 he studied Applied Physics at the Université Catholique de Louvain, Belgium. In 1991 he studied Applied Optics at the Imperial College of Science in London. In 1995 he completed his studies and earned a PhD in Physics, Molecular Spectroscopy, at the Université Catholique de Louvain, Belgium.

In 1995 he began working as a project manager in photonic networks at Belgacom S.A., where he was R&D manager when he left the company.

In 1998 he joined the Directorate General Information Society & Media of the European Commission where he started working as a Project Officer managing research projects of the European Framework Programs for Research. The main areas covered were optical telecommunications, photonics, quantum information processing, ICT security and foundational ICT research. Gustav Kalbe was among the Project officers that launched the 1st European Initiative of Quantum Technologies in 1999 and has stayed involved in this field throughout his different assignments in the European Commission.

In 2014 Gustav Kalbe became Head of Unit for Administration & Finance in the European Commission, in Directorate General Communications Networks, Content and Technology. In 2016 he was appointed Head of Unit of the newly created High Performance Computing and Quantum Technology unit in Directorate General Communications Networks, Content and Technology. In 2018 he was appointed Interim Executive Director of the European High Performance Computing Joint Undertaking.

The Quantum Flagship

The Quantum Flagship was launched in 2018 as one of the largest and most ambitious research initiatives of the European Union. With a budget of **€1 billion** and a duration of **10 years**, the flagship brings together research institutions, academia, industry, enterprises, and policy makers, in a joint and collaborative initiative on an unprecedented scale.

The main objective of the Flagship is to consolidate and expand European scientific leadership and excellence in this research area as well as to transfer quantum physics research from the lab to the market by means of commercial applications and disruptive technologies. With over **2000 researchers** from academia and industry involved in this initiative so far, it aims to create the next generation of disruptive technologies that will impact Europe's society, placing the region as a worldwide knowledge-based industry and technological leader in this field.

IN NUMBERS

October 2018

2000+ experts

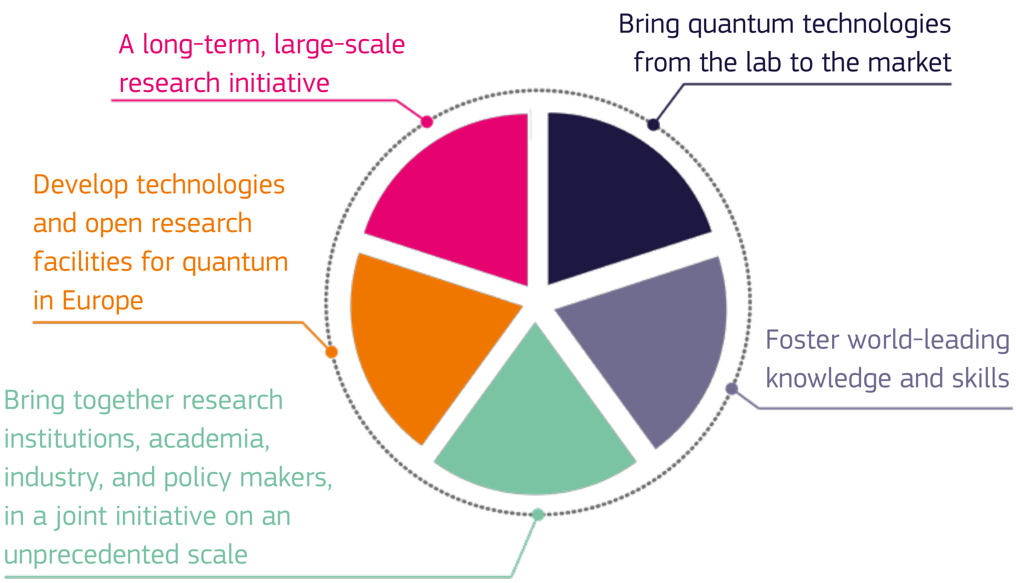
10 years

€1 billion

RAMP-UP PHASE 2018-2021

€152 million

20 EU-funded projects



The Goals of the Quantum Flagship

In order to consolidate Europe as a leader in Quantum Technologies, the goals of the flagship are the following:

1. Boost and drive a competitive European quantum industry to position Europe as a leader in the future global industrial landscape

2. Expand European scientific leadership and excellence in quantum research

3. Make Europe a dynamic and attractive region for innovative business and investments in quantum technologies

4. Benefit from advances in quantum technologies to provide better solutions to grand challenges in such fields as energy, health, security and the environment

The Quantum Flagship's activies will be pursued by...

- Creating a favourable ecosystem of innovation and business creation for quantum technologies.
- Coordinating public investments and strategies in Quantum Technologies at the European level.
- Creating a new generation of quantum technology professionals in Europe through focused education at the intersection of science, engineering and business, and by strengthening public awareness of key ideas and capabilities.
- Facilitating a new level of coordination between academia and industry to move advances in Quantum Technologies from the laboratory to industry.
- Supporting growth in scientific activities linked to Quantum Technologies.
- Promoting the involvement of member regions that do not currently have a strong quantum technologies research programme.

The Quantum Flagship Research Pillars

The first quantum revolution – understanding and applying physical laws in the microscopic realm – resulted in groundbreaking technologies such as the transistor, solid-state lighting and lasers, and GPS.

Today, our ability to use previously untapped quantum effects in customised systems and materials is paving the way for a **second revolution**.

With quantum theory now fully established, we are required to look at the world in a fundamentally new way: objects can be in different states at the same time (**superposition**) and can be deeply connected without any direct physical interaction (**entanglement**).

There are many transformative applications, varying from products with a relatively short time to market to revolutionary new technologies that may require more than a decade of research and development.

Quantum computers are expected to be able to solve, in a few minutes, problems that are unsolvable by classical supercomputers of today and tomorrow. This, in turn, will seed breakthroughs in the design of **chemical processes, new materials**, such as higher temperature superconductors, and new paradigms in machine learning and artificial intelligence. Based on **quantum coherence**, **data** can be **protected** in a **completely secure** way that makes eavesdropping impossible. Given the explosive growth of cybercrime and espionage, this is a highly strategic capability.

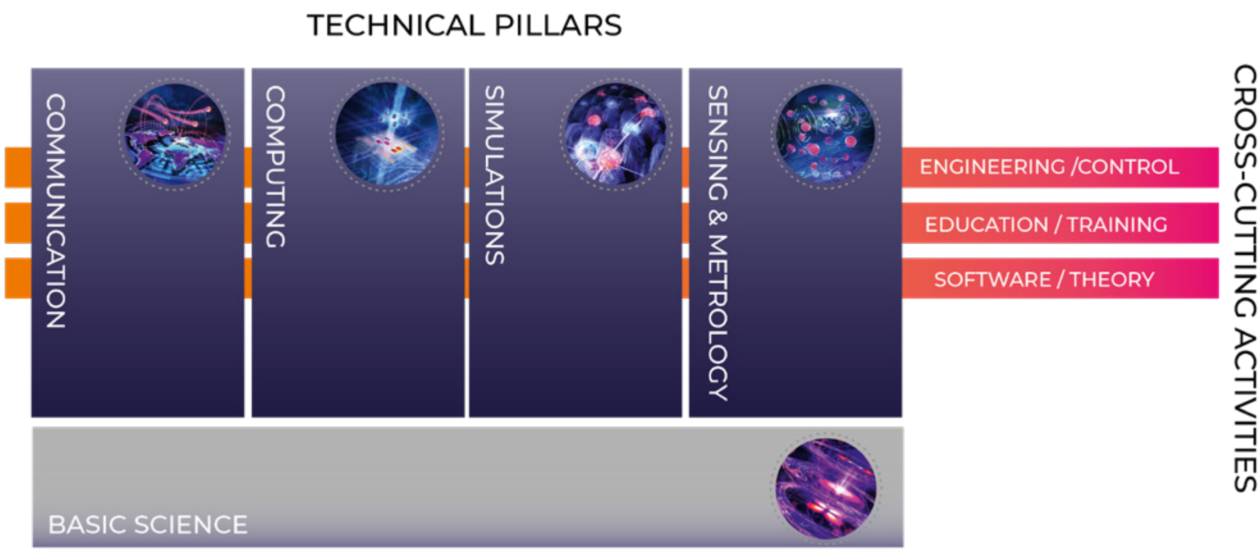
Quantum Technologies will also give rise to **simulation** techniques well beyond current capabilities for material and chemical synthesis, and to clocks and sensors with unprecedented sensitivity and accuracy, with potential impact in navigation, the synchronisation of future smart networks and medical diagnostics.

The developments in the leading areas of Quantum Technologies can be expected to produce transformative applications with real practical impact on ordinary people. Each of these areas has its own timeline.

New **quantum communication applications and quantum sensors** are expected to emerge in commercial markets in the near future, for instance, whereas **quantum computers** are still a long-term goal.

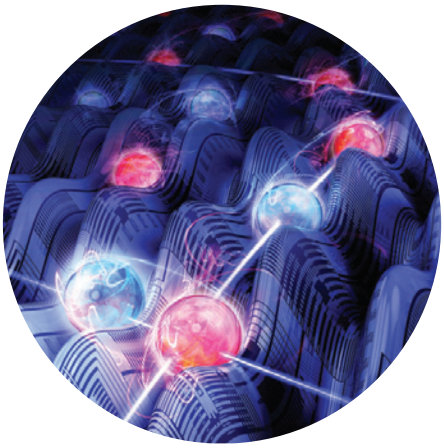
The five research pillars of the initiative are:

- **Quantum Communication**
- **Quantum Simulations**
- **Quantum Sensing and Metrology**
- **Quantum Computing**
- **Quantum Basic Science**



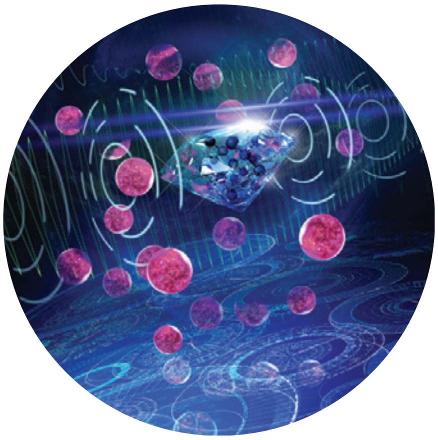
QUANTUM Communication

Quantum communication will help protect the increasing amounts of citizens' data transmitted digitally, for instance health records and financial transactions. A typical implementation of quantum networks uses single photons. If anything intercepts a single photon it will be noticed, meaning that with Quantum Technology we can achieve the most secure form of communication known, impossible to intercept without detection. For point-to-point communication, this is already on the market today and will be developed further into a quantum internet.



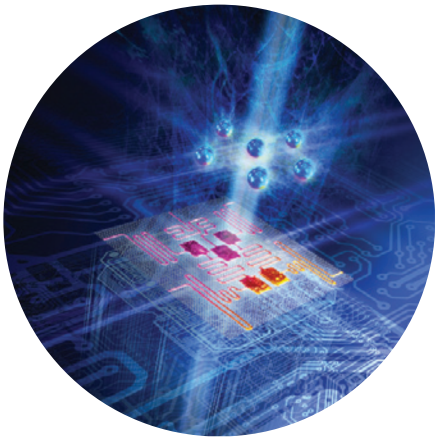
QUANTUM Simulations

Closely related to quantum computers are quantum simulators. They will be key to the design of new chemicals, from drugs to fertilisers for future medicine and agriculture, and of new materials, such as high-temperature superconductors for energy distribution without losses. Some quantum simulators are specialised quantum computers. Others imitate the idea of a wind tunnel: while there, small models are used to understand the aerodynamics of cars or planes, some quantum simulators use simple model quantum systems (such as an array of single atoms) to understand systems that would be even more difficult to experiment with.



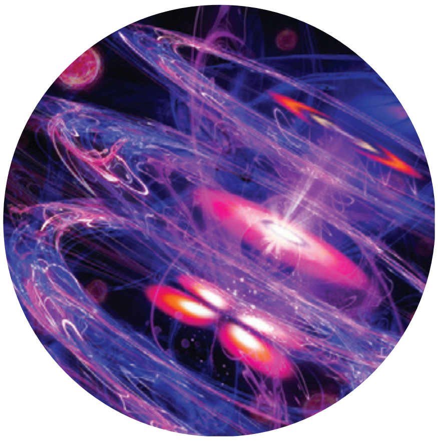
QUANTUM Sensing & Metrology

In addition to Quantum Communication, Quantum sensors will arguably be the basis for the first applications of Quantum Technologies. They provide the most accurate measurements and will drastically increase the performance of consumer devices and services, from medical diagnostics and imaging to high-precision navigation, to future applications in the Internet of Things. Quantum sensors use similar technologies as quantum computers and networks: they detect the tiniest disturbances because they are based on e.g., single electrons, the smallest possible charges and magnets. Quantum metrology uses quantum sensors to define the standards for, for instance, time-keeping or electrical measurements.



QUANTUM Computing

Quantum computers will have exponential running power compared to any classical computers to address problems that so far have not been achieved with classical computers. They are built from “quantum bits” (individual atoms, ions, photons or quantum electronic circuits) and exploit superposition and entanglement to solve problems we could never solve otherwise. That includes, for example, processing vast amounts of data faster than ever before to search databases, solve equations, and recognise patterns. They may even have the potential to train artificial intelligence systems, e.g. for digital assistants that help doctors to diagnose diseases and suggest the most promising therapy, or to optimise the routes of all cars in a city simultaneously to avoid traffic jams and reduce emissions.



QUANTUM Basic Science

The area of Basic Science covers the research and development of basic theories and components, addressing a foundational challenge of relevance for the development of quantum technologies in at least one of the four areas that have been mentioned previously (Quantum Communication, Quantum Simulations, Quantum Sensing and Metrology as well as Quantum Computing) to improve the performance of the components or subsystems targeted in those areas.

The Quantum Flagship Video

Youtube Quantum Flagship

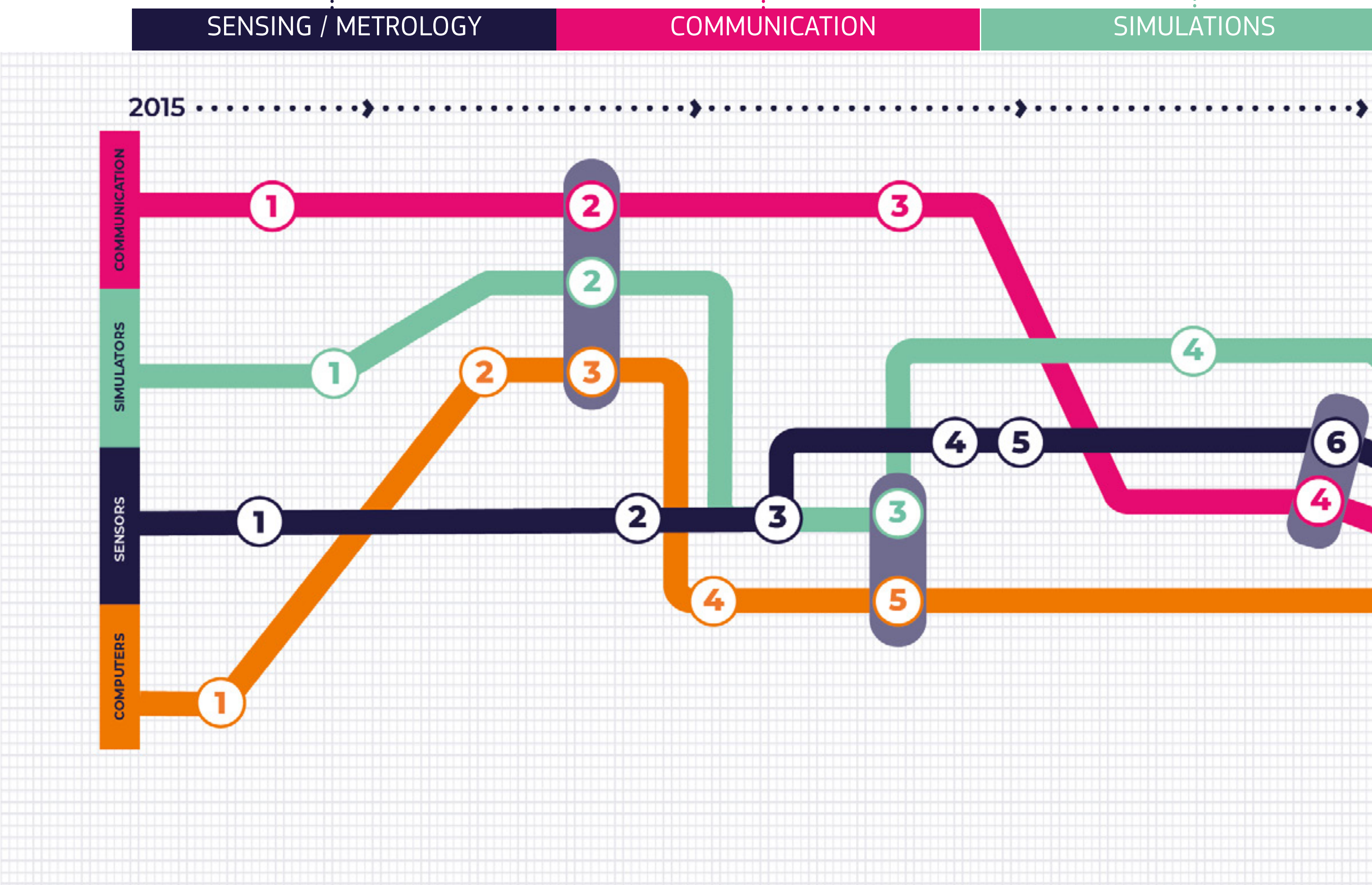
The Quantum Roadmap

Establishing the future of Quantum Technologies

The roadmap provides the major achievements and state-of-the-art accomplishments for the different research pillars of the quantum flagship.

Sensing / Metrology

1 → Quantum sensors for niche applications (health care, geosurvey, security...)
2 → More precise atomic clocks for synchronisation of future smart networks
3 → Quantum sensors for larger volume applications (automotive, construction...)
4 → Handheld quantum navigation devices
5 → Gravity imaging devices based on gravity sensors
6 → Integrate quantum sensors with consumer applications, including mobile devices

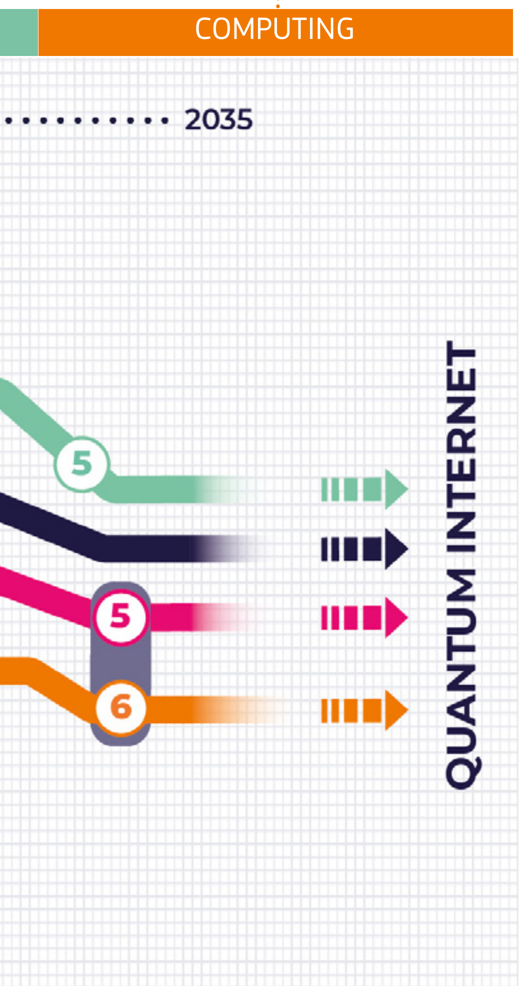


Communication

1 → Quantum repeaters and quantum memories
2 → Secure point-to-point quantum links
3 → Quantum networks between distant cities
4 → Quantum repeaters with cryptography and eavesdropping detection
5 → Secure Europe-wide internet merging quantum and classical communication

Simulation

1 → Simulator of motion of electrons in materials
2 → New algorithms for quantum simulators and networks
3 → Development and design of new complex materials
4 → Versatile simulator of quantum magnetism and electricity
5 → Simulators of quantum dynamics and chemical reaction mechanisms to support drug design



Computing

1 → Operation of a logical qubit protected by error correction or topologically [A qubit, or Quantum bit, is the basic unit of quantum computers]
2 → New algorithms for quantum computers
3 → Small quantum processors executing technologically relevant algorithms
4 → Solving chemistry and materials science problems with special purpose quantum computer > 100 physical qubits
5 → Integration of quantum circuit and cryogenic classical control hardware
6 → General purpose quantum computers exceed computational power of classical computers

20 Selected Projects
Ramp-up phase

QUANTUM Communication

4 projects

PROJECT: CiViQ
(Continuous Variable Quantum Communications)
Coordinating Institution:
ICFO - THE INSTITUTE OF PHOTONIC SCIENCES
Coordinator: Valerio Pruneri

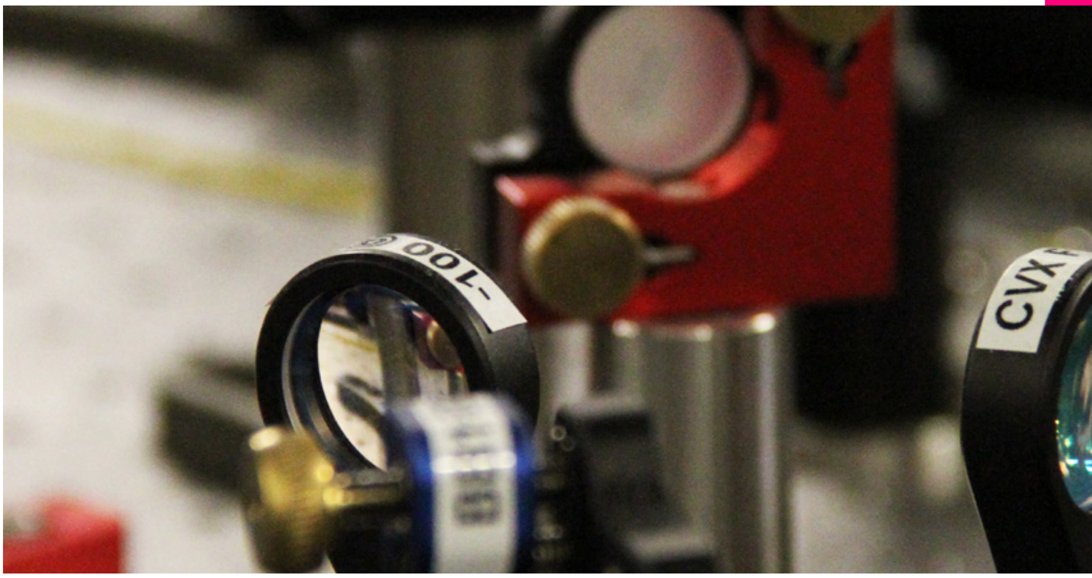
PROJECT: QIA
(Quantum Internet Alliance)
Coordinating Institution:
TECHNISCHE UNIVERSITEIT DELFT
Coordinator: Stephanie Wehner

PROJECT: QRANGE
(Quantum Random Number Generators: cheaper, faster and more secure)
Coordinating Institution:
UNIVERSITE DE GENEVE
Coordinator: Hugo Zbinden

PROJECT: UNIQORN
(Affordable Quantum Communication for Everyone: Revolutionizing the Quantum Ecosystem from Fabrication to Application)
Coordinating Institution:
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH
Coordinator: Hannes Hübel

PROJECT: CiViQ
(Continuous Variable Quantum Communications)
Coordinating Institution:
ICFO - THE INSTITUTE OF PHOTONIC SCIENCES
Coordinator: Valerio Pruneri

https://civiquantum.eu/



Spokesperson
Valerio Pruneri

Spoken Languages
English, Spanish, Italian

E-Mail
valerio.pruneri@icfo.eu

About the Project

The goal of the CiViQ project is to open a radically novel avenue towards flexible and cost-effective integration of quantum communication technologies, and in particular Continuous-Variable QKD, into emerging optical telecommunication networks.

CiViQ aims at a broad technological impact based on a systematic analysis of telecom-defined user-requirements. To this end CiViQ unites for the first time a broad interdisciplinary community of 21 partners with unique breadth of experience, involving major telecoms, integrators and developers of QKD. The work targets advancing both the QKD technology itself and the emerging “software network” approach to lay the foundations of future seamless integration of both. The technological advantage will more specifically aim to:

• Design architectures and implement protocol extensions of flexible “software based” networks for midterm country-wide QKD reach.

• Drive CV-QKD systems and components up to TRL 6, derive standardized set of interfaces, also allowing a network-aware software defined functionality and open modular development, and pursue cost reduction by seamless integration of off-the-shelf components.

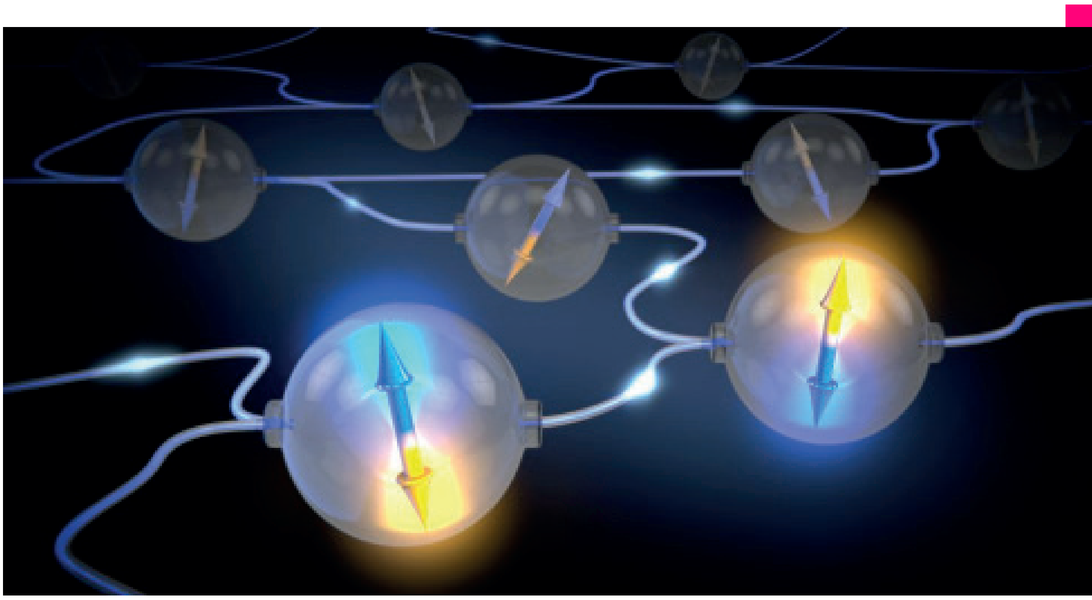
• Push CV-QKD performance boundary forward by developing high-performance photonic integrated circuits (PIC) for CV-QKD, i.e. opening the way for ultra-low cost systems, and improve further the CV-QKD hallmark coexistence capability with standard WDM channels, i.e. reducing dramatically the barriers to optical network co-integration.

• Prepare actively for next-generation networks by developing core enabling technologies and protocols aiming at quantum communication over global distances with minimal trust assumptions.

CiViQ will culminate in a validation in true telecom network environment. Project-specific network integration and software development work will empower QKD to be used as a physical-layer-anchor securing critical infrastructures, with demonstration in QKD-extended software-defined networks.

PROJECT: QIA
(Quantum Internet Alliance)
Coordinating Institution:
TECHNISCHE UNIVERSITEIT DELFT
Coordinator: Stephanie Wehner

http://quantum-internet.team/



Spokesperson
Stephanie Wehner

Spoken Languages
English, Dutch

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About the Project

The future Quantum Internet will provide radically new internet applications by enabling quantum communication between any two points on Earth. The Quantum Internet Alliance (QIA) targets a Blueprint for a pan-European Quantum Internet by ground-breaking technological advances, culminating in the first experimental demonstration of a fully integrated network stack running on a multi-node quantum network.

QIA will push the frontier of technology in both end nodes (trapped ion qubits, diamond NV qubits, neutral atom qubits) and quantum repeaters (rare-earth-based memories, atomic gases, quantum dots) and demonstrate the first integration of both subsystems. We will achieve entanglement and teleportation across three and four remote quantum network nodes, thereby making the leap from simple point-to-point connections to the first multi-node networks.

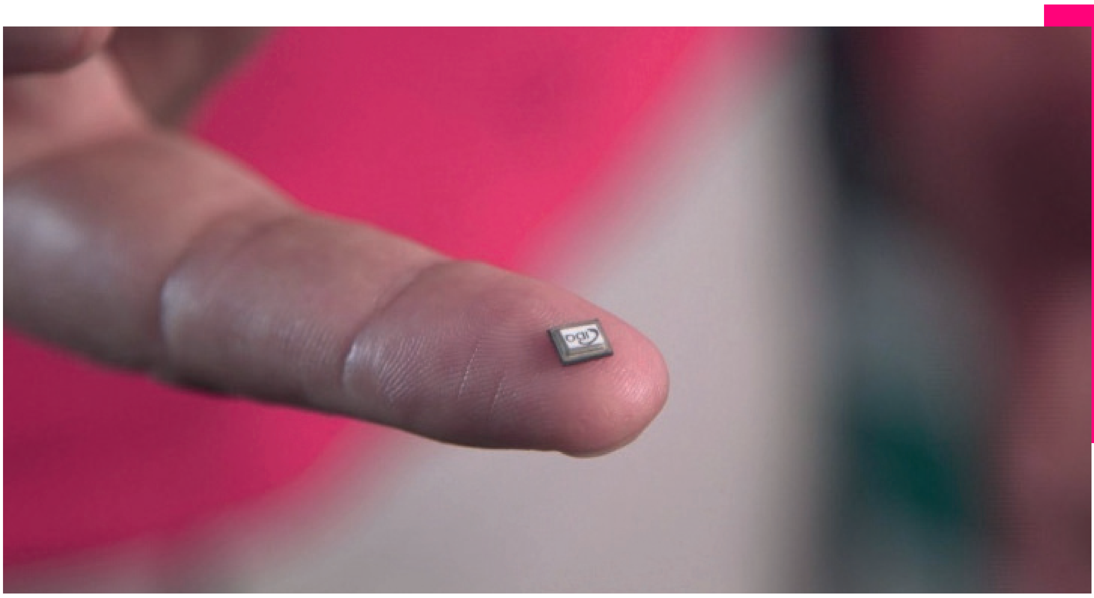
We will demonstrate the key enabling capabilities for memory-based quantum repeaters, resulting in proof-of-principle demonstrations of elementary long-distance repeater links in the real-world, including the longest such link worldwide.

Hand in hand with hardware development, we will realize a software stack that will provide fast, reactive control and allow arbitrary high-level applications to be realized in platform-independent software.

QIA's industry partners examine real world use cases of application protocols and their hardware requirements. We will validate the full stack on a small Quantum Internet by performing an elementary secure delegated quantum computation in the cloud. We will validate the design of the Blueprint architecture by a large-scale simulation of a pan-European Quantum Internet using real world fibre data. Through synergy of leading industrial, academic and RTO partners, QIA's Blueprint will provide a targeted roadmap for the main Flagship phase and set the stage for a world-leading European Quantum Internet industry.

PROJECT: QRANGE
(Quantum Random Number Generators: cheaper, faster and more secure)
Coordinating Institution:
UNIVERSITE DE GENEVE
Coordinator: Hugo Zbinden

https://qrange.eu/



Spokesperson
Hugo Zbinden

Spoken Languages
German, French, English

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About the Project

The generation of random numbers plays a crucial role in many applications in science and impacting society, in particular for simulation and cryptography. It is of fundamental importance that the generated numbers are truly random, as any deviation may adversely effect modelling or jeopardise security. Notably, recent breaches of cryptographic protocols have exploited weaknesses in the random number generation. In this context, schemes exploiting the inherent randomness of quantum physics have been extensively investigated.

Quantum random number generation (QRNG) devices are now commercially available, which arguably represents one of the most successful developments of quantum technologies so far. QRANGE wants to push the QRNG technology further, allowing for a wide range of commercial applications of QRNG.

We will build three different prototypes, which are cheaper, faster and more secure than existing devices:

i) A fully integrated low-cost QRNG based on standard CMOS technology with a cost of the order of 1€ for IoT.

ii) A high-speed phase-diffusion scheme based on the interference of laser pulses with random phase relationship featuring bit rates of up to 10Gb/s.

iii) Inspired by device independent schemes, a self-testing QRNG, which allows for a continuous estimation of the generated entropy, with few assumptions on the devices. Moreover, we will make considerable theoretical effort for modelling the devices, designing efficient randomness extractors and studying new semi device-independent concepts.

Last but not least, we will work together with the competent institutions towards a full certification scheme of QRNG devices compliant with the highest security standards. This project addresses many key points in the call and is well-aligned with the vision and objectives of the Quantum Technologies Flagship, especially in terms of taking quantum technologies from the laboratory to industry with concrete prototype applications and marketable products.

PROJECT: UNIQORN

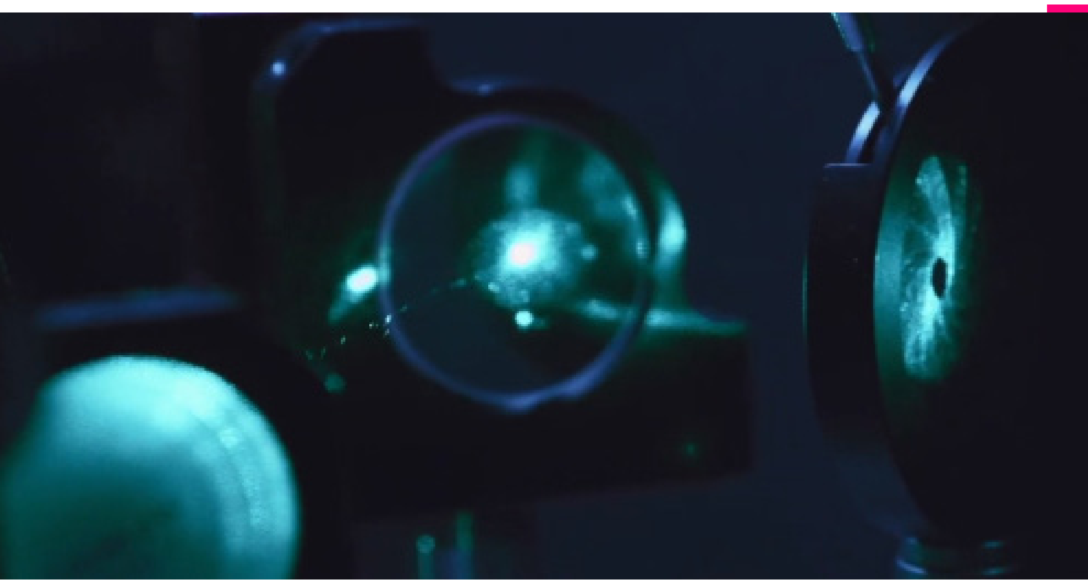
(Affordable Quantum Communication for Everyone: Revolutionizing the Quantum Ecosystem from Fabrication to Application)

Coordinating Institution:

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH

Coordinator: Hannes Hübel

https://quantum-uniqorn.eu/



Spokesperson
Hannes Hübel

Spoken Languages
German, English

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About the Project

Quantum Communication is recognised as one of the pillars for the second quantum revolution thanks to its unique potential for information-theoretical data security. Turning this promise into tangible assets depends however, on the availability of high-performance, compact and cost-effective modules for practical implementations.

UNIQORN is a well-orchestrated design and manufacturing framework aiming to advance the quantum communication technology for DV and CV systems by carefully laying out each element along the development chain from fabrication to application.

Component-wise, UNIQORN will leverage the monolithic integration potential of InP platform, the flexibility of polymer platform and low-cost assembly techniques to develop quantum system-on-chip modules in a cheap, scalable and reproducible way.

UNIQORN will deliver bright (10M pairs/s/mW/THz) heralded, entangled and squeezed light sources with 70-fold size reduction and almost 90% cost savings, room-temperature arrayed SPADs and a 10-GHz CV receiver with low-noise TIAs. Fully functional systems based on these assets will include:

(i) a network adapter card with integrated real-time QRNG engine,

(ii) the first DPS transmitter as pluggable SFP module for low-cost 1-kb/s QKD, and

(iii) novel oblivious transfer and quantum FPGA systems.

Network-integration and system evaluation in real fibre networks will be enabled by quantum-aware software defined networking and field trials in the live Smart-City demonstrator Bristol-is-Open. The power of the developed ecosystem will be also validated by pushing current QKD-centric work into higher grounds, and demonstrating one-time programs and secure database access through oblivious transfer.

The trans-disciplinary approach of UNIQORN brings together leading European players from quantum optics and photonics enabling to move from lab science to field deployment and bridge the quantum divide between large (governmental) and small (residential) end-users.

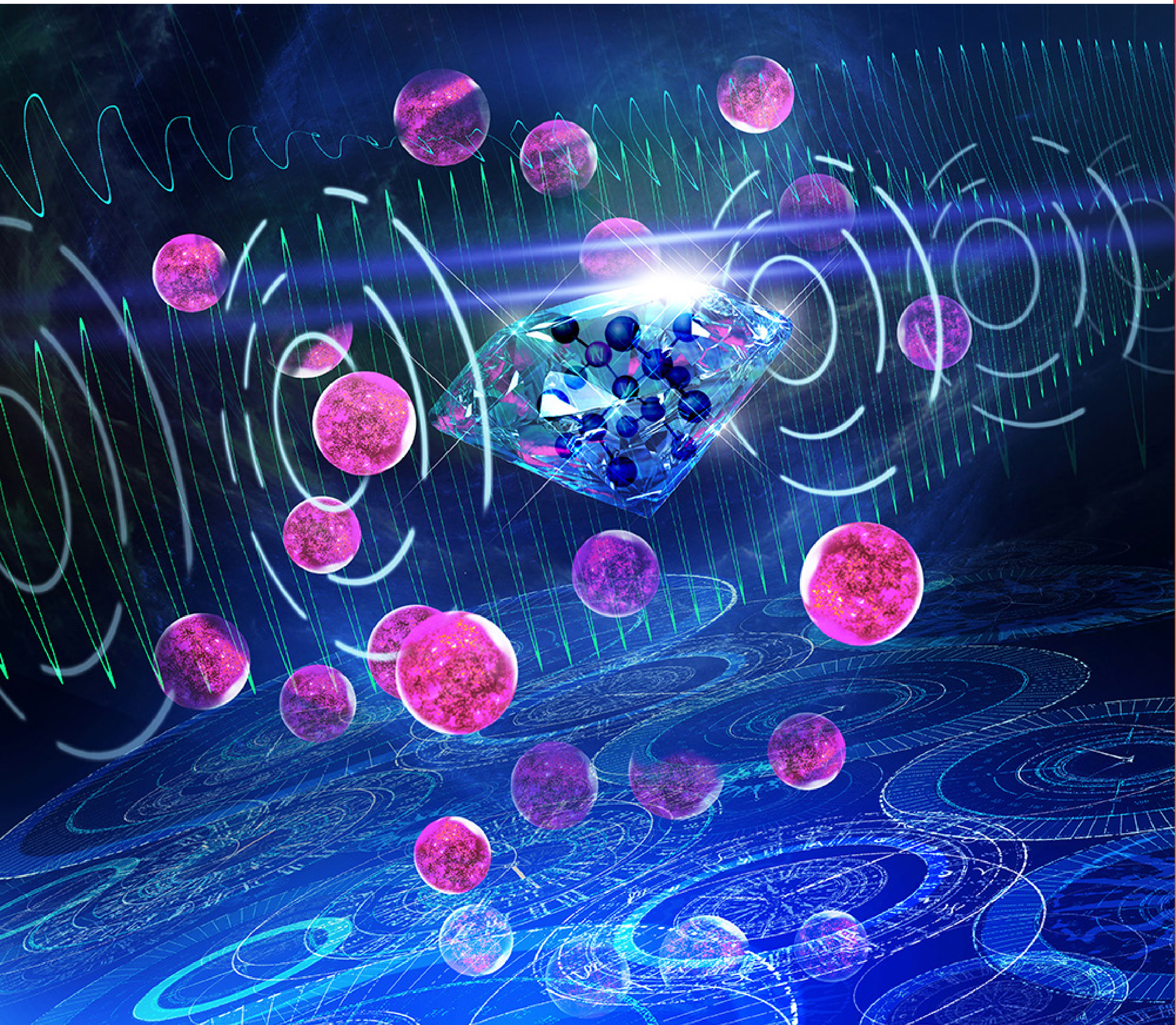
4 projects

PROJECT: **ASTERIQS**
(Advancing Science and TEchnology thRough dIamond Quantum Sensing)
Coordinating Institution:
THALES SA
Coordinator: Thierry Debuisschert

PROJECT: **iqClock**
(Integrated Quantum Clock)
Coordinating Institution:
UNIVERSITEIT VAN AMSTERDAM
Coordinator: Florian Schreck

PROJECT: **MetaboliQs**
(Leveraging room temperature diamond quantum dynamics to enable safe, first-of-its-kind, multimodal cardiac imaging)
Coordinating Institution:
FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.
Coordinator: Christoph Nebel

PROJECT: **macQsimal**
(Miniature Atomic vapor-Cells Quantum devices for SensIng and Metrology AppLications)
Coordinating Institution:
CSEM CENTRE SUISSE D'ELECTRONIQUE ET DE MICROTECHNIQUE SA - RECHERCHE ET DEVELOPPEMENT
Coordinator: Jacques Haesler



PROJECT: ASTERIQS
(Advancing Science and TEchnology thRough dIamond Quantum Sensing)
Coordinating Institution:
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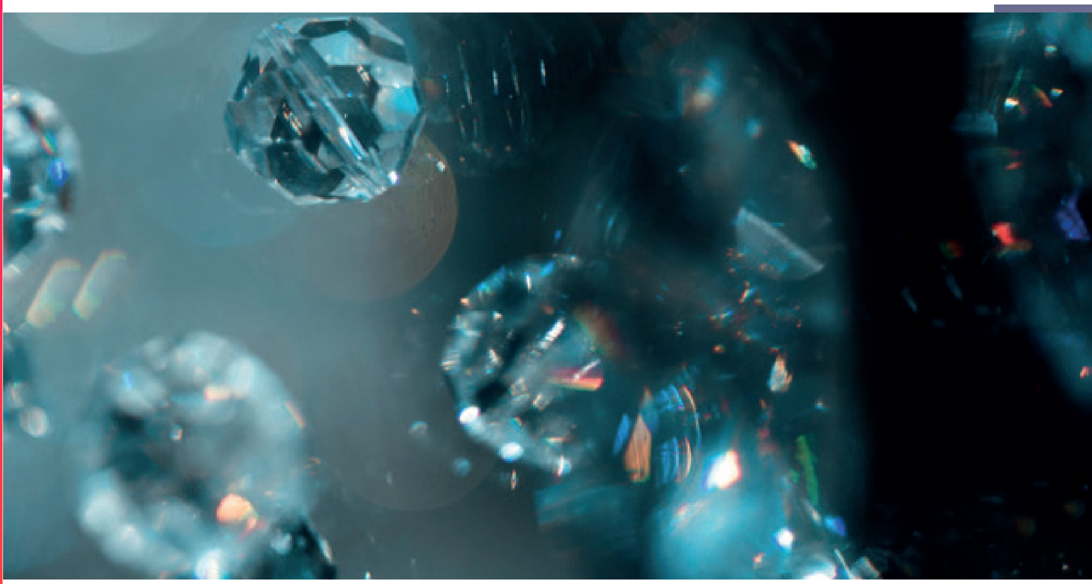
Coordinator: Thierry Debuisschert

https://www.asteriqs.eu/



Spokesperson
Thierry Debuisschert

Spoken Languages
French, English

E-Mail
thierry.debuisschert@thalesgroup.com

About the Project

ASTERIQS will exploit quantum sensing based on the NV centre in ultrapure diamond to bring solutions to societal and economical needs for which no solution exists yet. Its objectives are to develop:

1) Advanced applications based on magnetic field measurement: fully integrated scanning diamond magnetometer instrument for nanometer scale measurements, high dynamics range magnetic field sensor to control advanced batteries used in electrical car industry, lab-on-Chip Nuclear Magnetic Resonance (NMR) detector for early diagnosis of disease, magnetic field imaging camera for biology or robotics, instantaneous spectrum analyser for wireless communications management;

2) New sensing applications to sense temperature within a cell, to monitor new states of matter under high pressure, to sense electric field with ultimate sensitivity;

3) New measurement tools to elucidate the chemical structure of single molecules by NMR for pharmaceutical industry or the structure of spintronics devices at the nanoscale for new generation spin-based electronic devices.

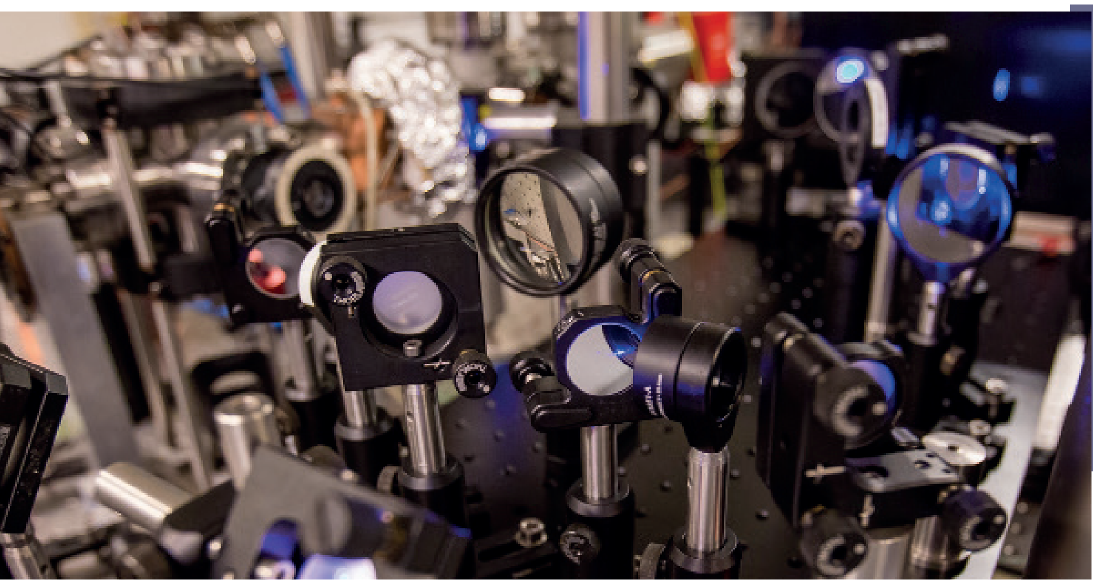
ASTERIQS will develop enabling tools to achieve these goals: highest grade diamond material with ultralow impurity level, advanced protocols to overcome residual noise in sensing schemes, optimized engineering for miniaturized and efficient devices.

ASTERIQS will disseminate its results towards academia and industry and educate next generation physicists and engineers. It will contribute to the strategic objectives of the Quantum Flagship to expand European leadership in quantum technologies, deliver scientific breakthroughs, make available European technological platforms and develop synergetic collaborations with them, and finally kick-start a competitive European quantum industry.

The ASTERIQS consortium federates world leading European academic and industrial partners to bring quantum sensing from the laboratory to applications for the benefit of European citizens.

PROJECT: iqClock
(Integrated Quantum Clock)
Coordinating Institution:
UNIVERSITEIT VAN AMSTERDAM
Coordinator: Florian Schreck

https://www.iqclock.eu/



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About the Project

Optical clocks are amazingly stable frequency standards, which would be off by only one second over the age of the universe. Bringing those clocks from the laboratory into a robust and compact form will have a large impact on telecommunication (e.g. network synchronization, traffic bandwidth, GPS free navigation), geology (e.g. underground exploration, monitoring of water tables or ice sheets), astronomy (e.g. low-frequency gravitational wave detection, radio telescope synchronization), and other fields. Likewise, techniques developed for robust clocks will improve laboratory clocks, potentially leading to physics beyond the standard model.

To make this a reality, we have founded the iqClock consortium, assembling leading experts from academia, strong industry partners, and relevant end users. We will seize on recent developments in clock concepts and technology to start-up a clock development pipeline along the TRL scale. Our consortium represents a nucleus for a European optical clock ecosystem, which will continuously deliver competitive products and foster the development of clock applications. Our first product prototype will be a field-ready strontium optical clock, which we will benchmark in real use cases, such as network synchronization (TRL 6).

This clock will be based on a modular concept, already with the next-generation clocks in mind, which our academic partners will realize (TRL 3-4). By their operation principle, these optical clocks are more robust than the current ones and have come into reach by recent breakthroughs, some of which achieved by our partners. We will leverage the foundational work by the consortia QuantERA Q-Clocks and JRP f17 USOQS, which have joined partners with us, and translate their work into a higher TRL. To increase our impact and to broaden our industry base, we will reach out to all stakeholders, train the next generation of quantum engineers, educate and listen to end users, and enrich the exchange of scientific ideas.

PROJECT: MetaboliQs

(Leveraging room temperature diamond quantum dynamics to enable safe, first-of-its-kind, multimodal cardiac imaging)

Coordinating Institution:

FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.

Coordinator: Christoph Nebel

http://www.metaboliqs.eu/

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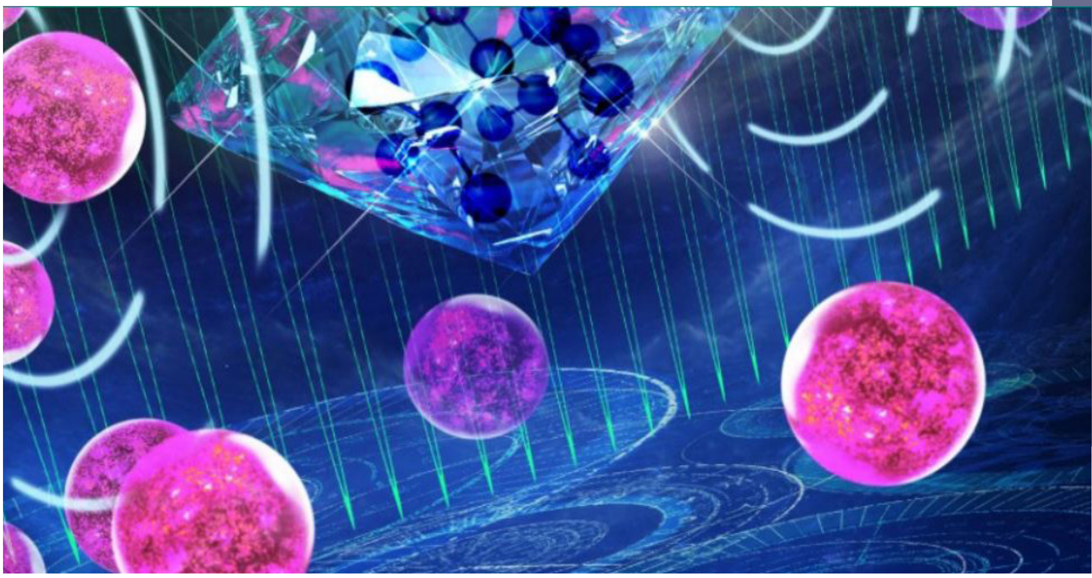

About the Project

Cardiovascular Diseases (CVDs) are the number 1 cause of death globally: more people die annually from CVDs than from any other cause. Despite emerging diagnostics tools and therapeutics, several areas of significant unmet need remain unaddressed among CVD patients.

The ability to personalize cardiovascular medical care and improve outcomes, will require characterization of disease processes at a molecular level. The current state-of-the-art, e.g., Positron emission tomography (PET), does not provide detailed information about the chemical state of the tissue at a molecular level, therefore it remains difficult to accurately diagnose and confidently select appropriate therapy in many circumstances.

The MetaboliQs project brings together two areas of European excellence - diamond-based quantum sensing and medical imaging. We will translate a newly developed hyperpolarization method for magnetic resonance imaging (MRI) based on the quantum dynamics of nitrogen-vacancy (NV) centers. This breakthrough quantum technology will enable previously unachievable, highly sensitive quantification of metabolic activity, paving the way for precision diagnostics and better personalized treatment of cardiovascular and other metabolic diseases.

For realizing and eventually commercializing the technology, MetaboliQs brings together a world-class multidisciplinary consortium with end to end expertise - leading diamond quantum technology research institutes (Fraunhofer IAF - quantum-grade diamond growth and fabrication, HUJI - quantum sensing) and innovative companies (Element 6 - worldwide leader in synthetic diamonds, NVision - inventor of diamond-based polarization), as well as two expert users of hyperpolarized and cardiovascular MRI (TUM, ETH Zurich - first in continental Europe to conduct clinical trials of hyperpolarized MRI for cardiovascular disease) and the market leader in electron paramagnetic resonance and preclinical MRI (Bruker).

PROJECT: **macQsimal**
(Miniature Atomic vapor-Cells Quantum devices for SensIng and Metrology AppLications)
Coordinating Institution:
CSEM CENTRE SUISSE D'ELECTRONIQUE ET DE MICROTECHNIQUE SA - RECHERCHE ET DEVELOPPEMENT
Coordinator: Jacques Haesler

https://www.macqsimal.eu/

Spokesperson
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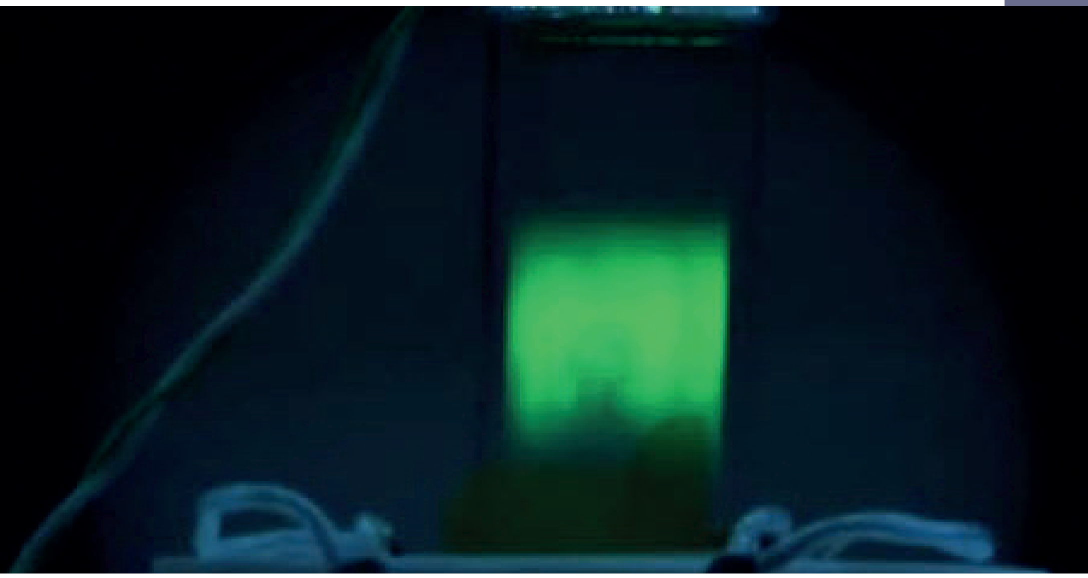


About the Project

Sensors provide the interface between the real world and the digital world. Quantum technologies are poised to revolutionize this interface, and with it sensor-driven industries such as navigation and medical imaging. MACQSIMAL combines the expertise of world-leading research groups, RTOs and companies, covering the whole knowledge chain from basic science to industrial deployment, and aims at breakthroughs that will firmly establish European leadership in the quantum sensor industry.

MACQSIMAL will develop quantum-enabled sensors with outstanding sensitivity for five key physical observables: magnetic fields, time, rotation, electro-magnetic radiation and gas concentration. These sensors are chosen for their high impact and their potential to quickly advance to a product: Within MACQSIMAL all these sensors will reach TRLs between 3 and 6 and will outperform other solutions in the respective markets.

The common core technology in these diverse sensors is atomic vapor cells realized as integrated microelectromechanical systems (MEMS). Atomic vapor cells make coherent quantum processes available to applications: advanced cell-based sensors optimally exploit single-particle coherence, with the potential to harness also multi-particle quantum coherence for still greater sensitivity. Fabricating such atomic vapor cells as MEMS allows for high-volume, high-reliability and low-cost deployment of miniaturized, integrated sensors, critical to wide-spread adoption.

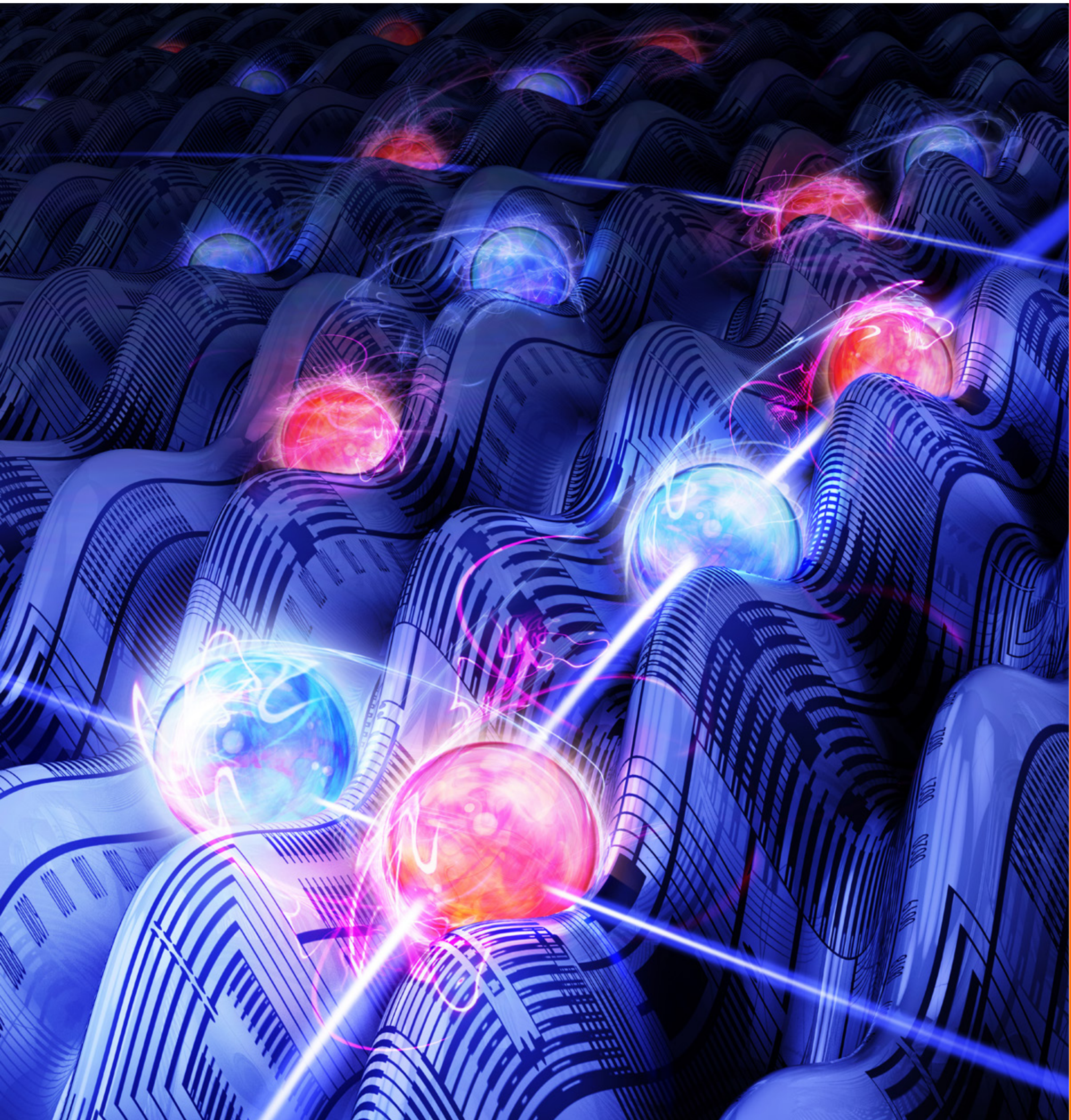
MACQSIMAL will combine state-of-the-art sensor physics with the MEMS atomic vapor cell platform, for highly advanced prototypes and demonstrators. Concurrently, advanced squeezing, entanglement and cavity-QED methods will be applied for the first time in miniaturized sensors, bringing quantum enhancement closer than ever to industrial application. This advanced, multi-target, quantum-enabled sensor platform will mark the start of a dynamic and multi-sector quantum sensor industry in Europe.

QUANTUM Simulations

2 projects

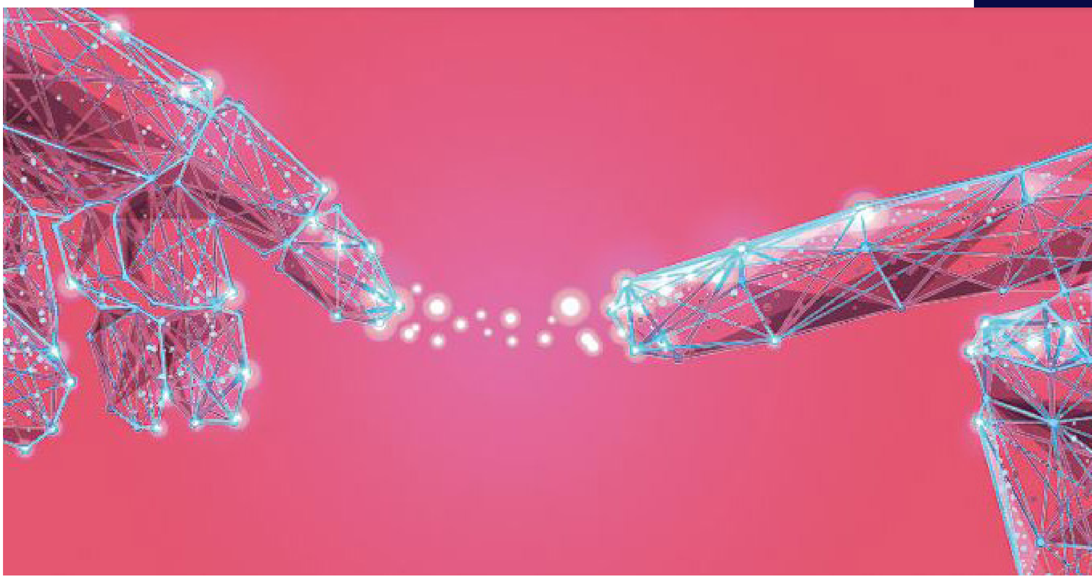
PROJECT: PASQuanS
(Programmable Atomic Large-Scale Quantum Simulation)
Coordinating Institution:
MAX-PLANCK-GESELLSCHAFT ZUR FORDERUNG DER WISSENSCHAFTEN EV
Coordinator: Immanuel Bloch

PROJECT: Qombs
(Quantum simulation and entanglement engineering in quantum cascade laser frequency combs)
Coordinating Institution:
CONSIGLIO NAZIONALE DELLE RICERCHE
Coordinator: Augusto Smerzi



PROJECT: PASQuanS
(Programmable Atomic Large-Scale Quantum Simulation)
Coordinating Institution:
MAX-PLANCK-GESELLSCHAFT ZUR FORDERUNG DER WISSENSCHAFTEN EV
Coordinator: Immanuel Bloch

https://pasquans.eu/



Spokesperson
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About the Project

PASQuanS will perform a decisive transformative step for quantum simulation towards programmable analogue simulators addressing questions in fundamental science, materials development, quantum chemistry and real-world problems of high importance in industry. PASQuanS builds on the impressive achievements of the most advanced quantum simulation platforms, based on atoms and ions.

The neutral-atom simulators handle more than 50 cold atoms in optical lattices or arrays of optical tweezers, interacting via either collisional or Rydberg-state-mediated interactions. The ion-trap platform reaches unsurpassed control with up to 20 ions. By scaling up these platforms towards >1000 atoms/ions, by improving control methods and making these simulators fully programmable, PASQuanS will push these already well-advanced platforms far beyond both the state-of-the-art and the reach of classical computation. Full programmability will make it possible to address quantum annealing or optimization problems much sooner than digital quantum computation.

PASQuanS will demonstrate a quantum advantage for non-trivial problems, paving the way towards practical and industrial applications.

PASQuanS tightly unites five experimental groups with complementary methods to achieve the technological goals, connected with six theoretical teams focusing on certification, control techniques and applications of the programmable platforms, and five industrial partners in charge of the key developments of enabling technologies and possible commercial spin-offs of the project.

PASQuanS will result in modular building blocks for a future generation of quantum simulators. Possible end-users of these simulators, major industrial actors, are tightly associated with the consortium. In a cross-fertilization process, they will be engaged in a dialogue on quantum simulation, and help to identify and implement key applications where quantum simulation provides a competitive advantage.

PROJECT: Qombs
(Quantum simulation and entanglement engineering in quantum cascade laser frequency combs)
Coordinating Institution:
CONSIGLIO NAZIONALE DELLE RICERCHE
Coordinator: Augusto Smerzi

https://www.qombs-project.eu/index.php/Home

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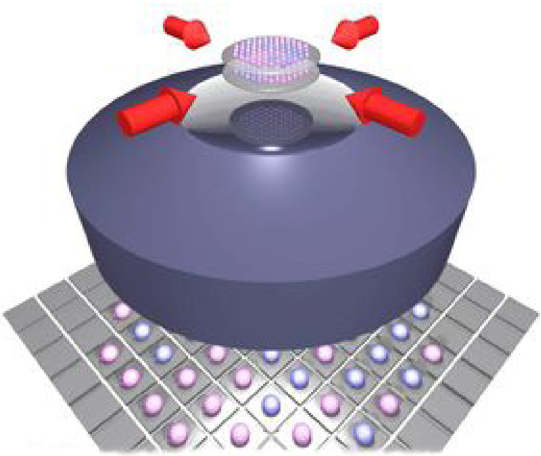


About the Project

The Qombs project aims to create a quantum simulator platform made of ultracold atoms in optical lattices. The quantum platform will allow to design and engineer a new generation of quantum cascade laser frequency combs. This unprecedented quantum simulation of semiconductor structures will endow the devices with brand new features, like non-classical emission modes, entanglement among the modes of the comb and parametric generation of comb patterns far from the central emission frequency. In parallel, the quantum simulation will allow to improve present-day performances of quantum cascade lasers (QCLs) and quantum well structures for photon detection. Full quantum simulation will be followed by real manufacturing and state-of-the-art characterization.

The consortium gathers Research Institutions that have a leading expertise in the physics of ultracold atoms, quantum optics and have first introduced and developed frequency comb synthesizers and quantum well structures during the last 20 years. Moreover, half of the ten partners of the Project are companies of different size that are already leading the QCL and frequency comb market. This unique combination will allow to rapidly move from the fundamental quantum simulation protocols to prototypes and eventually to the industrial production and commercialization of the new devices.

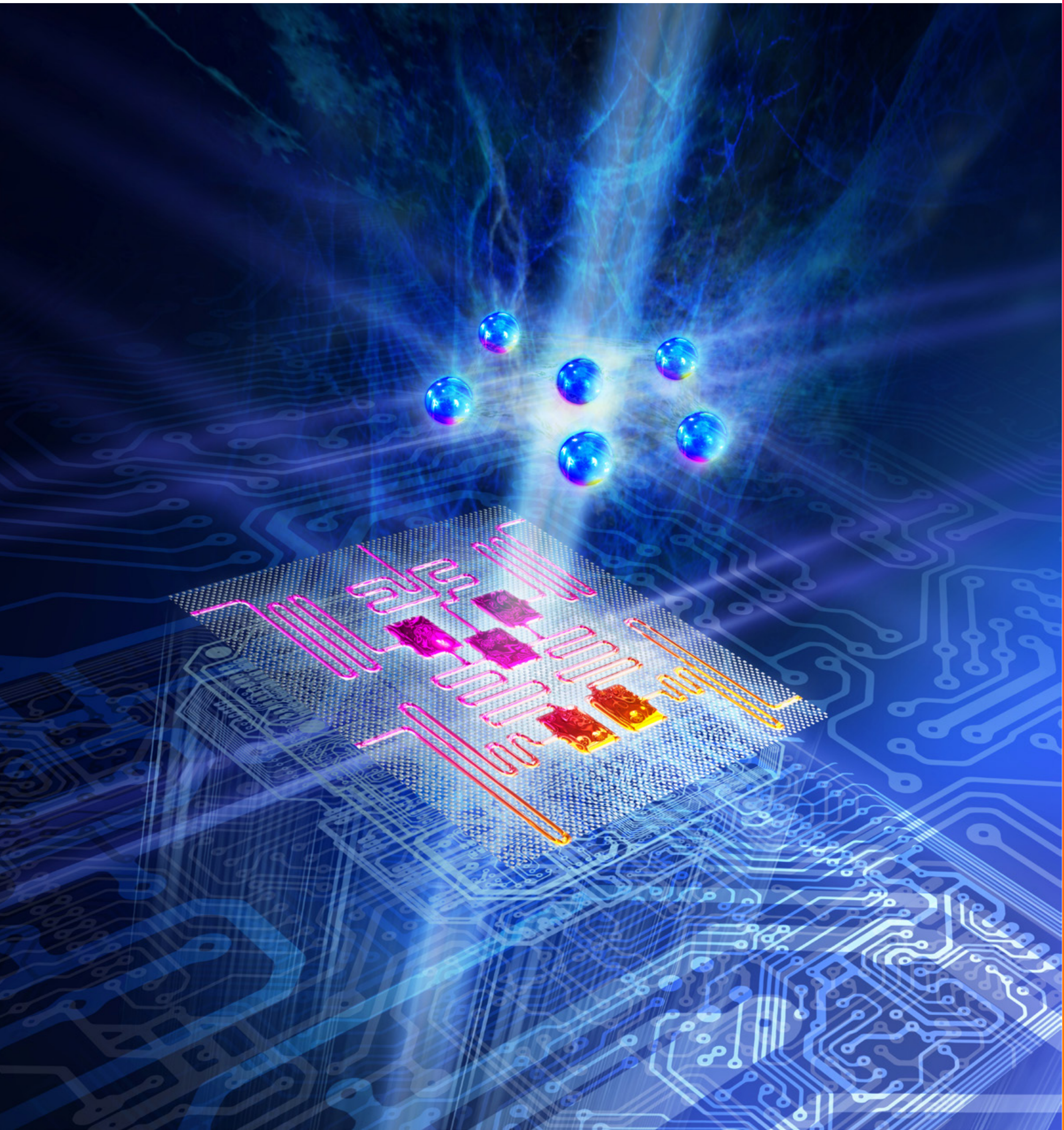
The long term vision of the Qombs consortium is to create a strong and world-wide leading European quantum industry on quantum cascade laser frequency combs tightly and strategically connected to the academic world.

QUANTUM Computing

2 projects

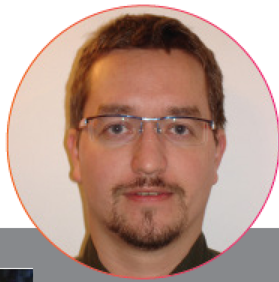
PROJECT: AQTION
(Advanced quantum computing with trapped ions)
Coordinating Institution:
UNIVERSITAET INNSBRUCK
Coordinator: Thomas Monz

PROJECT: OpenSuperQ
(An Open Superconducting Quantum Computer)
Coordinating Institution:
UNIVERSITAT DES SAARLANDES
Coordinator: Frank Wilhelm-Mauch



PROJECT: AQTION
(Advanced quantum computing with trapped ions)
Coordinating Institution:
UNIVERSITAET INNSBRUCK
Coordinator: Thomas Monz

https://www.aqtion.eu/



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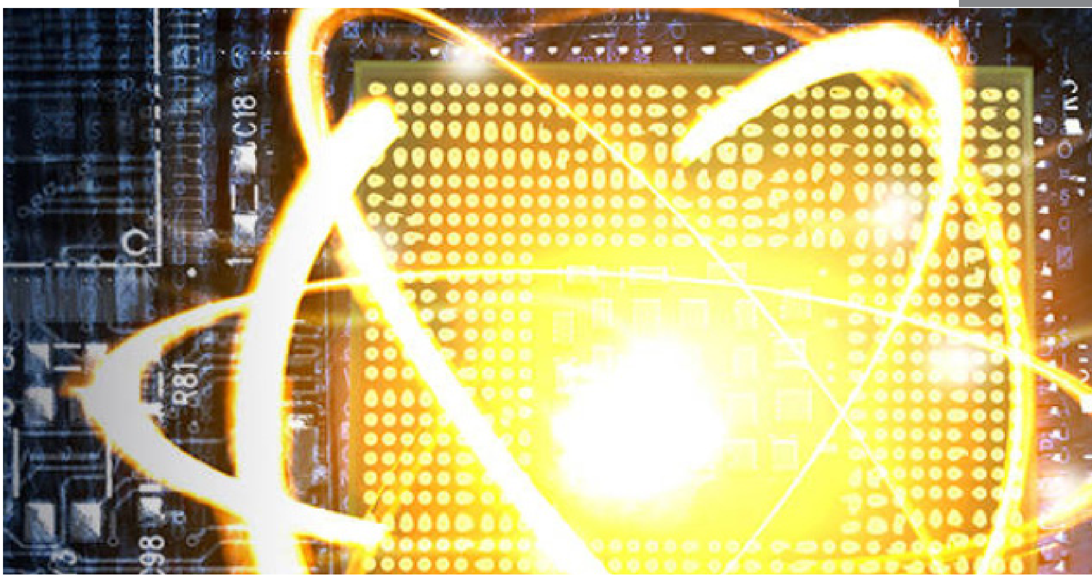


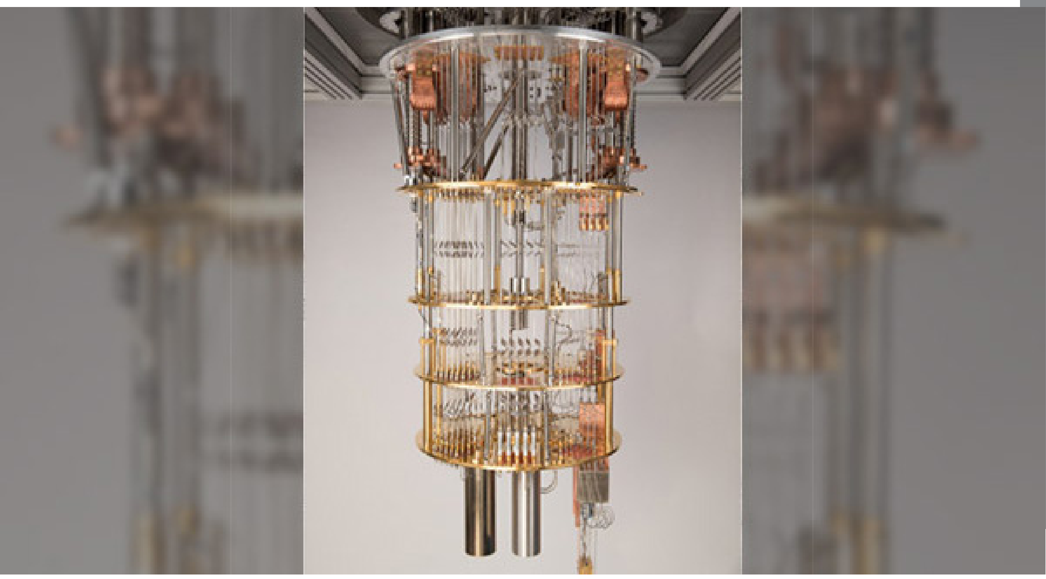
About the Project

This project focuses on scalability, availability, and applicability aspects of trapped-ion quantum computers, tackling the transition from current laboratory-based experiments to industry-grade quantum computing technologies. This project will provide the technological framework for quantum computers to solve real-world problems inaccessible to current classical computers.

Taking advantage of the unrivalled low error rates of operations available in trapped-ion quantum processors today, we will develop a fully connected 50-qubit device, allowing the implementation of calculations that are out of the reach of classical computers. The system will enable straightforward high-level user access via a robust hardware and software stack, allowing remote execution of complex algorithms without hardware-specific knowledge. We will pave the way to large-scale and fault-tolerant quantum computing by introducing long-range connectivity via ion-shuttling between sub-processors and by establishing remote operations between quantum processors using photonic interconnects. These scalable techniques will make systems exceeding thousands of qubits possible, in combination with error correction and entanglement purification techniques. Within this project, we will combine these quantum information techniques with trap fabrication and packaging technologies which integrate optical and electronic components to achieve stable long-term operation in an industrial environment. These scientific and technological advances will provide a powerful platform to demonstrate trapped-ion quantum computers capable of solving problems of major commercial importance including computational problems in chemistry and machine learning.

PROJECT: OpenSuperQ
(An Open Superconducting Quantum Computer)
Coordinating Institution:
UNIVERSITAT DES SAARLANDES
Coordinator: Frank Wilhelm-Mauch

http://opensuperq.eu/



Spokesperson
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Photo credit: @Thorsten_ Mohr

About the Project

OpenSuperQ aims at developing a full-stack quantum computing system of up to 100 qubits and to sustainably make it available at a central site for external users. This system will be applied to tasks of quantum simulation in quantum chemistry which serve as a high-level benchmark, and to problems related to optimization and machine learning. The core of the system will be a processor of superconducting qubits of the planar transmon type, with a square 2D layout and nearest-neighbour connectivity. The processor will be packaged with a control chip and integrated in a custom-made cryogenic system.

This quantum computing system will be equipped with integrated control soft- and hardware ready for applications. The computer will be among the leading platforms in the world, and the first of its kind in Europe. A distinguishing and globally unique feature of OpenSuperQ is its open approach ready to serve a large community of users of the system as well as of underlying technologies.

The OpenSuperQ consortium works in a collaborative way with broad distribution of tasks and brings together theoretical and experimental teams, a central site including a high-performance computing centre, and technology companies. It is supported by an advisory board, a basic science group, and a user board. This broad approach will lead to near-term exploitation, multi-level communication and will develop interfaces and standards made available to the quantum technology community at large.

QUANTUM Basic Science

7 projects

PROJECT: **S2QUIP**
(Scalable Two-Dimensional Quantum Integrated Photonics)
Coordinating Institution:
KUNGLIGA TEKNISKA HOEGSKOLAN
Coordinator: Klaus Jöns

PROJECT: **2D-SIPC**
(Two-dimensional quantum materials and devices for scalable integrated photonic circuits)
Coordinating Institution:
ICFO - THE INSTITUTE OF PHOTONIC SCIENCES
Coordinator: Dmitri Efetov

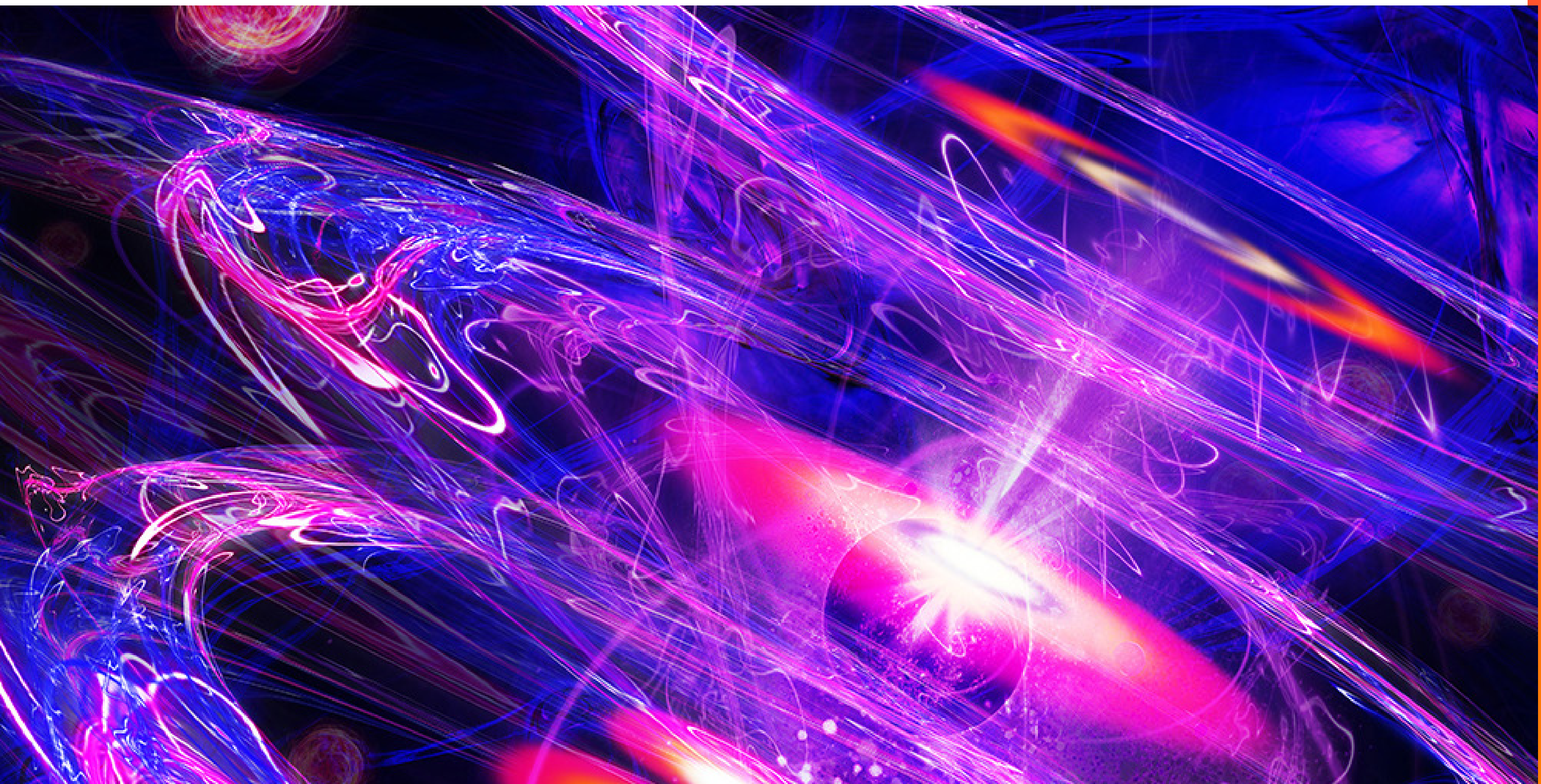
PROJECT: **QMiCS**
(Quantum Microwave Communcation and Sensing)
Coordinating Institution:
BAYERISCHE AKADEMIE DER WISSENSCHAFTEN
Coordinator: Frank Deppe

PROJECT: **SQUARE**
(Scalable Rare Earth Ion Quantum Computing Nodes)
Coordinating Institution:
KARLSRUHER INSTITUT FUER TECHNOLOGIE
Coordinator: David Hunger

PROJECT: **PhoG**
(Sub-Poissonian Photon Gun by Coherent Diffusive Photonics)
Coordinating Institution:
THE UNIVERSITY COURT OF THE UNIVERSITY OF ST ANDREWS
Coordinator: Natalia Korolkova

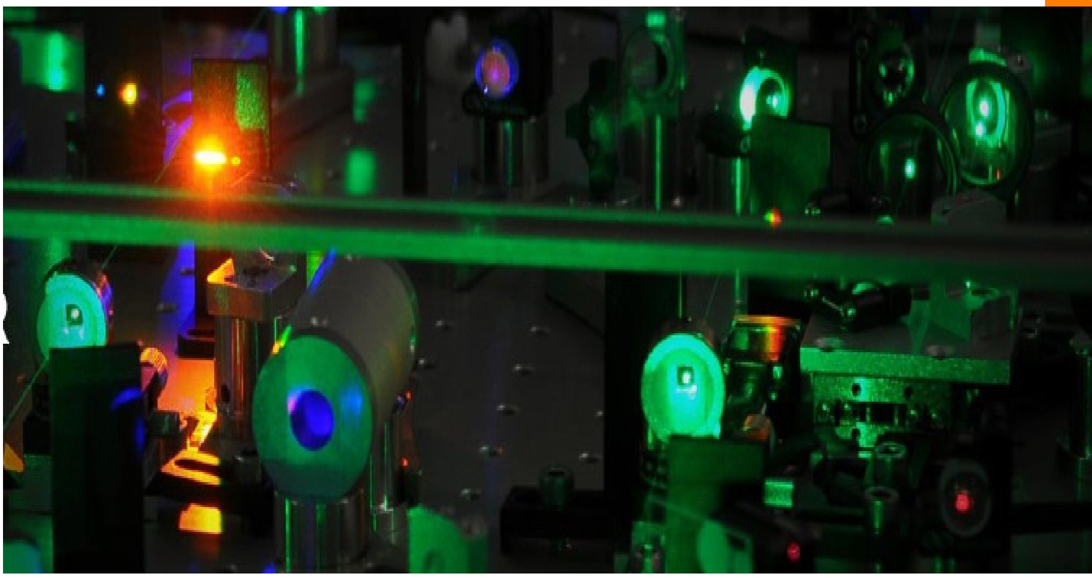
PROJECT: **PhoQuS**
(Photons for Quantum Simulation)
Coordinating Institution:
SORBONNE UNIVERSITE
Coordinator: Alberto Bramati

PROJECT: **MicroQC**
(Microwave driven ion trap quantum computing)
Coordinating Institution:
FOUNDATION FOR THEORETICAL AND COMPUTATIONAL PHYSICS AND ASTROPHYSICS
Coordinator: Nikolay Vitanov



PROJECT: **S2QUIP**
(Scalable Two-Dimensional Quantum Integrated Photonics)
Coordinating Institution:
KUNGLIGA TEKNISKA HOEGSKOLAN
Coordinator: Klaus Jöns

https://s2quip.eu/



Spokesperson
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About the Project

S2QUIP will introduce a paradigm shift in the development of scalable cost-effective integrated-chip quantum light sources. Scalable quantum light sources are of significant importance for the future quantum photonics technology applications.

Current technologies still lack on-chip scalability due to the cumbersome integration of quantum light sources (e.g. quantum dots or crystal defects) that require a high-quality bulk matrix environment to operate.

Here, S2QUIP aims to utilize atomically flat two-dimensional (2D) layered semiconductors to provide maximum flexibility for incorporation of quantum light sources into scalable photonic chip architectures using surface processing instead of bulk processing.

Single and entangled photons will be deterministically generated using 2D semiconductors and efficiently coupled to on-chip cavities and multiplexed using integrated waveguides, switches, and beam-splitters.

This approach will allow the demonstration of useful entangled photon states in a deterministic and scalable fashion that far surpasses the state-of-the-art using bulk semiconductors and optics. S2QUIP's ambitious goal is to achieve 20 multiplexed quantum light sources that can fulfil the long-awaited expectation of scalable on-chip quantum light sources for numerous quantum technologies (e.g., large-scale quantum computation, communication and sensing).

PROJECT: 2D-SIPC

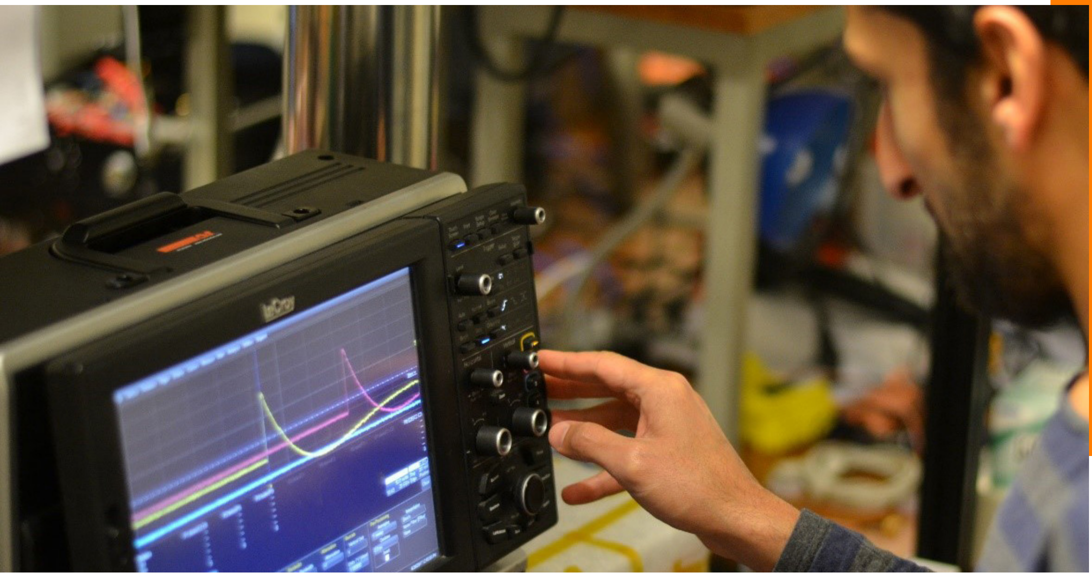
(Two-dimensional quantum materials and devices for scalable integrated photonic circuits)

Coordinating Institution:

ICFO - THE INSTITUTE OF PHOTONIC SCIENCES

Coordinator: Dmitri Efetov

http://2d-sipc.eu/



Spokesperson
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About the Project

The proposed project aims at developing scalable quantum networks, based on photonic chip integration of novel 2D material quantum devices, with the main goal to demonstrate all-optical on-chip quantum processing. The recent demonstration of effortless integration of 2D materials onto photonics and CMOS platforms will result in a breakthrough in the development of on-chip quantum networks.

2D-SIPC will take full advantage of the huge variety of 2D materials and heterostructures and prototype novel quantum devices with revolutionary functionalities. In particular, we will develop electrically driven and entangled single photon emitters, broadband and high temperature single photon detectors, ultra-fast waveguide integrated optical modulators and non-linear gates. To pave the way to scalable networks, 2D-SIPC will develop large scale growth techniques of the most promising 2D materials. With this unique combination of features 2D-SIPC will allow the first demonstration of on-chip optical quantum processing, a key milestone for many quantum network concepts, such as extended secure quantum communication, scaling up of quantum computers and simulators, and novel quantum sensing applications with entangled photons. In particular, as these topics cover all four Quantum Technology pillars of the Quantum Flagship, our proposal makes a strong strategic link to each one of them.

Beyond the 2D-SIPC platform, each developed component will be exploited in such distant fields as biological and medical imaging, radio-astronomy and environmental monitoring. The 2D-SIPC consortium includes four academic and one industrial partner with a high degree of complementarity that are at the forefronts of their fields, including single photon detection (ICFO), theory and fabrication of 2D materials and their heterostructures (UNIMAN), single photon emission (UCAM), chip based photonic circuits (CNIT) and commercial single photon detection, single photon emission and packaging (SQ).

PROJECT: QMiCS
(Quantum Microwave Communcation and Sensing)
Coordinating Institution:
BAYERISCHE AKADEMIE DER WISSENSCHAFTEN
Coordinator: Frank Deppe

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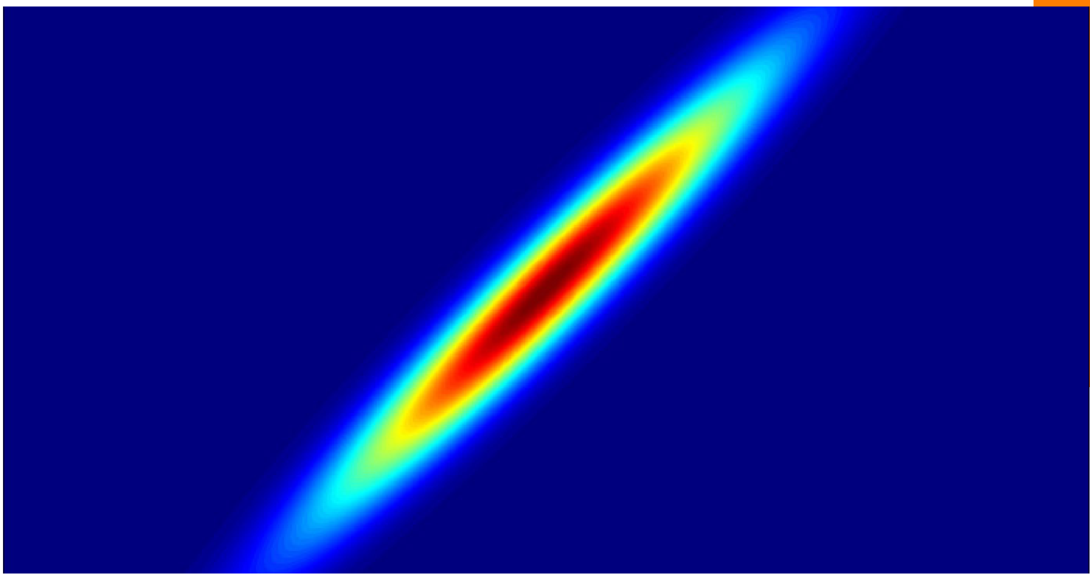

About the Project

The mission of QMiCS is to combine European expertise and lead the efforts in developing novel components, experimental techniques, and theory models building on the quantum properties of continuous-variable propagating microwaves. QMiCS' long-term visions are

(i) distributed quantum computing & communication via microwave quantum local area networks (QLANs) and

(ii) sensing applications based on the illumination of an object with quantum microwaves (quantum radar).

With respect to key quantum computing platforms (superconducting circuits, NV centres, quantum dots), microwaves intrinsically allow for zero frequency conversion loss since they are the natural frequency scale. They can be distributed via superconducting cables with surprisingly little losses, eventually allowing for quantum communication and cryptography applications. Radar works at gigahertz frequencies because of the atmospheric transparency windows anyways. Scientifically, QMiCS targets a QLAN demonstration via quantum teleportation, a quantum advantage in microwave illumination, and a roadmap to real-life applications for the second/third phase of the QT Flagship. Beneath these three grand goals lies a strong component of disruptive enabling technology provided by two full and one external industry partner: the development of a microwave QLAN cable connecting the millikevin stages of two dilution refrigerators, improved cryogenic semiconductor amplifiers, and packaged pre-quantum ultrasensitive microwave detectors.

The resulting ""enabling"" commercial products are beneficial for quantum technologies at microwave frequencies in general. Finally, QMiCS fosters awareness in industry about the revolutionary business potential of quantum microwave technologies, especially via the advisory third parties "Airbus Defence and Space Ltd" and "Cisco Systems GmbH". In this way, QMiCS helps placing Europe at the forefront of the second quantum revolution and kick-starting a competitive European quantum industry.

PROJECT: SQUARE
(Scalable Rare Earth Ion Quantum Computing Nodes)
Coordinating Institution:
KARLSRUHER INSTITUT FUER TECHNOLOGIE
Coordinator: David Hunger

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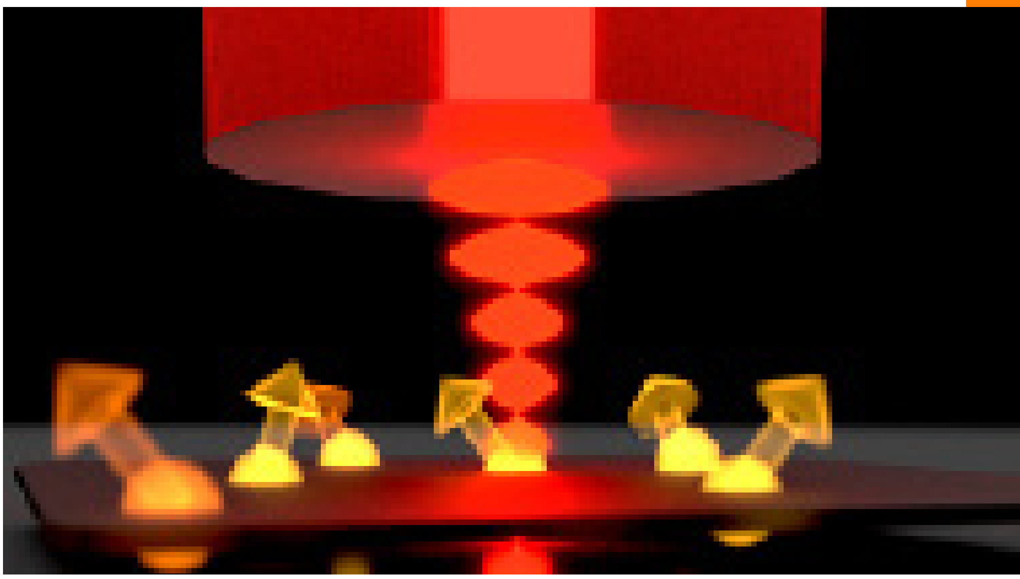


About the Project

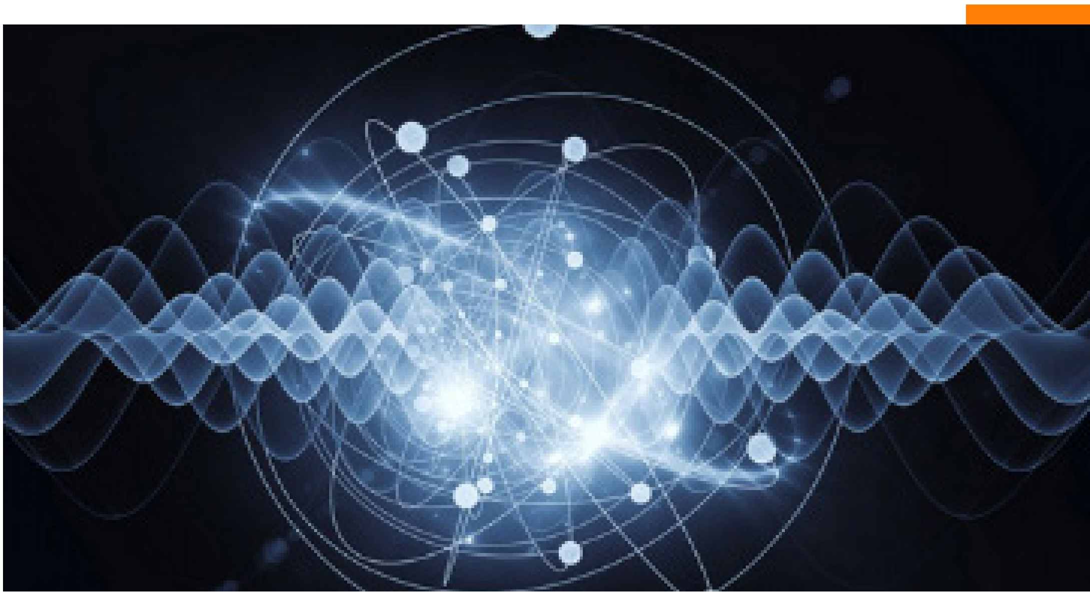
Quantum technologies rely on materials that offer the central resource of quantum coherence, that allow one to control this resource, and that provide suitable interactions to create entanglement. Rare earth ions (REI) doped into solids have an outstanding potential in this context and could serve as a scalable, multi-functional quantum material. REI provide a unique physical system enabling a quantum register with a large number of qubits, strong dipolar interactions between the qubits allowing fast quantum gates, and coupling to optical photons – including telecom wavelengths – opening the door to connect quantum processors in a quantum network.

This project aims at establishing individually addressable rare earth ions as a fundamental building block of a quantum computer, and to overcome the main roadblocks on the way towards scalable quantum hardware.

The goal is to realize the basic elements of a multifunctional quantum processor node, where multiple qubits can be used for quantum storage, quantum gates, and for coherent spin-photon quantum state mapping. Novel schemes and protocols targeting a scalable architecture will be developed. The central photonic elements that enable efficient single ion addressing will be engineered into deployable technologies.

PROJECT: **PhoG**
(Sub-Poissonian Photon Gun by Coherent Diffusive Photonics)
Coordinating Institution:
THE UNIVERSITY COURT OF THE UNIVERSITY OF ST ANDREWS
Coordinator: Natalia Korolkova

https://www.st-andrews.ac.uk/~phog/



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About the Project

The goal of the project is to deliver deterministic compact sources of highly non-classical states, from sub-Poissonian light to multi-mode entanglement, all utilizing a solitary technological platform.

The project will build their working prototypes and develop the technology foundation for applications of these sources in an advanced optical imaging and metrology. The proposed sources will be based on a novel paradigm in photonic devices: diffusive coherent photonics operating with dissipatively coupled photonic circuits.

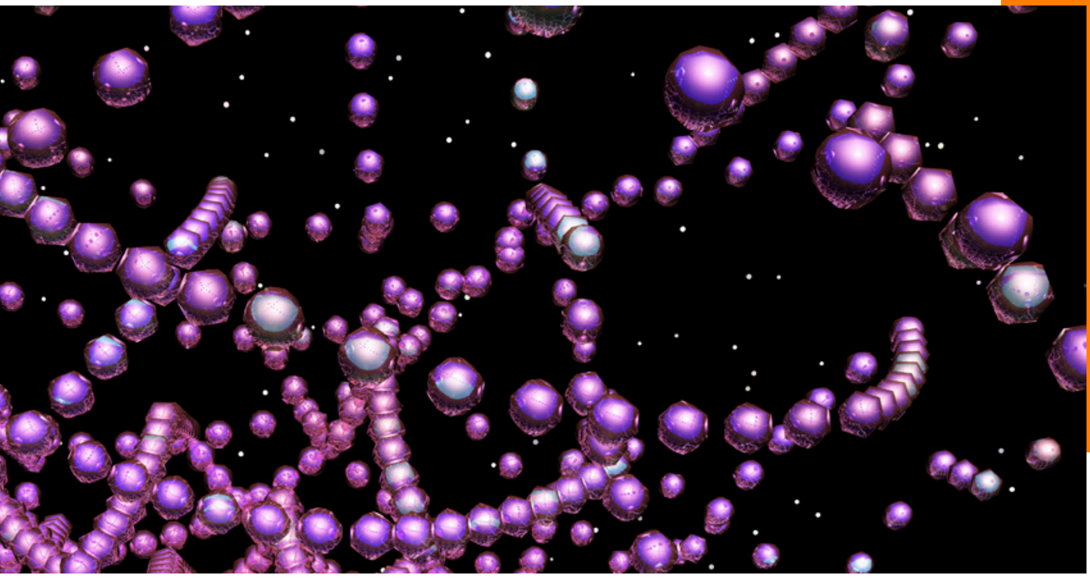
The project will demonstrate that light can flow diffusively retaining coherence and even entanglement, be effectively equalized, distributed in a controlled way or even localized in perfectly periodic structures by means of dissipative coupling. Such unique light propagation regimes will be realized with the help of a photonic analogue of a tight-binding lattice using coupled waveguide networks in linear and non-linear glass materials. These coherent photonic devices will be fabricated by ultrafast laser inscription, and the dissipative coupling implemented by mutually coupling each pair of waveguides in the chain to a linear arrangement of waveguides. Efficient quantum diagnostics methods will be developed to verify the source characteristics and to assess their technological readiness. We expect coherent diffusive photonic devices to find applications in photonic networks and in a range of metrology tasks, potentially also for simulations of complex quantum dynamics.

The project goal thus is:

1) to implement a family of compact sub-Poissonian photon guns, capable of robust generation of mesoscopic non-classical and entangled states;

2) to perform a feasibility study of their applications in entanglement-enhanced imaging and atomic clocks aiming at the 2 times better clock frequency stability.

PROJECT: PhoQuS
(Photons for Quantum Simulation)
Coordinating Institution:
SORBONNE UNIVERSITE
Coordinator: Alberto Bramati



Spokesperson
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About the Project

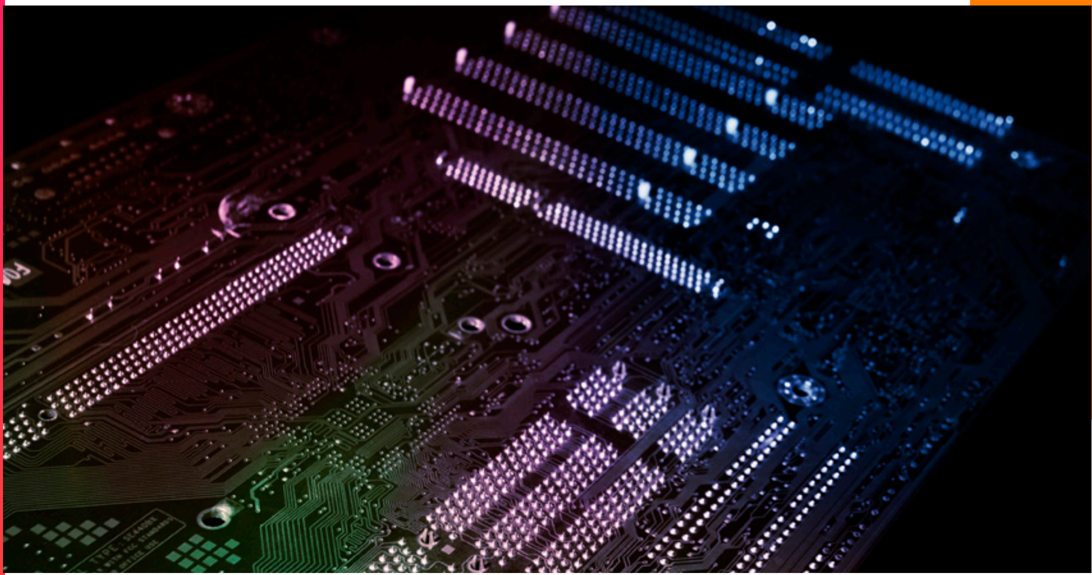
Quantum simulation is an emerging and exciting field for which several systems, such as ultracold-atoms, trapped ions or superconducting circuits are being actively investigated. In this project we aim to develop a novel platform for quantum simulation, based on photonic quantum fluids. Quantum fluids of light can be realised in different photonic systems with suitable nonlinearities, thus engineering an effective photon-photon interaction.

The photon-photon interaction necessary to form a superfluid is provided by the optical nonlinearity of the medium. We will first fully characterize the superfluid and quantum turbulent regimes for quantum fluids of light, investigating the propagation in optically controlled landscapes with the demonstration of important milestones such as many-body localization and the superfluid to Mott–insulator transition.

Based on these achievements and on the unprecedented flexibility offered by the all- optical control in quantum fluids of light, we will implement quantum simulations and simulate systems of very different nature, ranging from astrophysics to condensed matter. Fundamental open questions such as superconductivity, black hole physics, and quantum gravity will be addressed within the photon fluid platform.

PROJECT: MicroQC
(Microwave driven ion trap quantum computing)
Coordinating Institution:
FOUNDATION FOR THEORETICAL AND COMPUTATIONAL PHYSICS AND ASTROPHYSICS
Coordinator: Nikolay Vitanov

http://microqc.eu/



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About the Project

The construction of a large-scale trapped-ion quantum information processor can be made decisively simpler by using the well-developed and compact microwave technology present already in today's mobile phones and other devices. Microwave technology has tremendous simplification potential by condensing experimental effort from an optical table with several square meters of accurately aligned optical components down to an engineered conductor microstructure embedded into a chip surface and a few off-the-shelve microwave components.

Thus, this technology can be the key enabling step for addressing the formidable challenge of a scalable quantum processor. Although the field is still in its infancy, there is rapid progress: a fidelity of over 99.9999% has been achieved for single-qubit gates and 99.7% for two-qubit gates. This technology allows execution of quantum gates by the application of a voltage to a microchip potentially replacing millions of laser beams and it can operate at room temperature or mild cooling.

There are still enormous technical challenges in scaling ion trap (or any other) systems up to the millions of qubits required to implement meaningful full-sale quantum computation and simulation. The main objective of MicroQC is to demonstrate, through state-of-art quantum engineering, fast and fault-tolerant microwave two-qubit and multi-qubit gates and to design scalable technology components that apply these techniques in multi-qubit quantum processors.

The successful accomplishment of these objectives, in a combined effort by five leading groups in this field – three experimental groups, including the pioneers in microwave quantum logic with static and oscillating magnetic gradients, and two leading theory groups – will make large-scale quantum computation and simulation with microwave-controlled microfabricated ion traps possible. In addition, MicroQC will produce a roadmap, to take microwave quantum computation to high technology readiness levels.

Quantum Community Network

In order to be able to engage the large number of stakeholders in Europe appropriately, the Quantum Support Action (QSA) has established a network of multipliers, the Quantum Community Network (QCN).

The QCN is composed of distinguished members of the Quantum Technology (QT) community, who have agreed to commit to liaising with their national stakeholders and build the links to the QSA.

QCN members are encouraged to carry out the following actions:

- Collect and share information and/or best practices on QT-relevant activities in their country
- Help coordinate the interaction between the Flagship and National Initiatives
- Assist in the promotion of gender equality in science
- Provide, upon request, additional information about activities, regulation etc. in their country

List of the current QCN members

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European Initiatives and Targets for the next Multiannual Financial Framework

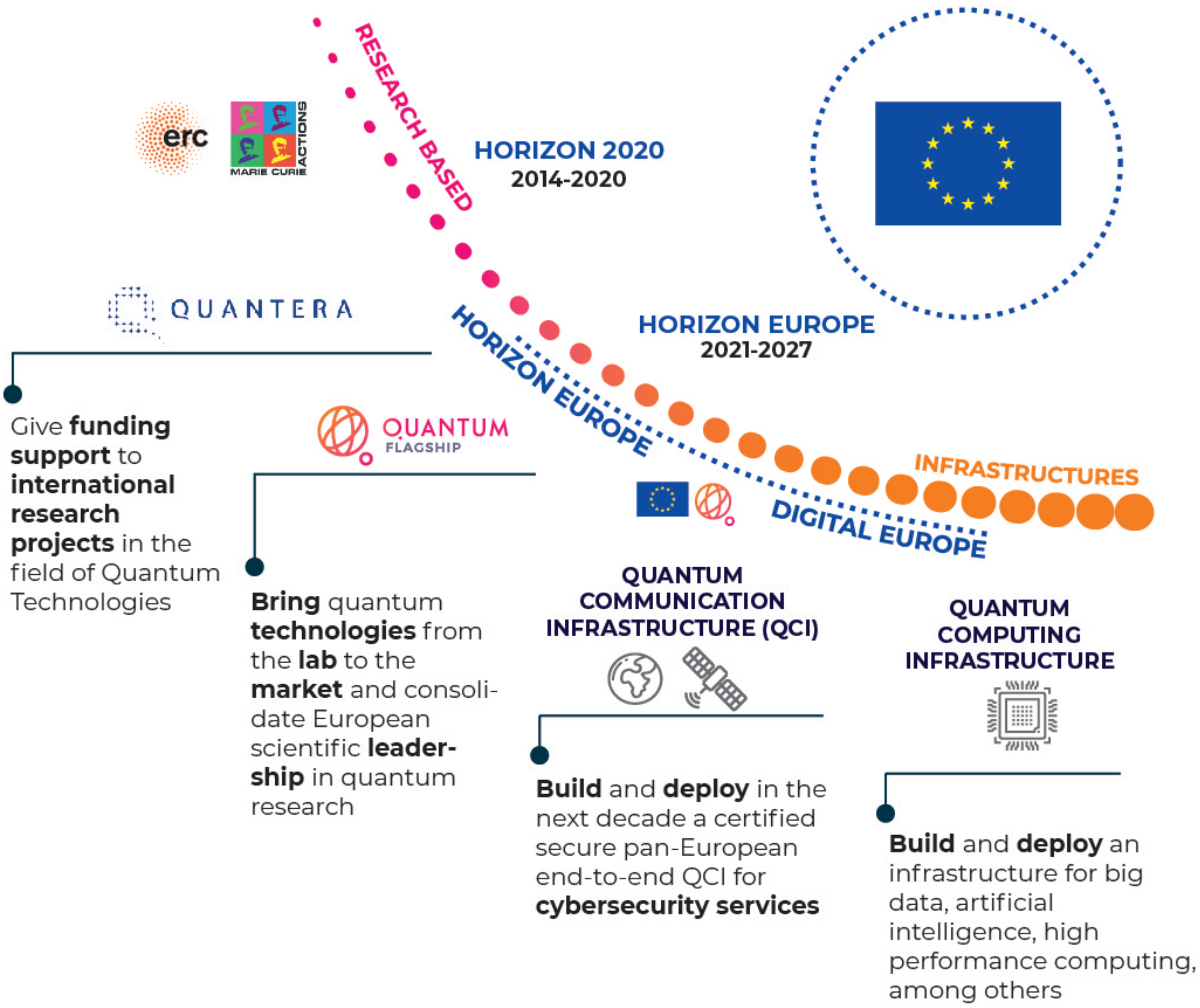
Quantum Communication Infrastructure - QCI

The aim of the QCI initiative is to build a quantum secure communication shield across the EU that would protect our economy and society from cyber threats. The QCI's main function will be to allow quantum key distribution, an ultra-secure form of encryption. A combination of terrestrial and space implementation of quantum-based communication infrastructure can guarantee security of digital transactions over short and long distances covering both the EU and other continents.

Early users of the QCI infrastructure could be government agencies and authorities of Member States and the EU that require a high level of security to transmit confidential information.

In the longer term, the QCI infrastructure will accommodate additional functionalities alongside quantum key distribution, such as digital signatures, authentication, and secret sharing schemes (e.g. e-voting). QCI would ultimately evolve into a Quantum Internet, linking quantum processors and sensors and enabling an EU-wide distributed quantum computing and communication capability.

On 9 April 2019, a technical agreement signed between the European Commission and the European Space Agency laid the first stone in the creation of a pan-European quantum communication infrastructure. The European Space Agency is making its expertise in satellite and optical communications available in order to meet the technological challenges of delivering quantum key distribution services, which are not achievable by ground-based solutions alone.



Quantum Key Distribution

The current technologies for ground-based QKD have a distance limit due to signal light attenuation, but its range of communication can be extended by employing satellites equipped with high-quality optical links. Future concepts already propose the deployment of a mixed terrestrial-satellite network. With a satellite QKD capability, cryptographic keys could be distributed to users located anywhere within the satellite's coverage. Several cross-linked satellites using QKD technologies could connect networks of land, sea, air, and space-based users.

The link between the QCI and the Quantum Flagship

The European Quantum Technologies Flagship was launched in October 2018, with a budget of €1 billion over the next ten years. The projects it funds aim to develop state-of-the-art devices and systems that will be available to the QCI infrastructure. In addition, open access to the QCI will be provided to attract new stakeholders and to foster synergies with other Quantum Flagship projects.

The objective of the QCI is to build and deploy in the next decade a certified secure pan-European end-to-end QCI for cybersecurity services. The QCI will:

Integrate quantum cryptography into critical communication systems

Combine terrestrial and satellite components for wide coverage

Permit the protection of data networks, clock synchronization, e-voting...

Be the backbone infrastructure for the quantum internet

Link to the QCI video

Q&A: Link to Frequently Asked questions

OPENQKD Project

Paving the way for a secure Pan-European Quantum Communication Infrastructure

The European Commission has announced the launch of a pilot project, OPENQKD, that will install a test quantum communication infrastructure in several European countries.

OPENQKD will aim to bring about a change in the way we see, understand and use quantum communication. Its main focus is to create and test a communication network infrastructure with a built-in quantum element, using Quantum Key Distribution (QKD), an ultra-secure form of encryption that allows data to be transmitted with a very high level of security.

It will lay the groundwork for a pan-European quantum communication infrastructure that uses satellite as well as ground-based solutions: recently, the European Commission and several EU countries announced plans to work together to explore the development of such a quantum communication infrastructure linking European regions and cities.

Building closer European links

The Europe Commission chose to fund OPENQKD following a Horizon 2020 call for proposals in 2018. Its mission is to develop an experimental testbed based on QKD and to test the interoperability of equipment supplied by different manufacturers of quantum. OPENQKD's activities will take place all over Europe (in Austria, Spain, Poland, Germany, Netherlands, Switzerland, France, Italy, UK, Greece and the Czech Republic). It will focus on several key fields of operations, especially the telecommunications sector, where data traffic in transit and at rest needs to be secured. Other applications, such as securing medical and governmental data or the transmission of secure control signals in the electricity grid will also be demonstrated and evaluated.

In addition, OPENQKD will address the development of a European ecosystem for quantum technology providers, application developers. It will also work to identify new use-cases by supporting start-ups and SMEs, as well as offering modern test facilities to new quantum stakeholders. A further objective for the project is to devise standards and security certifications for this infrastructure.

To achieve its ambitious goals, the OPENQKD project will last three years and have a budget of €15 million. Its consortium consists of 38 partners from 13 Member States and Horizon 2020 Associated States. The consortium partners cover a wide range of competences including quantum equipment manufacturers, network operators, system integrators, small and medium-sized enterprises, Research and Technology Organisations, universities, certification and standardisation bodies and end users.

Link to Cordis Reference/ Fact Sheet

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