QUANTERA

DECADE OF IMPACT 2016-2026

Quantum Technologies Research & Innovation in Europe

The QuantERA Project Catalogue: Call 2025

We fund quantum research and innovation that connects people, drives excellence and embraces responsibility – across borders, sectors and disciplines.

CONTENTS

FOREWORD

Implementation of Call 2025 reaffirmed the critical role played by the QuantERA initiative in the European quantum ecosystem. Record numbers of proposals have been received in two call topics: 148 in Quantum Phenomena and Resources and 139 in Applied Quantum Science. These figures vividly illustrate the wealth of fresh ideas and concepts that quantum research community seeks to explore through transnational collaborations.

Thanks to the commitment of research funding organisations participating in the call and the substantial EU financial contribution, in total 39 of the highest-ranked proposals have been selected for funding in both topics.

The results of QuantERA-funded projects will undoubtedly strengthen European position in the global efforts to benefit from the second quantum revolution.

Professor Konrad Banaszek
QuantERA Scientific Coordinator

Quantum technologies are built long before they reach the market – they begin with bold scientific ideas and researchers willing to explore them. While Europe accelerates efforts to bring quantum technologies closer to market, it is equally important to keep the innovation pipeline continuously fed with the discoveries and knowledge that will drive the next generation of breakthroughs. This is where QuantERA plays a unique role: by bringing together ambitious researchers across Europe and beyond, enabling them to combine complementary expertise, share knowledge across borders, and build lasting scientific collaborations. Since 2016 QuantERA has supported 140 collaborative projects involving 740 research teams from more than 30 countries, helping to build one of Europe's largest collaborative quantum research communities.

This catalogue showcases the outstanding projects selected under the QuantERA Call 2025 and celebrates the researchers whose creativity, collaboration, and scientific ambition are driving Europe's quantum future.

Elżbieta Hryniewicka
QuantERA III Programme Coordinator

QuantERA Programme 2016-2026: A Decade of Building the European Quantum Ecosystem

Our story

The QuantERA Programme was officially **launched in December 2016**, following two years of preparatory efforts aimed at bringing together the European quantum research community and Research Funding Organisations (RFOs) within a dedicated transnational funding framework.

Under the EU Horizon 2020 ERA-NET Cofund, QuantERA laid the foundations of a pan-European network and launched its first two joint transnational calls for proposals in Quantum Technologies, in 2017 and 2019. QuantERA II further expanded the consortium to 41 Research Funding Organisations from 31 countries and organised two joint calls for proposals in 2021 and 2023, supporting a new generation of multinational quantum research projects. Throughout its development, QuantERA has also hosted strategic conferences, bringing together researchers, policymakers and funding organisations to align priorities and strengthen cooperation across the European quantum ecosystem.

In mid-2025, the Programme entered its third phase with the launch of QuantERA III, followed by the announcement of its first call the same year; the Programme builds on a decade of joint efforts and reflects a programme-wide evolution, placing stronger emphasis on inclusiveness, sustainability and long-term ecosystem resilience, as well as expanded global partnerships beyond Europe – exemplified by the accession of the Republic of Korea.

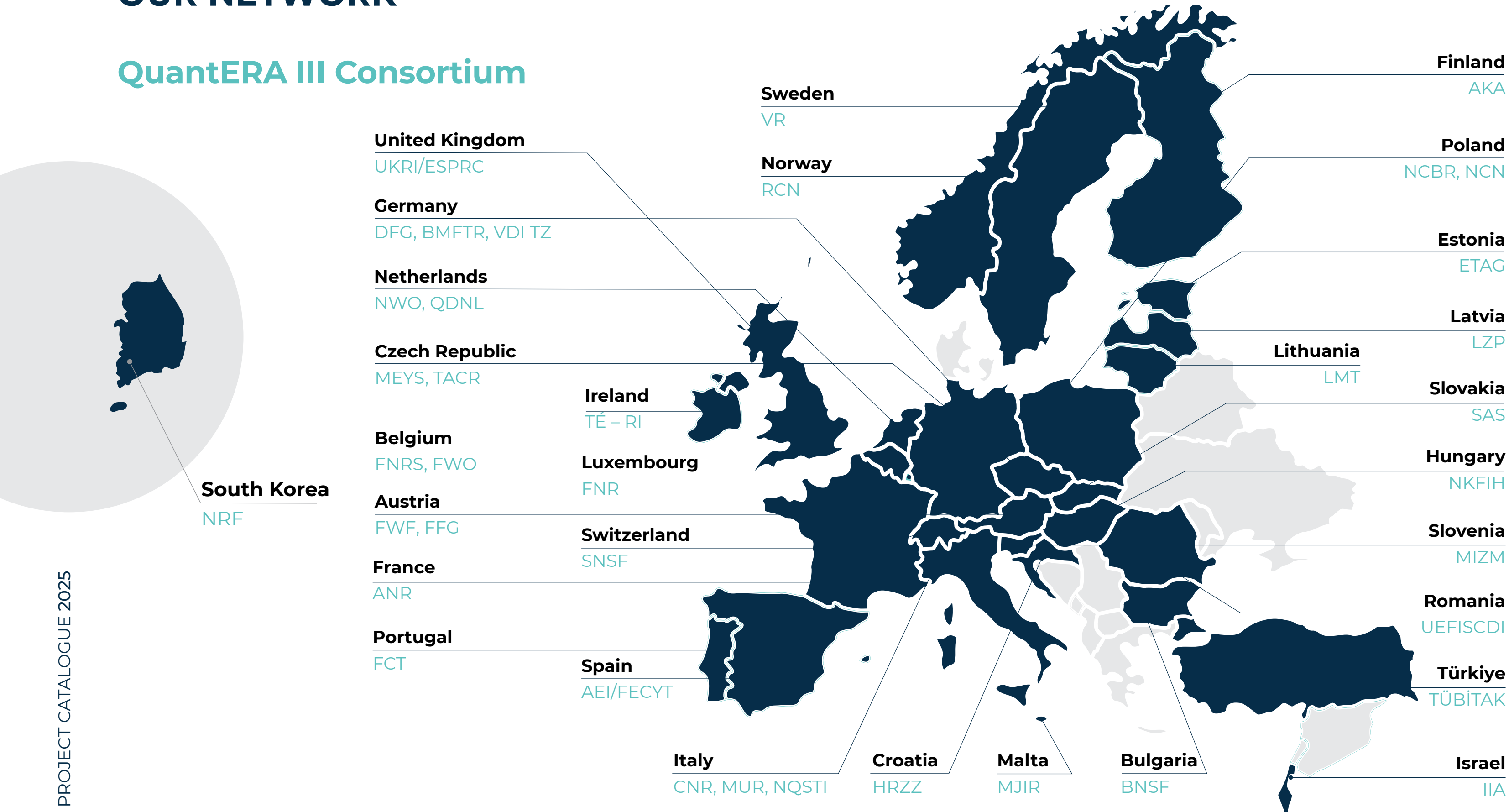
Our mission

QuantERA receives support by the **European Commission** and operates in close alignment with the **European Quantum Flagship** and other European quantum initiatives. By connecting national and regional research funding organisations, conducting mapping of public policies, and supporting coordinated strategic reflection, the Programme strengthens coordination across Europe, supports bottom-up scientific excellence, and contributes to a coherent and resilient European quantum ecosystem.

We envision a future where Quantum Technologies are advanced through a strong, connected and inclusive network — with Europe at its heart, cooperating with partners worldwide who share common values. We believe in a forward-looking quantum ecosystem built on trust, transparency and scientific excellence, serving societies, enhancing security and contributing to solutions for emerging challenges.

OUR NETWORK

QuantERA III Consortium



The QuantERA III Consortium comprises 40 organisations from 30 countries, of which 34 organisations from 29 countries took part in the Call 2025. The Call 2025 marked an important step in the Programme's international outreach, with South Korea participating for the first time.

QuantERA Strategic Advisory Board, 2026

The QuantERA Consortium is supported by the Strategic Advisory Board, composed of leading quantum technology researchers and industry representatives. The Board provides strategic guidance, expert advice, and helps ensure that QuantERA initiatives remain aligned with the latest scientific and technological developments, fostering innovation in the field.

Alain Aspect (Nobel Prize Winner), Institut d'Optique

Harry Buhrman, University of Amsterdam / CWI

Tommaso Calarco, Forschungszentrum Jülich GmbH

Eleni Diamanti, CNRS and Sorbonne Université

Nicolas Gisin, University of Geneva

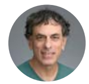
Jennifer Hastie, University of Strathclyde

Igor Jex, Czech Technical University in Prague

Peter L. Knight, Imperial College London

Jozef Lazar, Institute of Scientific Instruments, Czech Academy of Science

Gerd Leuchs, Max Planck Society



Yehuda Naveh, Classiq

Saverio Pascazio, Università degli Studi di Bari

Andrew Shields, Toshiba Research Labs Europe

Jiri Vala, Maynooth University

Dominik Zumbühl, University of Basel

Marek Żukowski, University of Gdańsk

QuantERA Community at the Quantum Horizons Conference, Gdańsk, Poland, 2025. Phot. J. Bielawski

QuantERA is, above all, a **community**. At its heart are **researchers**, whose work, ideas and collaboration form the foundation of the Programme. It brings together representatives of **Research Funding Organisations**, the **Scientific Advisory Board**, **policymakers** and **scientific experts**, who collectively contribute to its quality, coherence and long-term impact.

Beyond its funding activities, QuantERA fosters dialogue and knowledge exchange within this community, which regularly comes together at Strategic Conferences serving as key platforms for reflection, coordination and shaping future Programme directions.

quantera.eu

QuantERA
as a Research Funding Network

10 years in numbers

5 CALLS FOR PROPOSALS RESULTING IN:

140 FUNDED PROJECTS

RUN BY **740** NATIONAL TEAMS

INVOLVING **1500** RESEARCHERS

€170 M FUNDING

17% TOTAL SUCCESS RATE

TYPICAL PROJECT:

4 COUNTRIES

5 PARTNER ORGANISATIONS

€1.2 M BUDGET

OUTPUTS ACROSS 50 PROJECTS FINALISED SO FAR AND 51 UNDER IMPLEMENTATION:

3300+ PUBLICATIONS, CONFERENCE PRESENTATIONS AND POSTERS

470 NEWLY CREATED AND EXTENDED POSITIONS

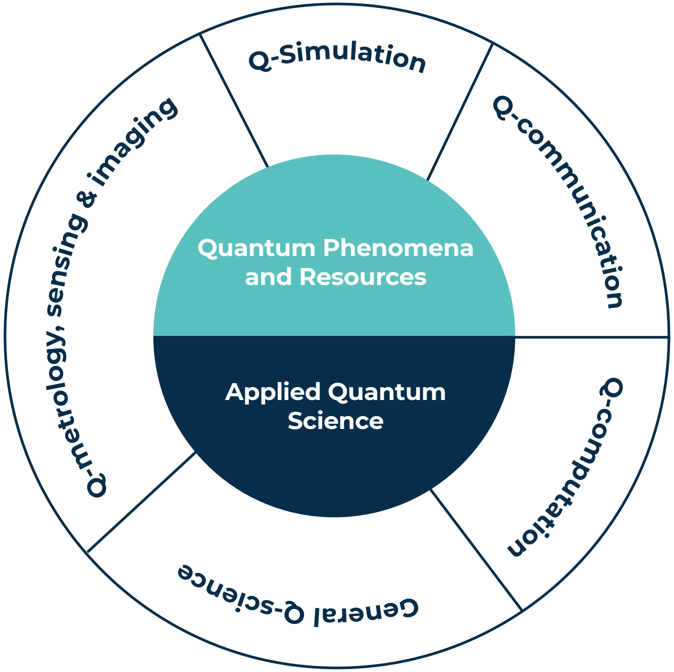
230 RESEARCH MOBILITY ACTIVITIES

48% TEAMS SHARED RESEARCH INFRASTRUCTURE WITHIN QUANTERA PROJECTS

Strengthening the Quantum Research Environment

QuantERA brings together research funders supporting collaborative research across the full spectrum of quantum science and technologies. Since its establishment, QuantERA has implemented five transnational calls for proposals. Across its calls, Programme has consistently structured its funding activity around two complementary research topics: **Quantum Phenomena and Resources (QPR)** and **Applied Quantum Science (AQS)**. This approach reflects the Programme's commitment to supporting both fundamental, curiosity-driven research and application-oriented scientific and technological development.

Research targeted in the QuantERA calls

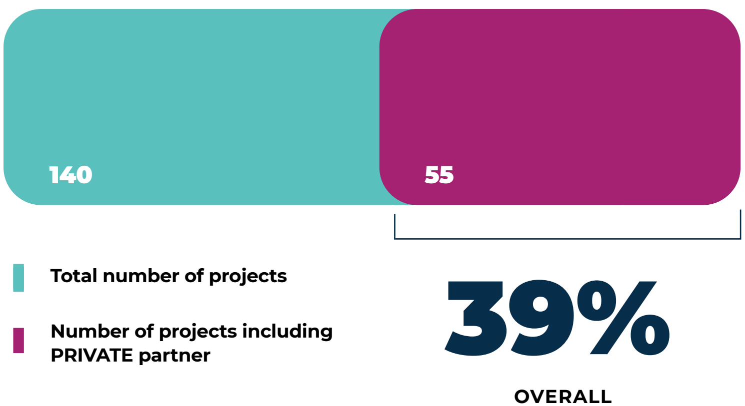


By maintaining this thematic structure, QuantERA ensures a balanced and integrated funding portfolio covering key QT areas

Developing Industry Connections

The QuantERA Programme aims to stimulate and intensify industry interests in Quantum Technologies and, while boosting scientific excellence, induces researchers to find their way towards commercial applications. Industry stakeholders have an opportunity to be actively engaged in the QuantERA calls. Numerous research consortia include industry entities which is a promising sign.

Share of projects including private sector partners across QuantERA calls



Inclusive and Responsible Excellence

Inclusive and Responsible Excellence in QuantERA reflects the Programme's commitment to strengthening the European quantum ecosystem through **diversity, capacity building and responsible research practices**. These principles are integrated across the funding cycle — from call design to project monitoring and dissemination — ensuring that excellence remains both scientifically rigorous and socially grounded.

Strategic Focus

- Empowering Widening Countries
- Inclusive research cultures, with particular attention to gender equality and support for early-career researchers

Supporting RRI Dimensions

- Open, transparent and safe science
- Anticipation and ethical reflection
- Public engagement and shared understanding

Widening Participation

QuantERA places a particular emphasis on the participation of **Widening Countries***, reflecting the understanding that Europe's long-term leadership in quantum field depends on the coherence and inclusiveness of its research ecosystem.

By pooling fragmented national resources into a coordinated European effort, **QuantERA creates a critical mass that no single country could achieve alone**, while reducing duplication of scientific efforts and avoiding structural exclusion.

Nearly all EU Member States classified as Widening countries have been involved in QuantERA Programme, with 14 out of 15 currently participating in the consortium.

ACROSS 5 CALLS

29% PROJECT COORDINATORS FROM WIDENING COUNTRIES

73% PROJECTS INCLUDING WIDENING COUNTRIES

● Widening Countries

- Bulgaria
- Croatia
- Czechia
- Estonia
- Hungary
- Latvia
- Lithuania
- Malta
- Poland
- Portugal
- Romania
- Slovakia
- Slovenia
- Türkiye

* Widening Countries: countries eligible under EU Framework Programmes for measures supporting increased participation and capacity building across the European Research Area.

Gender Balance and Support for Early Career Researchers

Inclusive Excellence in QuantERA is also reflected in its commitment to gender balance and the active involvement of early-career researchers (ECRs*) as essential components of a sustainable quantum ecosystem. The Programme promotes equal participation in funded consortia, evaluation panels and events, while encouraging project teams to create supportive research environments that enable emerging researchers to develop leadership, mobility and interdisciplinary collaboration.

* Understood as all members of research teams at postdoctoral level or below

Early Career Researchers Support

83%

OF RESEARCH MOBILITY ACTIONS CARRIED OUT BY ECRs

85%

OF NEW OR PROLONGED POSITIONS HELD BY ECRs

75%

COMPLETED PROJECTS WITH PhD THESES

across 50 projects finalised so far and 51 under implementation

83%

OF QUANTERA-FUNDED PROJECTS REPORT GENDER EQUALITY ACTIONS, INCLUDING:

outreach promoting women in science

inclusive recruitment practices

work–life balance support

Success rate of women and men Principal Investigators (%) across 5 calls

23%	22%
WOMEN PIs	MEN PIs

Gender balance is promoted in QuantERA at multiple dimensions

General activities

Inclusive and visibility practises across consortium partners

Call design

Gender balance integrated into evaluation and review procedures

Funded projects

Monitoring and support for inclusive research environ-ments

Call 2025 Overview

Growing Demand for QuantERA Funding

The QuantERA Call 2025 proved to be record-breaking in terms of the number of submitted transnational proposals, reflecting exceptionally strong engagement from the research community and confirming the Programme's growing visibility and relevance within the European and international quantum research landscape.

Call 2025 Key Figures

PARTICIPATION:

29 countries

BUDGET:

€53 M

SUBMITTED:

287 proposals

1408 RESEARCH TEAMS

€336 M REQUESTED FUNDING

SELECTED:

39 projects

15% SUCCESS RATE*

196 RESEARCH TEAMS

€53 M GRANTED FUNDING

Call 2025 timeline

June 2025	September 2025	December 2025	May 2026	June-September 2026
Call Pre-announcement	Call Announcement	Deadline for proposals submission	Call results	Start of the funded projects

*Success rate is the ratio of the number of the selected proposals against the number of proposals submitted, expressed as a percentage.

Topics and Research Areas

The funded projects cover a broad spectrum of quantum research, with a balanced distribution between **Applied Quantum Science (46%)** and **Quantum Phenomena and Resources (54%)**.

The portfolio is led by **Quantum Sensing and Metrology (33%)** and **General Quantum Science (28%)**, followed by **Quantum Computation (18%)**, **Quantum Communication (15%)** and **Quantum Simulation (5%).**

Consortium Composition

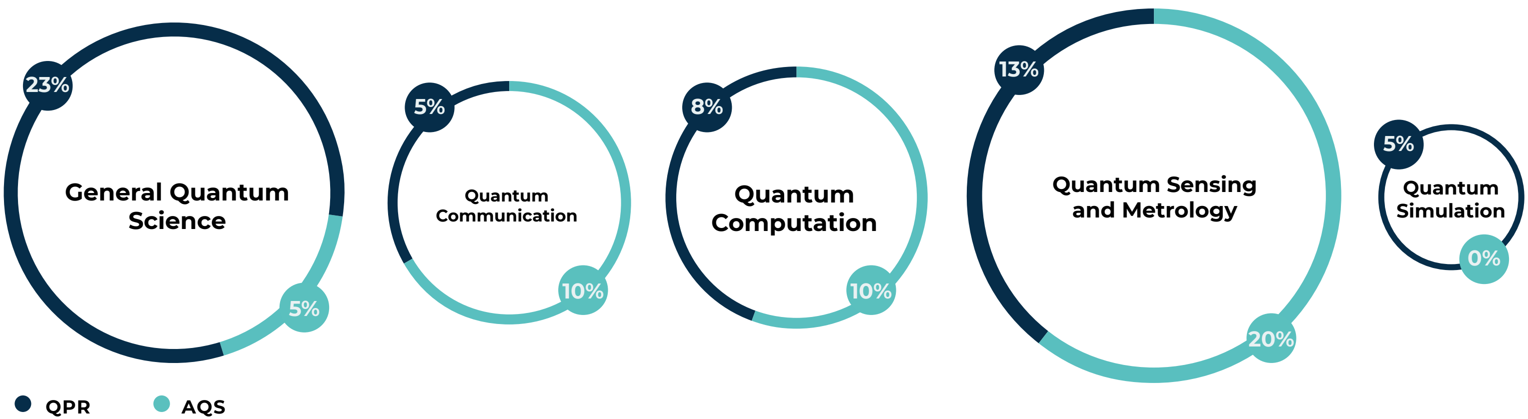
Funded projects in Call 2025 most frequently involve five partners (20 projects), while the majority include participants from either two or three countries (31 projects). Consortium sizes range from 3 to 9 partners, and participating organisations represent between 3 and 6 countries.

Partners per consortium

39 PROJECTS

NUMBER OF PARTNERS	3	4	5	6	7	9
NUMBER OF CONSORTIA	2	8	20	7	1	1

Topics distribution



Projects per Country

- GERMANY 25
- FRANCE 19
- UNITED KINGDOM 14
- AUSTRIA 11
- CZECHIA 8
- NETHERLANDS 8
- SPAIN 8
- ITALY 8
- POLAND 7
- FINLAND 7
- SWITZERLAND 5
- HUNGARY 3
- SWEDEN 3
- SLOVENIA 2
- LITHUANIA 2
- BULGARIA 2
- NORWAY 2
- BELGIUM 2
- SOUTH KOREA 2
- SINGAPORE | IRELAND | LUXEMBOURG | CANADA 1
- CROATIA | ROMANIA | TÜRKIYE | MALTA 1

● Widening Countries

● Other participating Countries

Project consortia may include partners from countries outside QuantERA calls, provided they secure their own funding and are not based in EU-sanctioned countries.

Industry Connections

QuantERA encourages to engage with ambitious high-tech SMEs to drive innovation and research forward.

44% OF FUNDED PROJECTS INCLUDE AT LEAST ONE PRIVATE-SECTOR PARTNER

9% OF PARTICIPATING PARTNERS REPRESENT THE PRIVATE SECTOR

Widening Participation

The projects structure of Call 2025 reflects the active integration of Widening Countries within collaborative European quantum research networks.

62% OF FUNDED PROJECTS INCLUDE WIDENING COUNTRIES

14% OF RESEARCH TEAMS ARE BASED IN WIDENING COUNTRIES

10% SUCCESS RATE AMONG PRINCIPAL INVESTIGATORS FROM WIDENING COUNTRIES

Gender balance

Despite the women under-representation typically observed in STEM fields, women and men Principal Investigators achieved nearly identical success rates in Call 2025.

Number of Men vs Women Principal Investigators (PIs) in the submitted proposals and funded projects

	Submitted Proposals	Funded Projects	Success Rate
MEN PIs	1102	154	14%
WOMEN PIs	252	34	13%

Funded Projects Outlines

2DQUEST

Quantum Engineering in Superconducting Graphene for Topological Qubits

The main objective of 2DQUEST is to establish graphene-based materials as a new platform for creating and controlling robust quantum states that could enable more reliable quantum technologies.

Quantum computers have the potential to address problems that are beyond the reach of conventional machines. However, their basic units of information are highly sensitive to noise, making it difficult to preserve and process quantum information reliably. Topological quantum computing offers a possible solution by storing information in states that are naturally protected against many disturbances.

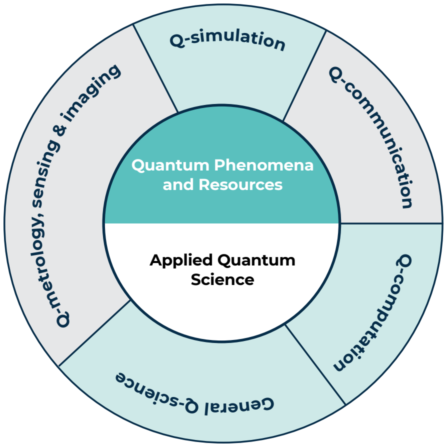
2DQUEST will investigate whether specially designed structures made from graphene combined with other ultra-thin materials can host such protected states. Graphene is particularly promising because of its exceptional quality, flexibility, and electrical tunability. The project will combine advanced material fabrication, sensitive measurements, and theoretical modelling to design and test new quantum devices.

A central goal is to identify clear signatures of exotic quantum states associated with Majorana modes, which are considered important building blocks for fault-tolerant quantum computing. Rather than relying on a single route, the project will explore complementary ways of creating these states while maintaining a strong connection between experiment and theory.

By bringing together expertise in quantum materials, device engineering, measurement, and modelling, 2DQUEST aims to deliver convincing evidence of protected quantum states in a two-dimensional platform. Its results could establish graphene heterostructures as a foundation for future quantum technologies that are more stable, scalable, and resistant to errors.

2dquest

Areas of research



Duration

September 2026 → August 2029

Consortium

- **Coordinator:**
  Saroj Dash
  Chalmers University of Technology (SE)
- **Thomas Weitz**
  Georg-August-Universität Göttingen (DE)
- **Jaroslav Fabian**
  University of Regensburg (DE)
- **Tobias Stauber**
  Consejo Superior de Investigaciones Científicas (ES)

Funding organisations

- **Sweden: VR**
- **Germany: DFG**
- **Spain: AEI**

BATiR LE CHAT

Bosonic quAntum compuTeRs, LEarning, CHaracterization And Testing

BATiR LE CHAT aims to accelerate the development of a promising new generation of quantum computers based on bosonic quantum systems, which store information in quantum states of light or oscillators rather than conventional qubits. These platforms are emerging as strong candidates for building large-scale, fault-tolerant quantum computers, but they currently lack the powerful diagnostic and verification tools that have been crucial to the success of qubit-based technologies.

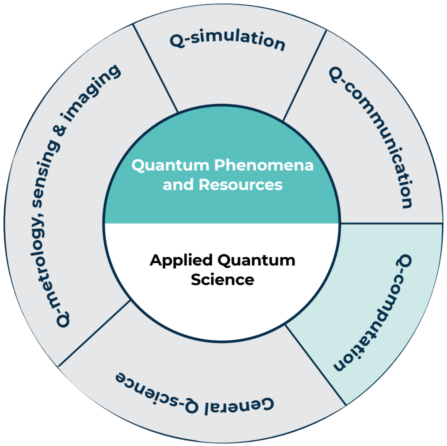
The main objective of the project is to develop the first comprehensive toolbox for characterizing, testing, and learning about bosonic quantum computers. Such tools are essential for determining whether a quantum device is functioning correctly, identifying sources of error, and guiding improvements in hardware and control.

To achieve this, the project will develop new methods for benchmarking bosonic quantum devices, reconstructing quantum states from measurements, and testing whether key quantum resources have been successfully created. It will also establish the mathematical foundations needed to extend modern quantum characterization techniques to bosonic systems, whose infinite-dimensional nature makes many existing approaches unsuitable.

The consortium brings together leading experts from the Netherlands, France, and Germany, including the quantum computing company Alice & Bob. In addition to fundamental scientific advances, the project will deliver open-source software and practical tools that can be directly used by experimental researchers.

By providing the methods needed to reliably assess and improve bosonic quantum hardware, BATiR LE CHAT will help transform a rapidly emerging technology into a scalable platform for future quantum computing and strengthen Europe's position at the forefront of quantum innovation.

Areas of research



Duration

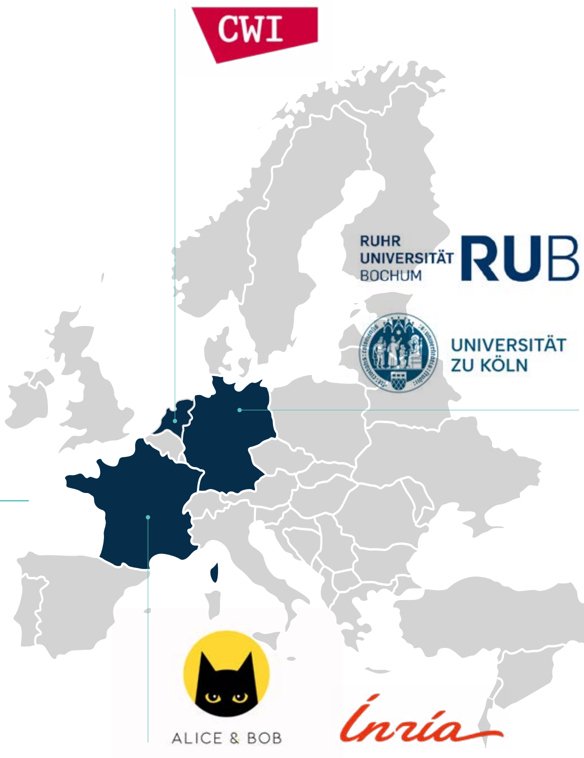
December 2026 → November 2029

Consortium

- **Coordinator:**
  Jonas Helsen
  Centrum Wiskunde & Informatica (NL)
- **Markus Heinrich**
  University of Cologne (DE)
- **Jonas Haferkamp**
  Ruhr University Bochum (DE)
- **Ulysse Chabaud**
  Institut National De Recherche En Informatique Et En Automatique – Inria Centre Paris (FR)
- **Christophe Vuillot**
  Alice & Bob (FR)

Funding organisations

- **Netherlands: QDNL**
- **Germany: DFG**
- **France: ANR**



CoMaQLev

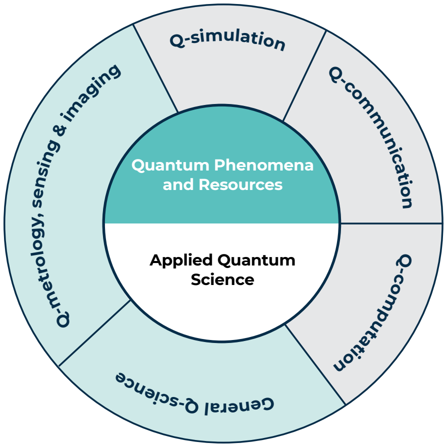
Magnetically Co-Levitated Superconductors in the Quantum Regime

Micrometer-sized superconductors can be levitated by magnetic traps in ultra-high vacuum, where their motion can be monitored and controlled via magnetic fields while external noise is kept to a minimum. Levitated superconducting microparticles thus offer a promising platform for sensing of forces, torques, and accelerations at and beyond the standard quantum limit, with great potential for future quantum technologies and foundational tests of quantum mechanics.

The CoMaQLev project team will take the crucial next steps to tap into their outstanding potential by developing the experimental and theoretical techniques to co-levitate, monitor, and control two superconducting microparticles in double-trap configurations.

Achieving this will enable differential sensing and common-noise rejection in these systems, as required for future applications in quantum sensing and gravitational metrology with sub-milligram masses.

Areas of research



Duration

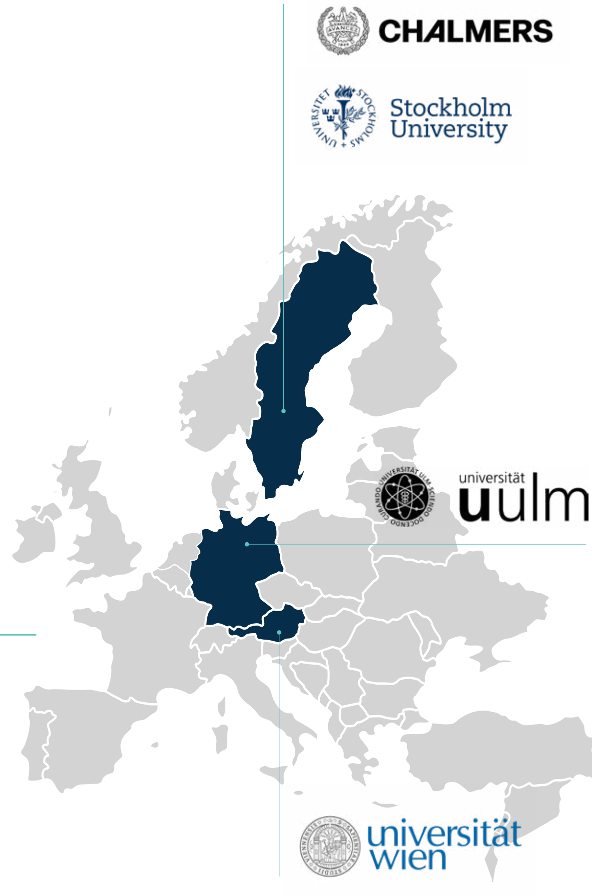
September 2026 → August 2029

Consortium

- **Coordinator:**
  Benjamin Stickler
  Ulm University (DE)
- **Martin Plenio**
  Ulm University (DE)
- **Markus Aspelmeyer**
  University of Vienna (AT)
- **Witlef Wieczorek**
  Chalmers University (SE)
- **Magdalena Zych**
  Stockholm University (SE)

Funding organisations

- **Germany: DFG**
- **Austria: FWF**
- **Sweden: VR**



DigiAnaQsim

Digital methods in analog quantum simulation

DigiAnaQsim aims to make quantum simulators more powerful, flexible, and useful for understanding complex quantum systems. Many important materials and molecules are governed by quantum effects that are extremely difficult to calculate with conventional computers. Quantum simulators offer an alternative route: they realize key quantum behaviour in a controlled laboratory system, such as ultracold atoms arranged in optical lattices.

The main objective of DigiAnaQsim is to develop new digital methods that enhance the power of analog quantum simulation. In practice, this means combining the strengths of two approaches:

- Analog quantum simulators naturally reproduce the collective behaviour of many interacting particles,
- Digital quantum methods provide precise tools for controlling, preparing, and measuring quantum states.

By bringing these ideas together, the project will expand what cold-atom quantum simulators can do.

The project will focus on three broad goals:

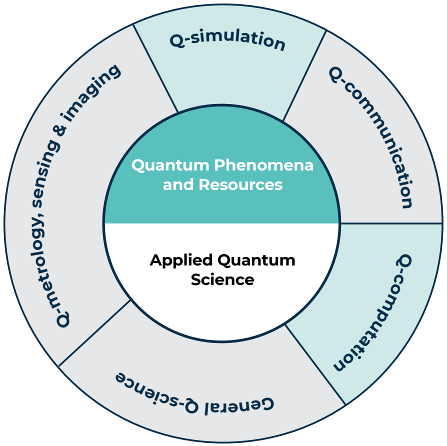
- It will make it possible to study a wider range of quantum models, including models that are currently hard to realize directly in experiments.
- It will develop better strategies for preparing useful quantum states, including states that resemble those found in quantum materials.
- It will improve how information is extracted from experiments, so that quantities such as correlations, energies, and signs of entanglement can be measured more accurately.

DigiAnaQsim brings together theoretical and experimental teams from across Europe. The theory teams will design new methods and test them through numerical simulations, while the experimental teams will implement and refine them in state-of-the-art cold-atom platforms. This feedback loop between theory and experiment is central to the project.

By the end of the project, DigiAnaQsim aims to provide a practical toolbox for next-generation analog quantum simulators. These developed techniques will help researchers explore quantum matter in regimes that are difficult to access otherwise, supporting progress toward a deeper understanding of complex materials, quantum technologies, and the foundations of many-particle quantum physics.

digianaqsim.eu

Areas of research



Duration

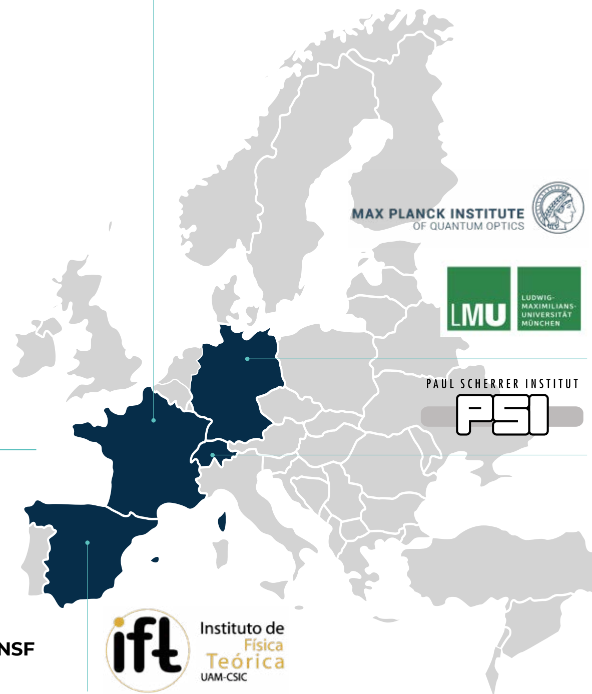
November 2026 → October 2029

Consortium

- **Coordinator:**
  Alexander Schuckert
  Département d'Informatique de l'Ecole Normale Supérieure (FR)
- **Monika Aidelsburger**
  Ludwig-Maximilians-Universität München (DE)
- **Philipp Preiss**
  Max-Planck Institut für Quantenoptik (DE)
- **Daniel González-Cuadra**
  Consejo Superior de Investigaciones Científicas (ES)
- **Andreas Elben**
  Paul Scherrer Institute (CH)

Funding organisations

- **France: ANR**
- **Germany: DFG**
- **Spain: AEI**
- **Switzerland: SNSF**



ENTUNE

Entangled and Tunable Nanomechanical Quantum Systems

Quantum technologies could transform how we sense, communicate, and compute, yet they rely on delicate quantum states that are extraordinarily hard to create, control, and protect. ENTUNE explores a fundamentally new building block for these technologies: a superconducting electrical element whose quantum behavior is steered by tiny mechanical motion.

At the heart of most superconducting quantum circuits lies a "Josephson junction," a weak link through which electric current flows without resistance. Conventionally this link is a fixed, solid insulating barrier. ENTUNE replaces it with an empty vacuum gap only a few atoms wide, so the junction itself can gently move. Because the strength of the quantum link depends on this gap, motion smaller than a billionth of a meter can directly shape the electrical quantum state — and, in turn, that state can set the tiny mechanical object into distinctly quantum motion.

Remarkably, no such mechanically moving Josephson junction has ever been built, so realizing one would itself open a genuinely new direction for quantum hardware.

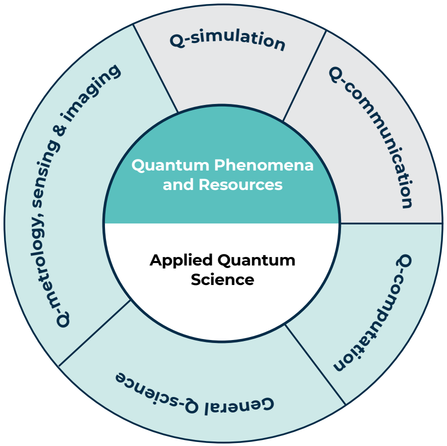
The project's main objective is to demonstrate that such a "vacuum-gap Josephson junction" can act as a controllable quantum resource. Working all the way from theory to experiment, the project team will aim to create and detect non-classical states of motion – including "Schrödinger-cat" states that vibrate in two ways at once – to transport quantum information by mechanical means, and to keep these fragile states stable long enough to be useful.

Mechanical vibrations can also store and carry quantum information. Under suitable conditions, they may do so with relatively low loss. This could, in time, make them useful links between the parts of future quantum computers and networks. If successful, ENTUNE will establish a new class of mechanically tunable quantum components, with potential uses in quantum sensing, communication, and information processing.

ENTUNE will reinforce a long-standing Korean–European partnership. POSTECH (Korea) will coordinate the project and will lead the nanofabrication and ultra-low temperature measurements, while Pukyong National University (Korea) and the Universities of Zagreb (Croatia), Charles (Czechia), and Gothenburg (Sweden) will contribute internationally recognized theory and simulation.

Beyond the science, the project will train a new generation of interdisciplinary quantum researchers and strengthen scientific ties between Europe and Korea.

Areas of research



Duration

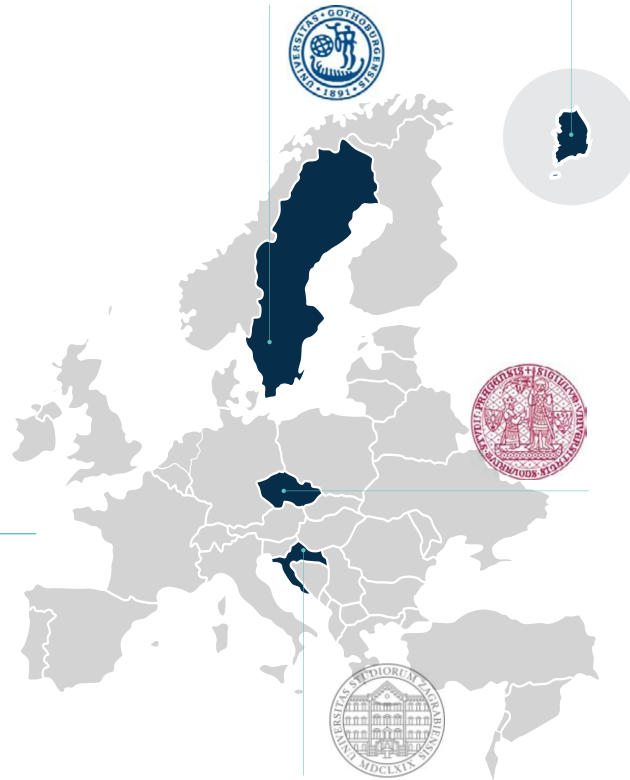
September 2026 → August 2029

Consortium

- **Coordinator:**
  Junho Suh
  POSTECH -Pohang University of Science and Technology (KR)
- **Hee Chul Park**
  Pukyong National University (KR)
- **Danko Radić**
  University of Zagreb (HR)
- **Mats Jonson**
  University of Gothenburg (SE)
- **Tomáš Novotný**
  Charles University (CZ)

Funding organisations

- **South Korea: NRF**
- **Croatia: HRZZ**
- **Sweden: VR**
- **Czechia: MEYS**



EQUALITIES

Efficient Fault-Tolerant Quantum Computing via Fine-Grained Logic Gates on Qudit Codes

Quantum computing holds the potential to transform many fields of research and industry by solving a range of problems significantly faster than the best classical devices. Yet achieving this promise hinges critically on our ability to protect fragile quantum information against noise and errors.

Quantum error correction aims to achieve this by redundantly encoding quantum information into collective degrees of freedom, forming logical qubits, to achieve fault-tolerance. Yet, quantum error correction comes with large overheads and only allows for a restricted, discrete set of gate operations that can be applied while maintaining protection against errors.

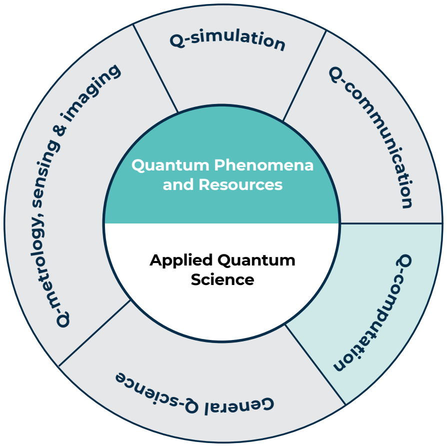
Typically, such gate sets consist of all Clifford gates and a single non-Clifford T gate. While such gate sets can arbitrarily approximate any target unitary gate, the resulting circuits can often require a large number of logical operations. As a result, the overheads of current approaches to quantum error correction are excessive, which severely limits their applicability to real-world quantum computing use-cases and hardware.

The EQUALITIES project aims to address this challenge by developing novel resource-efficient quantum error correction codes that support extended logical gate sets featuring fine-grained, i.e. small-angle fault-tolerant non-Clifford gate operations as well as native operation on logical qudits, rather than qubits only.

Both of these approaches have the potential to greatly improve the efficiency of quantum error correction by reducing the circuit complexity at the logical level, which in turn reduces the requirements on the logical error rates required for algorithmic applications. Fine-grained non-Clifford gates directly address the challenge of reducing the overhead of approximating arbitrary unitaries by a small discrete gate set, while native error-corrected qudit support alleviates the challenge of having to transpile native qudit applications into inefficient qubit-based circuits.

The combination of these two research developments will lay the groundwork of a new framework of resource-efficient fault-tolerant quantum computing and will boost the practical realisation of versatile fault-tolerant quantum processors.

Areas of research



Duration

September 2026 → August 2029

Consortium

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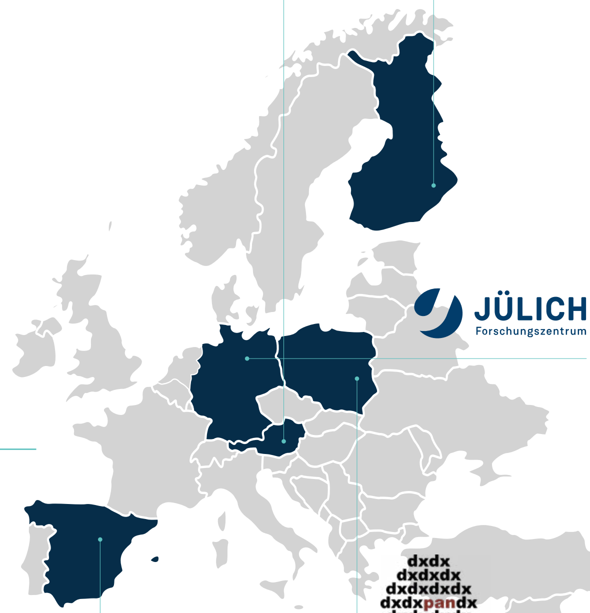


Funding organisations

- **Austria: FWF**
- **Germany: DFG**
- **Spain: AEI**
- **Finland: AKA**

EQUINOCS

Enhanced QUantum INteractions for Optical ClockS

Atomic clocks are central to a vast range of science and technology, from telecommunication networks to fundamental research. Ever more precise, fast and accurate atomic clocks are needed to push the applications to new levels. The development of optical atomic clocks was a revolution, yet limits to their performances are now in sight.

State-of-the-art optical atomic clocks are "passive" clocks, where the frequency of some stable laser is periodically compared and tuned to the frequency of an optical transition in atomic shells. This comparison is performed with ensembles of cold trapped atoms non-correlated with each other. The inaccuracy of such a comparison decreases as a square root of the number of atoms, i.e., to make a 10 times more precise optical clock, one needs to use 100 times more atoms. But significantly increasing the number of trapped atoms above the modern level is technically challenging. Furthermore, frequency fluctuations of the laser constantly disrupt the tuning, degenerating the precision of the clock.

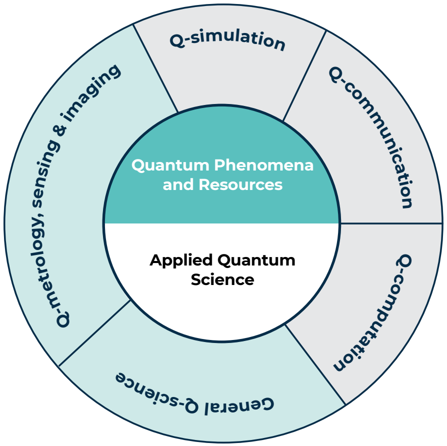
EQUINOCS aim is to bootstrap a new generation of optical clocks that relies on interrelated atoms and thereby beats limitations of state-of-the-art clocks. The project aims at leveraging cavity-enhanced interactions to induce different kinds of inter-atomic correlations.

Firstly, the project team will build a novel kind of optical clock, namely active optical clocks called "superradiant lasers". Here, interactions are exploited to enhance the emission of atomic radiation from very narrow transitions, triggering and sustaining continuous superradiant emission. This radiation is then used as an optical frequency reference. Multiple architectures will be developed in parallel to explore the advantages and limitations of divergent technological avenues.

Secondly, following the "traditional" approach of (passive) clocks that rely on repeated spectroscopic measurements, the project team will leverage cavity-enhanced interactions to produce "squeezing". This is a kind of quantum correlations between the atoms, which allows us to surpass the square root scaling of the clock precision. Here, the challenge is to produce squeezing in a system fully designed as a high-precision optical clock.

The experimental efforts will work hand-in-hand with theory, using a unified theoretical framework, to reach beyond the basic demonstration and explore and overcome limitations from real-world imperfections.

Areas of research



Duration

September 2026 → September 2029

Consortium

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Funding organisations

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- **Austria: FWF**
- **Netherland: QDNL**

FeedbacQ

Feedback-enabled quantum optimization and control

Quantum computing is well on track to disrupt the way we design and run numerical algorithms for a large variety of impactful applications. Yet, research still faces major challenges on both the hardware and the algorithmic level. Current devices suffer from a number of error sources that hinder scalability beyond classical limits. Moreover, even with ideal hardware, the use-cases of quantum computers are limited to only a selected set of algorithms for which computational speedups are proven or can be expected.

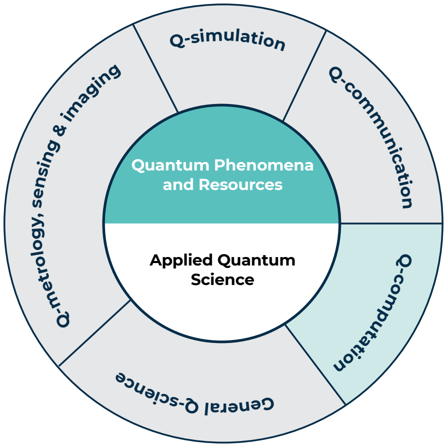
FeedbacQ aims to overcome these barriers by rethinking how quantum computations are designed and controlled. The focus is on using quantum computers for solving optimization problems, i.e., tasks that involve finding the best solution among many possibilities, which are central to countless problems across science and industry.

The project's key idea is to rely on feedback by monitoring a quantum system and using the obtained information to guide its behavior in real time. While feedback is a standard tool in engineering, it has not yet been fully exploited in quantum computing. By integrating feedback across multiple levels, from quantum algorithms to hardware, the project team will aim to make quantum optimization more efficient, reliable, and broadly applicable.

New methods will be developed to translate real-world optimization problems into forms that quantum computers can handle. In addition, novel quantum algorithms will be designed that go beyond standard approaches by incorporating measurement and interaction with the environment, enabling faster and more resource-efficient computations. To address the fragility of quantum hardware, new error-correction techniques will be created based on continuous monitoring and control. The project team will also develop improved ways to implement these methods on actual quantum devices. With real experiments on quantum computers, including a gate-based device available at one of the partner institutions, the project will experimentally validate the findings and demonstrate their practical impact.

FeedbacQ project is interdisciplinary and encompasses PIs and research topics spanning physics, mathematics, engineering, and computer science. The central underlying theme for achieving the project goals and the common language is control theory, in particular the application of feedback and measurement.

Areas of research



Duration

September 2026 – September 2029

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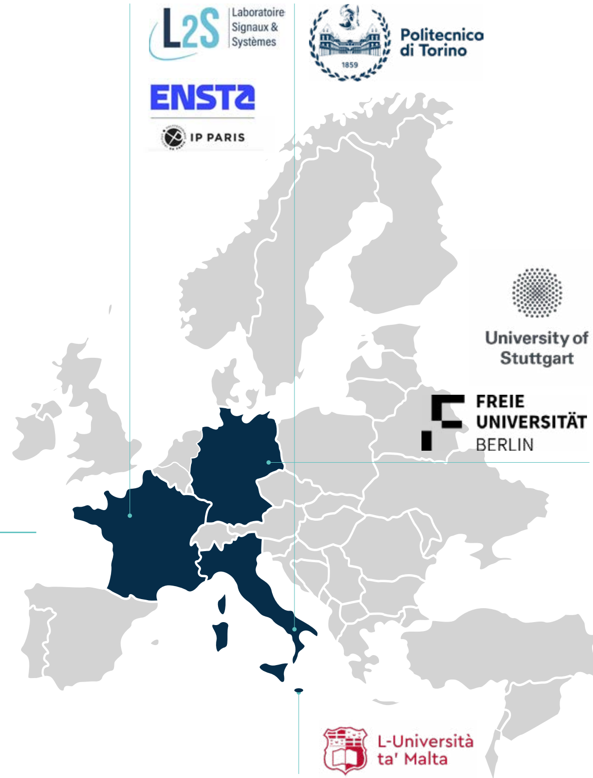


Funding organisations

- **Germany: DFG**
- **France: ANR**
- **Italy: MUR**
- **Malta: MJIR**

HEMS

Heat and Entropy Management in Superconducting Devices

Quantum technologies promise transformative advances in computing, sensing, and communication. Among the leading approaches are quantum circuits based on superconducting and hybrid devices, which can process and exchange information with remarkable efficiency. However, one of the major obstacles to building larger and more powerful quantum systems is the management of heat generated during operation.

Even at extremely low temperatures, quantum devices produce and absorb small amounts of energy while being controlled and measured. Additional heating can arise from imperfections in materials and from interactions with the surrounding environment. As quantum processors grow in size and complexity, understanding and controlling these energy flows becomes increasingly important to maintain performance and reliability.

Recent advances have revealed that heat transport in quantum devices is far more complex than previously assumed, requiring new approaches that go beyond traditional descriptions of system–environment interactions. Thanks to the high level of control achievable in superconducting quantum circuits, these platforms offer a unique opportunity to explore how heat generation and entropy production can be actively monitored and managed in real time.

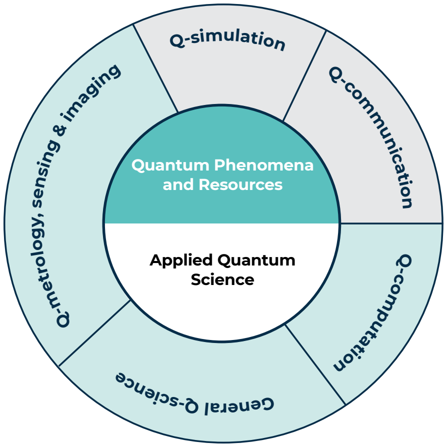
HEMS addresses this challenge by developing new strategies to control energy and heat transport in quantum circuits, including operating conditions where devices are strongly driven and interact intensely with their surroundings.

The project will combine realistic models of quantum environments with advanced control methods to design protocols that minimize unwanted heating and improve operational efficiency. It will also exploit the flexibility of modern quantum-circuit architectures to test these concepts experimentally.

The ultimate goal is to establish practical methods for heat and entropy management that can be integrated directly into future quantum hardware. Achieving this capability is a crucial step toward scalable quantum technologies containing thousands of qubits and capable of performing complex tasks reliably.

By bringing together expertise in superconducting quantum hardware, quantum theory, and optimal control, HEMS creates a unified pathway from fundamental understanding to experimental validation, helping lay the foundations for the next generation of large-scale quantum systems.

Areas of research



Duration

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Funding organisations

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- **Germany: DFG**
- **Finland: AKA**
- **Poland: NCN**

INTEGRA

Innovative Architectures for Next-Geneation Trapped Atom Interferometers

INTEGRA aims to develop a new generation of quantum sensors based on trapped atom interferometers, a promising technology that could transform the way we measure gravity, motion, electromagnetic fields, and other extremely weak forces.

Atom interferometers exploit one of the most fascinating features of quantum physics: matter can behave like a wave. By splitting and recombining atomic matter waves, scientists can measure tiny changes in the surrounding environment with extraordinary precision. Today's most advanced atom interferometers typically operate with atoms in free fall, a technique that has already enabled major breakthroughs in fundamental physics and precision sensing. However, free-fall operation imposes fundamental limits on how long the measurement can last and on the spatial resolution that can be achieved.

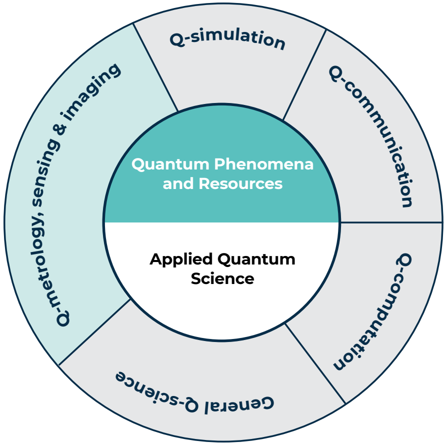
INTEGRA explores a radically different approach. Instead of letting atoms fall, the project team will keep them trapped and precisely controlled using specially engineered light fields. This strategy could allow quantum superpositions of matter waves to be maintained for much longer times and over much larger separations than currently possible. Achieving this goal would dramatically increase the sensitivity of atom-based quantum sensors while also enabling measurements with unprecedented spatial resolution.

The project brings together leading European groups that will investigate complementary solutions to the key challenges that currently limit trapped atom interferometers. Different teams will develop innovative methods to create, manipulate, and preserve quantum coherence, including advanced optical trapping techniques, optimal quantum-control protocols, cavity-enhanced light fields, and new approaches based on quantum correlations and entanglement.

By combining these efforts, INTEGRA aims to demonstrate trapped atom interferometers capable of operating beyond the current state of the art. The technologies developed within the project could pave the way for compact and highly sensitive instruments for gravity mapping, underground exploration, inertial navigation, environmental monitoring, and precision measurements near surfaces. At the same time, they will provide powerful new tools for exploring some of the most fundamental questions in physics, including the search for new interactions and unexplained forms of matter and energy.

By extending the reach of quantum superpositions in both space and time, INTEGRA seeks to unlock the full potential of trapped matter-wave interferometry and establish a new platform for future quantum technologies.

Areas of research



Duration

September 2026 → September 2029

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Funding organisations

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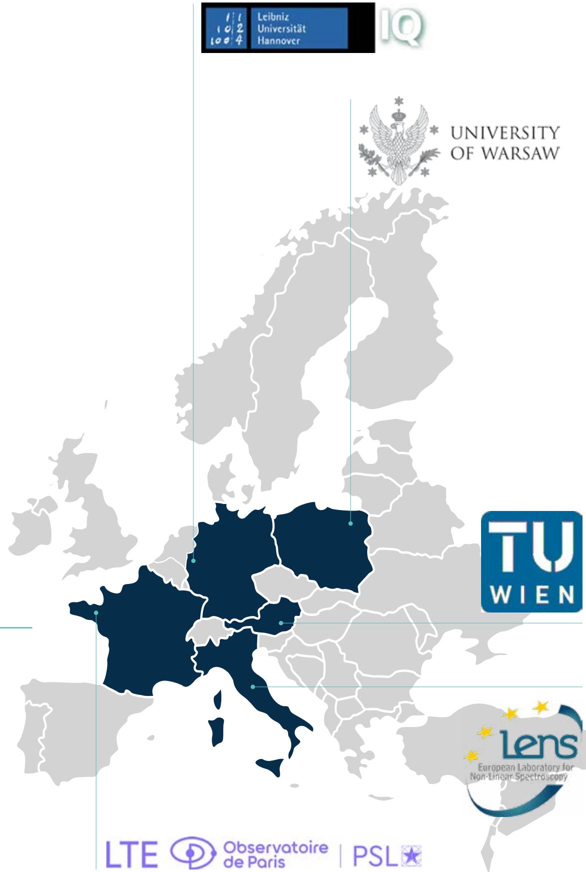
- **Austria: DWF**
- **France: ANR**
- **Poland: NCN**



MultiQS

Supper-resolved MULTI-parameter Quantum Sensing with arrays of diamond nanoneedles

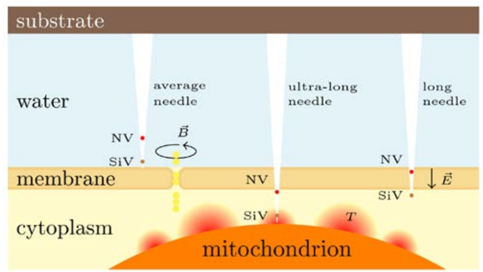
Every living cell depends on a delicate balance of physical and chemical conditions, such as temperature, acidity (pH), electrical activity, magnetic fields, and reactive molecules. Changes in these conditions can reveal how cells function, adapt, or become diseased. However, current technologies cannot measure several of these signals at the same time, with high precision, inside living cells, and without disturbing their natural behaviour.

The MultiQS project aims to overcome this challenge by developing a new generation of quantum sensors based on diamond. These sensors use tiny defects in diamond crystals that are extremely sensitive to their surroundings. Unlike previous approaches that relied on individual sensing needles, MultiQS will create ordered arrays of nanoscale diamond needles on a chip. This design enables stable measurements, precise calibration, and highly detailed mapping of multiple cellular signals simultaneously.

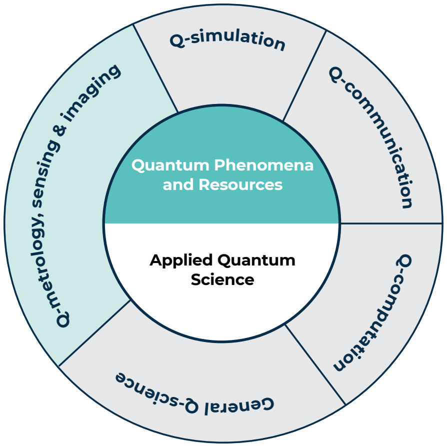
The technology will allow researchers to monitor temperature, magnetic and electric fields, pH, and reactive oxygen species in living cells in real time and at an unprecedented scale. This could provide new insights into fundamental biological processes and help scientists better understand diseases such as cancer, neurodegenerative disorders, and cardiovascular conditions.

By combining expertise from Germany, Finland, Czechia, and Lithuania, MultiQS will advance both quantum technology and life sciences. The project will strengthen European leadership in quantum sensing, support the training of young researchers, and promote scientific excellence across Europe.

Ultimately, MultiQS will create powerful new tools for studying life at the nanoscale and open new opportunities for future biomedical and healthcare applications.



Areas of research



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Duration

September 2026 → **August 2029**

Funding organisations

- **Finland: AKA**
- **Germany: DFG**
- **Lithuania: LMT**
- **Czechia: MEYS**

QM3L

Quantum protocols for Multimode Mechanics advanced by Machine Learning

QM3L will use machine learning to understand, design, control, and certify complex quantum states in multimode mechanical systems. The project focuses on quantum acoustics and micromechanics, where collective mechanical vibrations are controlled at the quantum level.

These platforms are promising for quantum technologies because they combine long coherence times, multimode operation, and compatibility with superconducting and microwave circuits.

QM3L brings together theory, algorithms, and experiments in two complementary settings:

- superconducting-qubit devices coupled to high-overtone bulk acoustic resonators,
- arrays of acoustic resonators and microwave optomechanical systems.

The central goal is to develop an integrated theory–experiment approach in which machine learning supports the identification of device models, the design of control protocols, the preparation of target states, and the verification their properties.

On the theory side, the project will develop ML-assisted methods for Hamiltonian discovery and engineering, noise-resilient control and optimization, and scalable criteria for detecting quantum non-Gaussianity, entanglement, and multipartite correlations. These methods will be designed around experimentally available measurements, including parity, excitation number, and quadrature readout, avoiding the need for full state tomography in large multimode systems.

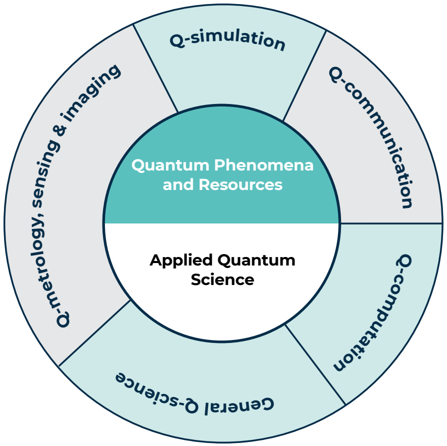
Experimentally, QM3L will implement and benchmark these methods in state-of-the-art circuit quantum acoustodynamics, HBAR-array, and microwave optomechanical platforms.

Target demonstrations include multimode squeezing, quantum non-Gaussian state preparation and detection, protected acoustic modes, and elementary bosonic code-state building blocks such as cat, binomial, and GKP-like states. Machine learning will also be used to identify effective noise environments and device imperfections, supporting improved hardware design and operation.

By combining expertise in quantum acoustics, optomechanics, machine learning, quantum control, and non-Gaussian-state certification, QM3L will deliver new algorithms, software, and benchmarks for multimode quantum platforms.

The project will advance fundamental quantum science while supporting future applications in bosonic error correction, quantum simulation, sensing, and metrology.

Areas of research



Duration

October 2026 – September 2029

Consortium

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Funding organisations

- **Norway: RCN**
- **Germany: DFG**
- **Finland: AKA**
- **Switzerland: SNSF**
- **Czechia: MEYS**

QNA

Quantum Network Algorithms

Quantum technology is advancing quickly, and one possible future is a quantum Internet: a global network in which quantum computers can share quantum information, not just ordinary digital messages. But if such networks become available, what would they be useful for?

Researchers have already shown that quantum networks could solve some carefully designed tasks much faster than today's classical networks. However, these examples are mostly proofs of principle. They are not yet useful in practice, and they would be difficult to run on near-future quantum hardware.

The main goal of QNA project is to find more realistic uses for quantum networks. The project team will look for practical tasks where connected quantum computers could offer a real benefit. They will design algorithms that could work with the quantum technology expected in the coming years.

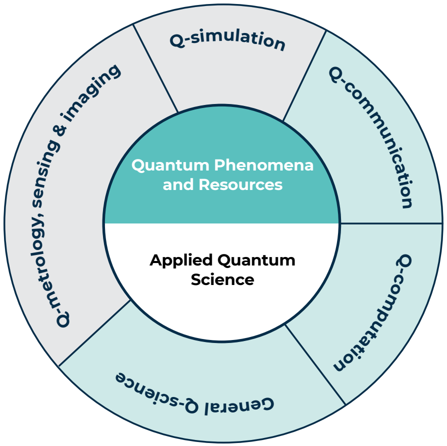
QNA will also study the limits of quantum networks: the cases where they do not help. This is just as important, because it can help researchers, engineers, and industry focus on the applications where the quantum Internet could make a genuine difference.

The project brings together computer scientists and quantum physicists from universities, research institutes, and industry.

Together, QNA team aims to answer fundamental questions about what quantum networks can and cannot do, and to help lay the foundations for a future quantum Internet.

research.cs.aalto.fi/da/qna/

Areas of research



Duration

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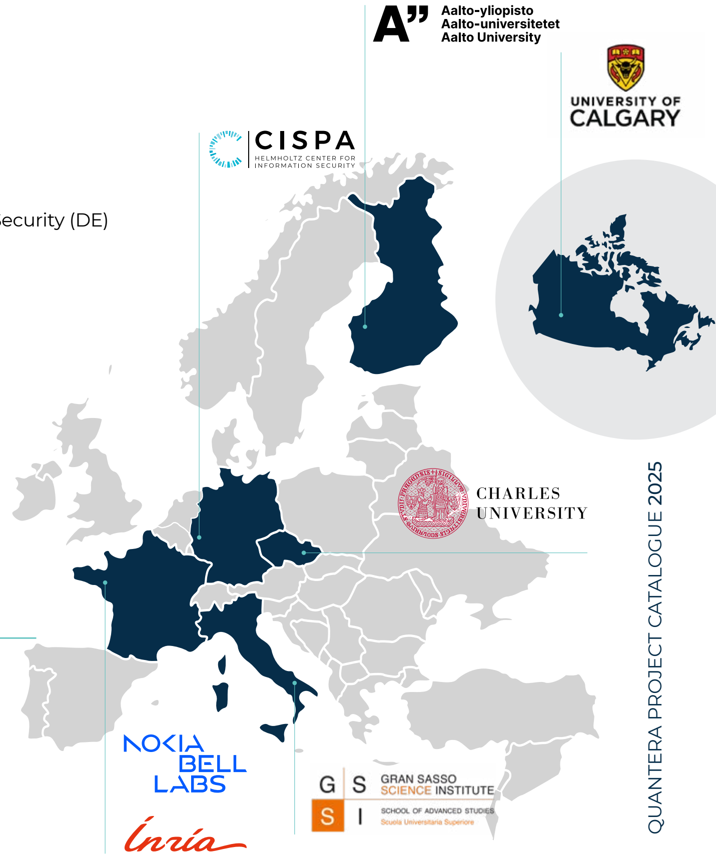


Funding organisations

- **Finland: AKA**
- **Germany: DFG**
- **France: ANR**
- **Italy: MUR**
- **Czechia: MEYS**

QUARCKS

Quantum Robust hyper-ClocKs and atomic Sensors

QUARCKS aims to develop a new generation of highly robust optical clocks and atomic sensors that can operate with exceptional precision even in the presence of noise and real-world imperfections. Today's best atomic clocks already measure time with extraordinary accuracy, but their performance is still limited by two major challenges: disturbances from the environment and unwanted shifts caused by the laser light used to probe the atoms. These effects restrict how long the atoms can be observed and ultimately limit the stability and accuracy of optical clocks.

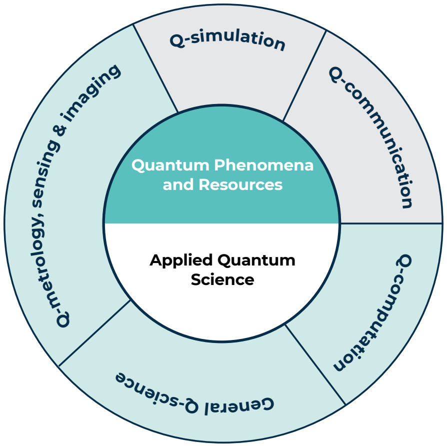
The project will address these limitations by combining advanced methods for controlling atoms with strategies that protect fragile quantum states from decoherence. QUARCKS will design new interrogation protocols based on time separated sequences of refocusing laser pulses that allow atoms to keep their quantum memory for longer, while also cancelling important sources of errors. Such a dual protection is the core objective of the project. It will make clocks and sensors not only more accurate in ideal laboratory conditions, but also more reliable in practical, noisy environments for field applications. In addition, dynamical decoupling techniques will be introduced to reduce loss of contrast in harsh electromagnetic environments.

The project brings together leading expertise in high-performance optical clocks, trapped ions, atomic sensors, precision metrology, and quantum control. The consortium will first design and simulate the new protocols, then test them on advanced atomic-clock platforms, and finally explore their use in scalable systems such as multi-ion clocks, optical lattices, and atom interferometers. This step-by-step approach will ensure that the methods are not limited to one specific experiment, but can become a general tool for future fault-tolerant quantum technologies.

If successful, QUARCKS will contribute to clocks and sensors with improved stability, accuracy, and robustness. Such devices could support applications in geodesy, navigation, networked timekeeping, searches for dark matter, tests of fundamental physics, and future quantum sensing technologies.

Beyond its immediate scientific goals, the project will train young researchers, strengthen European leadership in quantum metrology, and provide open methods and data that can be used by the wider scientific and technological community. By making precision measurement more resilient and transferable, QUARCKS will help move quantum clocks and atomic sensors from highly controlled laboratories toward practical, field-deployable technologies with broad scientific and societal impact.

Areas of research



Duration

October 2026 → October 2029

Consortium

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  Centre for Quantum Technologies (SG)

Funding organisations

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- **Germany: DFG**
- **Bulgaria: BNSF**

QUASIMODO

QUAntum SImulations with MulticOmponent ultracolD atOms

QUASIMODO studies new forms of matter using "building blocks" made from multilevel ultracold atoms such as dysprosium (Dy), potassium (K), and ytterbium (Yb). When atoms are cooled to temperatures just a tiny fraction above absolute zero, they begin to behave in unusual and fascinating ways as they interact and organize themselves according to the laws of quantum mechanics. Furthermore, using lasers, we can nowadays create "synthetic forces" that act like magnetic fields or make atoms behave as if they are moving in extra dimensions that do not exist in everyday life.

With these tools, the team plans to assemble entirely new quantum block structures that do not occur naturally. The main objective of the QUASIMODO project is creating and understanding strongly correlated and topological quantum phases. These are special states of matter in which many atoms act together in a highly coordinated way, producing collective behaviors that are extremely stable and difficult to disturb.

A useful analogy is a knotted rope: once tied, the knot is hard to undo unless the rope is cut. Similarly, in topologically protected quantum states, it is the overall pattern of the system, not the precise position of each individual atom, that provides stability. This built-in robustness is crucial for future quantum technologies, where even tiny errors can have major consequences.

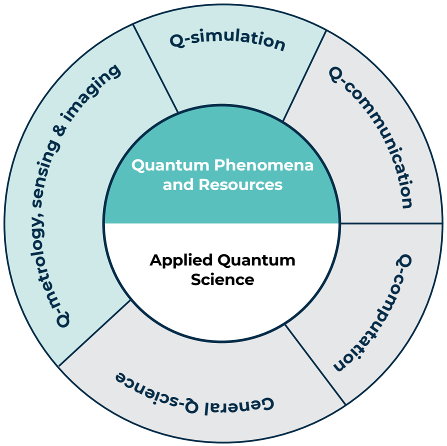
To explore these exotic states, QUASIMODO combines two approaches:

- Experimentally, it will build finely controlled quantum simulators, small atomic "laboratories" where they can test how new forms of matter behave. The project team will use advanced techniques such as Raman coupling, Floquet engineering, and optical lattices to shape how atoms move and interact.
- Theoretically, the team will develop mathematical models that connect the microscopic rules governing these systems to the measurable properties observed in the laboratory. These models will help explain how phenomena such as long-lived quantum coherence arise.

QUASIMODO aims to create quantum building-block platforms made of atoms, engineered with light, and structured to entirely new, naturally robust forms of matter. The expected outcome is a deeper understanding of how to create and stabilize topological quantum matter with implications to future quantum technologies.

www.zilberberg.uni-konstanz.de/home/quasimodo/

Areas of research



Duration

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Funding organisations

- **Germany: DFG**
- **Spain: AEI**
- **France: ANR**
- **Lithuania: LMT**
- **Poland: NCN**

ResonaTHOR

Resonator-based nuclear optical frequency reference

Thorium-229 (^{229}Th) provides the lowest-energy excited nuclear state of all isotopes, only 8.356 eV above the ground state, making it the only nuclear quantum system accessible to coherent laser manipulation. A lifetime exceeding 10 minutes and an intrinsic insensitivity of the nuclear transition frequency against external perturbations makes it a promising candidate for a novel metrology reference standard, a "nuclear clock".

^{229}Th can be embedded into crystalline materials, maintaining favourable reference transition properties. Laser excitation and precision nuclear spectroscopy have been realized and a prototype solid-state optical nuclear clock has been demonstrated in 2024. The solid-state approach promises a compact and robust implementation, comparable to the microwave Chip-Scale Atomic Clock (CSAC) modules based on miniaturized atomic vapor cells.

The main challenge is the weak interaction cross section of the ^{229}Th nuclear transition with the excitation laser light, leading to very low excitation probabilities of at currently available laser powers. This leads to low signal rates, necessitating complex single-photon detection schemes, increasing the noise, and degrading clock performance. Compensation by increasing the ^{229}Th density or increasing the laser power leads to higher radioactivity, material damage, and increased footprint and ultimately cost.

To overcome this roadblock, the ResonaTHOR project will combine ^{229}Th nuclear laser excitation with high quality factor whispering gallery resonators (WGMRs), to dramatically enhance the nuclear excitation rate and detection signal strength, coupling to the resonator's optical mode structure in excitation and emission.

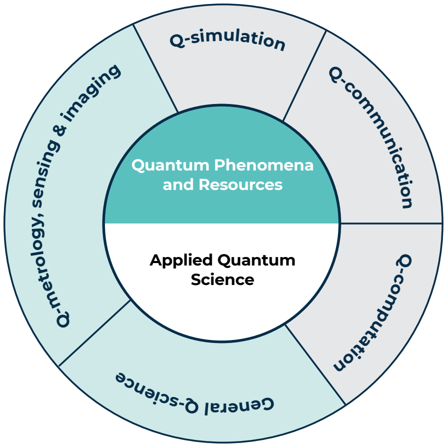
The project team will explore two complementary pumping schemes (1- and 2-photon excitation) across two resonator platforms:

- ^{229}Th implanted into crystalline WGMRs (CaF_2, MgF_2)
- Resonators fabricated directly from ^{229}Th-doped crystal

Specifically, the project will aim for <1 kBq activity in both approaches (EU exemption limit), exciting with 10 mW (296.7 nm), and 1 nW (148.3 nm) in the 2- and 1-photon scenario, respectively.

As a long-term-goal, the project will aim to develop a fully integrated chip-scale nuclear frequency reference, including lasers, ^{229}Th interrogation, and detection. The consortium has demonstrated the general feasibility of the approach in two pilot experiments; the concept is being patented in parallel with this application.

Areas of research



Duration

September 2026 → August 2029

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- **Kasper Van Gasse**
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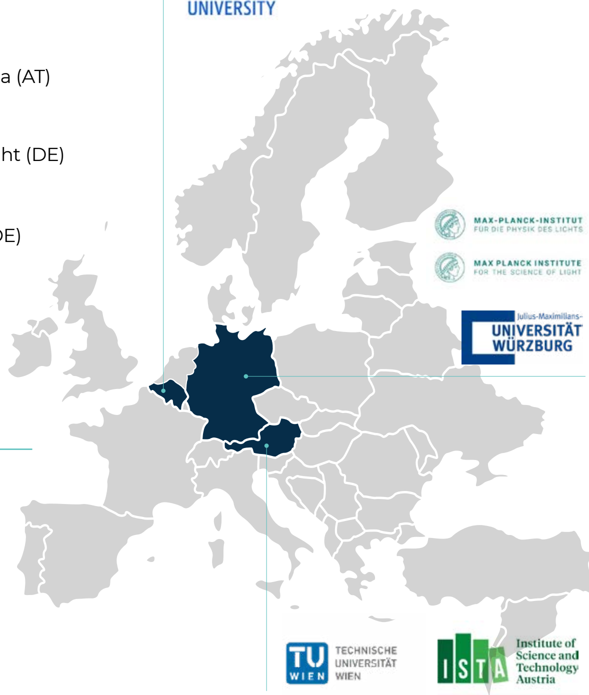
Funding organisations

- **Austria: FWF**
- **Germany: DFG**
- **Belgium: FWO**



SDPCODE

Semidefinite foundations for quantum codes: convergence, bounds, and constructions

Fault-tolerant quantum computation relies on quantum error correction to rein in decoherence and on the distillation of special “magic” states, yet the fundamental limits and practical design principles of such schemes are still poorly understood. SDPCode brings together five European partners to develop a semidefinite-programming–based foundation for analysing and constructing quantum codes and related resources over 36 months.

The project has three main goals:

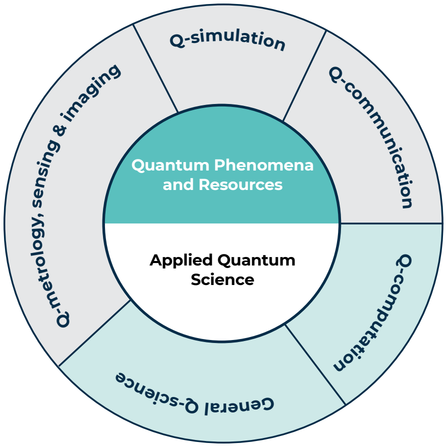
- **to establish rigorous convergence rates for widely used non-commutative semidefinite hierarchies, turning them from heuristic tools into algorithms with quantitative guarantees**
- **to obtain scalable and exact bounds on the parameters of quantum error-correcting codes and magic-state distillation protocols, including new higher-order MacWilliams-type identities**
- **to devise constructive algorithms that turn convex relaxations into concrete quantum objects – stabilizer codes, many-body ground states, and continuous-variable codes.**

Methodologically, SDPCode adapts kernel techniques to quantify how fast SDP hierarchies approach the true optimum, develops symmetry- and sparsity-exploiting solvers for quantum coding problems, and designs randomized rounding schemes for tensor-network and circuit ansätze, as well as sphere-packing–based CV codes with improved robustness to Gaussian noise.

The project will deliver general theorems, benchmark tables and open-source software implementing these methods, providing a mathematically solid and practically useful toolbox for quantum error correction, resource estimation and quantum simulation.

quantera-sdpcode.github.io/

Areas of research



Duration

September 2026 → August 2029

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Funding organisations

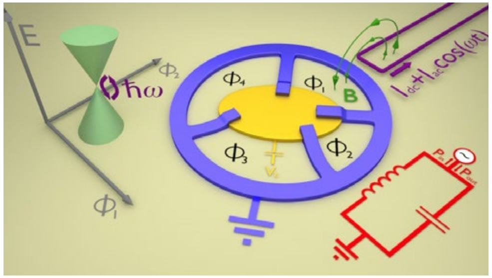
- **Poland: NCN**
- **Germany: DFG**
- **France: ANR**
- **Slovenia: MIZM**

STAQuS

Synthetic Topological Andreev States: Protected Qubits & Simulators

The field of quantum technology is driven by two major directions: Quantum Computation (QC), which targets universal gate-based systems, and Quantum Simulation (QS), which models complex many-body problems beyond classical hardware. As topological phases become crucial for fault-tolerant QC, developing robust quantum simulators and protected qubits is increasingly important. Our project tackles this by establishing Multi-Terminal Josephson Junctions (MTJJs) as a unified platform for both.

The project leverages the multi-dimensionality of Andreev Bound States (ABS) in (n+1)-terminal JJs, where superconducting phase differences serve as synthetic quasi-momenta. This enables electrically tunable synthetic Brillouin zones capable of simulating complex band structures, including Weyl semimetals. We combine high-mobility semiconductor–superconductor hybrids with highly transparent, gate-tunable graphene junctions, enabling precise control and Floquet engineering. Using DC and RF techniques, band structures, transport, and quantum geometry can be measured with high resolution.

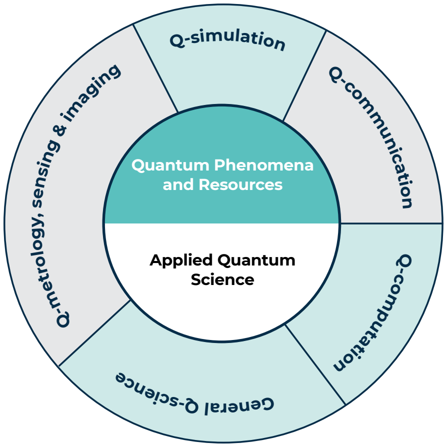


The aim of the project is to develop four-terminal JJs (4TJJs) and Floquet-driven three-terminal JJs (3TJJs) to pursue two scientific goals:

- **realizing Weyl-type and Floquet-topological phases,**
- **demonstrating a protected '0–π qubit', recently proposed to emerge from a partially looped 3TJJ in the tunneling limit.**

dept.physics.bme.hu/Staqus

Areas of research



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Duration

September 2026 → **September 2029**

Funding organisations

- **Hungary: NKFIH**
- **France: ANR**
- **South Korea: NRF**

TEMISIS

Taming the tElecom eMIssion of Spin-defects Integrated in Silicon

Color centers are structural defects found in crystals and gemstones that are known to alter the crystal's color. When isolated individually, they are of interest to physicists because they obey the laws of quantum mechanics. Indeed, they have the ability to emit particles of light, called photons, one by one. Furthermore, some of these defects exhibit a second quantum property, associated with a magnetic property known as spin, which can be used as quantum memory to store and process information. Recently, scientists have succeeded in isolating such individual fluorescent defects in the flagship material of microelectronics, silicon, for which large-scale nanofabrication techniques are by far the most advanced.

Furthermore, these color centers in silicon have the enormous advantage of emitting directly in the range of light wavelengths used in telecommunications networks, and are thus barely subjected to absorption losses during propagation in optical fibers.

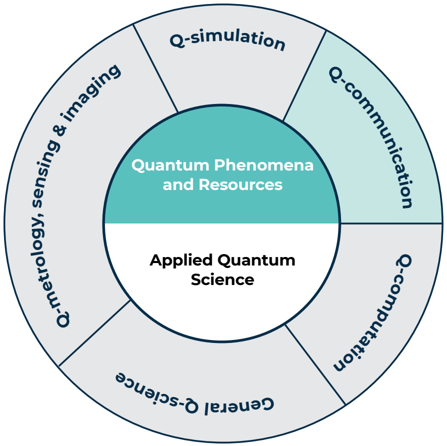
To be able to use these fluorescent defects in quantum communication networks or in quantum photonic chips, the challenge is to control their light emission so that they emit socalled indistinguishable photons - that is, photons with identical properties. This objective is extremely challenging because these emitters are embedded in a crystal and are therefore subject to numerous external perturbations such as fluctuations of surrounding electric charges or inhomogeneous strain.

As a result, the properties of the single photons generated by these defects not only vary over time but also differ between distinct color centers, limiting their use in quantum applications.

The goal of the TEMISIS project is to investigate the optical interface of individual color centers in silicon, to achieve the emission of indistinguishable single photons. The TEMISIS consortium will combine new methods for the ultrapure growth of silicon and the engineering of these defects - with deterministic control of their positions relative to the interfaces and original techniques for tuning their emission wavelengths.

The final objective of TEMISIS is to demonstrate true indistinguishable single-photon emission between two independent color centers in silicon. The applications opened up by TEMISIS include the development of quantum communication networks and silicon-based integrated quantum photonics.

Areas of research



Duration

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Consortium

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Funding organisations

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- **Austria: FWF**
- **Hungary: NKFIH**
- **Netherlands: QDNL**

ToDiQT

Towards Device-independent Quantum Technologies

The disruptive potential of quantum technologies critically depends on the reliability and certification of quantum devices. In quantum cryptography, the security of quantum key distribution, for instance, relies on several assumptions about device behaviour: if these assumptions are violated, security can be severely compromised. In quantum computing, verification is even more challenging, since confirming that a device performs the intended computation is intrinsically difficult: in general, its outputs cannot be efficiently simulated on classical computers. Moreover, imperfections such as noise and temporal drift further complicate certification and are difficult to detect without relying on strong assumptions about the device's internal workings.

The device-independent (DI) paradigm offers a radical solution to these challenges by enabling the certification of quantum devices based solely on observed correlations, without requiring detailed knowledge of their inner workings.

ToDiQT will establish the theoretical foundations necessary to elevate device-independent technologies to the next technology readiness level, addressing key certification bottlenecks in quantum communication and quantum computing.

To achieve this, ToDiQT will develop robust mathematical methods and certification tools to bridge the gap between abstract DI protocols and their practical implementation.

The project is structured around two complementary research directions:

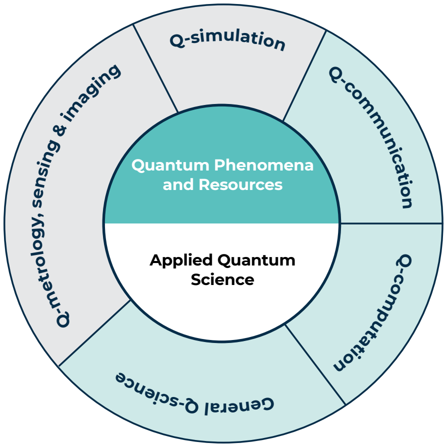
- Developing robust DI quantum cryptography, by exploring novel scenarios, beyond standard Bell tests, to design practical protocols that are implementable over long-distances on near-term platforms
- Extending DI to quantum computing, by designing resource efficient and noise-tolerant certification protocols suited for both noisy intermediate-scale (NISQ) and fault-tolerant architectures.

By tackling the core problem of quantum device certification through the lens of device independence, ToDiQT aims to set a new standard for foundational and practically relevant quantum technologies, combining theoretical breakthroughs with pathways toward real-world implementation.

In the long term, this project seeks to provide the theoretical blueprint for reliable, scalable, and certifiable quantum technologies.

quantera-todiqt.github.io/

Areas of research



Duration

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Funding organisations

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- **Belgium: F.R.S-FNRS**
- **France: ANR**
- **Poland: NCN**

ULTRANARROW

Ultranarrow optical and spin transitions in ultrapure crystals

Quantum technologies promise major advances in secure communication, precision sensing, computing, and timekeeping. However, their performance is currently limited by a fundamental challenge: quantum systems are highly sensitive to perturbations from their environment.

Such disturbances can even be caused by single impurity atoms in a material and can quickly destroy fragile quantum states.

The ULTRANARROW project aims to overcome this limitation as much as possible based on two major ingredients:

- First, using quantum emitters that couple very weakly to environmental perturbations
- Second, minimizing these perturbations as much as possible by developing a new generation of ultra-pure materials.

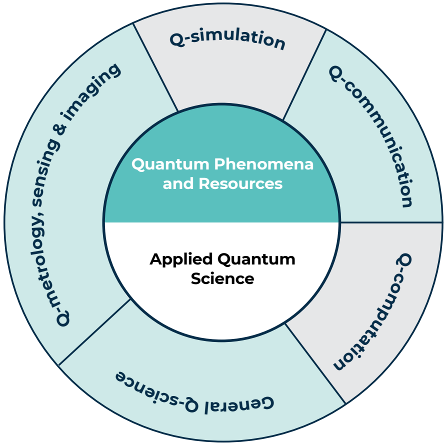
Specifically ULTRANARROW will explore rare-earth atoms embedded in specially engineered calcium tungstate crystals. To this end, the goals are:

- First, to grow ultrapure crystals with extremely low levels of defects and impurities
- Second, to fabricate advanced photonic and quantum devices while preserving the exceptional crystal quality
- Third, to identify operating conditions where the quantum emitters are naturally protected against environmental noise
- Finally, based on the combined results, to demonstrate first applications in precision timekeeping, quantum sensing, quantum memories, and quantum communication.

To achieve the project goals, the consortium combines expertise in crystal growth, nanotechnology, spectroscopy, cryogenics, and quantum optics from leading European research institutions in Germany, France, and the Netherlands. Moreover, the project will contribute to training young researchers and to promoting open science by broadly disseminating results and by making data publicly accessible.

In addition to advancing fundamental science, ULTRANARROW will strengthen Europe's position in quantum technologies by creating a new materials platform with strong innovation and industrial potential.

Areas of research



Duration

September 2026 → August 2029

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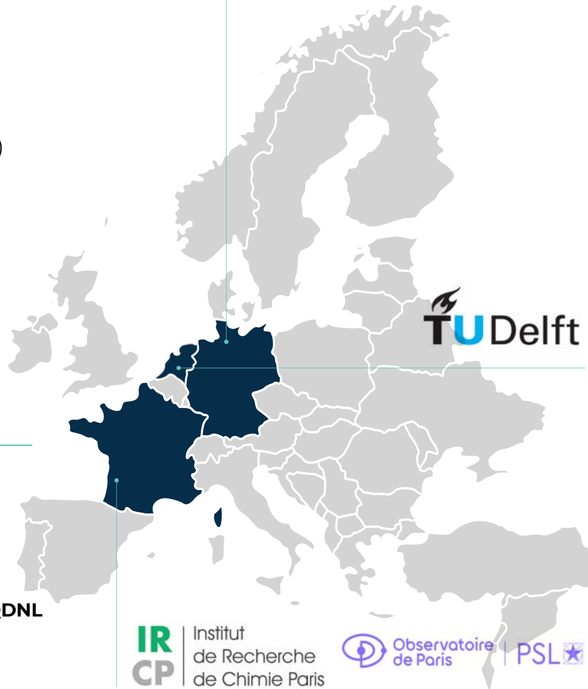
Funding organisations

- **Germany: DFG**
- **France: ANR**
- **Netherlands: QDNL**



AL FreSQO

Atom-Light Free-Space Quantum Optics networking

Quantum entanglement, which allows secure communications and enables more efficient sensing and computation, is a fundamental resource for quantum information technologies and will be distributed by quantum networks. Quantum memories (QMems) will be essential components of quantum networks, enabling long-distance distribution of entanglement with quantum repeaters, acting as quantum information buffers, and providing synchronisation and coordination functionality.

QMems will need to interface with a diverse set of quantum links, operating at different wavelengths, and will often have to operate in remote and challenging environments. QMems will also need to be able to accept high bandwidth quantum signals for greater compatibility with a large range of single photon and entangled pairs sources.

The AL FreSQO project aims to advance the readiness of QMems for deployment by demonstrating cold atom QMems operating in conjunction with free-space quantum optical channels, together with quantum frequency conversion (QFC) from telecoms wavelengths, as well as the development of compatible single photon sources based on hexagonal boron nitride.

These physical platforms have the potential to obviate the need for cryogenic systems, making them more suitable for mobile and remote applications, such as on satellites as part of a global space-based quantum entanglement distribution network.

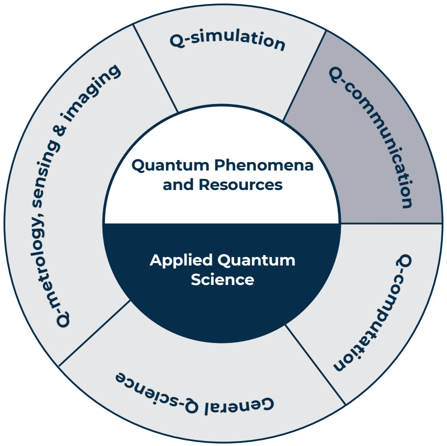
The project will implement high bandwidth QMems and QFC, together with optimised free-space optical channel links, and identify suitable solid state quantum emitters for cold atom coupling.

Ultimately, AL FreSQO will advance the practicality of QMems by demonstrating their integration within a quantum link together with QFC, together with quantum signal sources, expanding their compatibility, and greatly improving their performance.

www.linkedin.com/groups/19661025/

al-fresqo.phys.strath.ac.uk/

Areas of research



Duration

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Funding organisations

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- **Italy: MUR**
- **Germany: BMFTR**
- **Türkiye: TÜBITAK**

APPSUNCAP

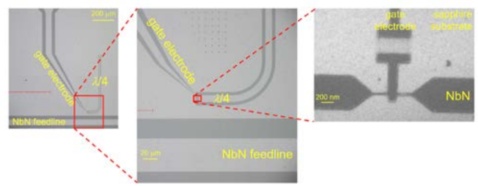
Applications of Superconducting Non-Linear Capacitors

The Josephson junction is the canonical quantum-coherent device whose non-linear *inductive* properties form the foundation of all superconducting circuits. But there are many applications in quantum electronics which require non-linear *capacitive* devices. Furthermore radically new device functionalities can be achieved by combining both non-linear inductors and non-linear capacitors in so-called *doubly non-linear* circuits.

Within APPSUNCAP, quantum applications based on novel devices exploiting the known quantum effect, i.e. coherent quantum phase-slips (CQPS) will be developed, together with new applications in the fields of quantum computing, quantum sensing and quantum metrology.

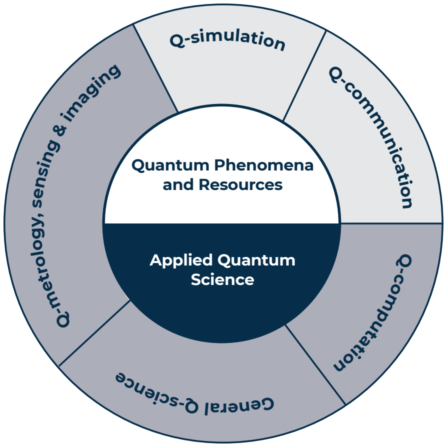
In particular the goals of APPSUNCAP are to develop:

1. Novel radio-frequency parametric amplifiers exploiting the capacitive non-linearity of superconducting nanowires. This will enable quantum-limited amplification of signals generated by quantum devices with high output impedance and improved magnetic-field resilience, and, by combining with Josephson elements, may enable optimal phase matching in travelling-wave amplifiers.
2. Quantum current standards based on dual-Shapiro steps in nanoscale Josephson junctions. This will enable completion of the metrological triangle along with the existing Josephson voltage standard and quantum Hall resistance standard.
3. Radio-frequency coupling structures tailored for thermalising and eliminating spurious lossy and decohering modes in non-linear high-impedance devices. Measurement techniques for their characterisation will be developed using calibrated cryogenic setups.
4. Theoretical models to enable calculation of quantum phase-slip rates in superconducting nanowires of various material composition and disorder, including pseudo-gapped materials close to the superconductor-insulator transition.



Prototype parametric amplifier based on the non-linear capacitance of superconducting nanowires, magnification increasing from left to right.

Areas of research



Duration

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Funding organisations

- **United Kingdom: EPSRC**
- **Slovenia: MIZM**
- **France: ANR**

DEMAND

Deterministic Electrically-driven Monolithic Architecture for quantum Network Distribution

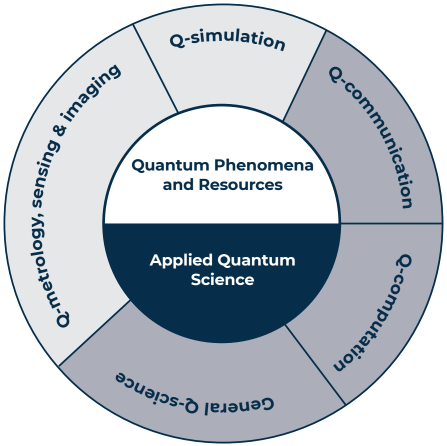
The DEMAND project aims to solve a major roadblock in the development of practical, large-scale quantum technologies. Currently, the single-photon sources required for secure quantum communication rely on large, power-hungry setups with complex external lasers that are difficult to align and connect to existing optical fibre networks. DEMAND will replace these bulky, fragile systems with a single, compact, and robust microchip.

To achieve this, the project's main objective is to pioneer a novel "epitaxy-to-application" manufacturing approach. Unlike previous technologies that forced a compromise between high performance and compact size, DEMAND will deliver the world's first fully monolithic, electrically driven, deterministic single-photon source. By engineering both the active pump laser and the passive quantum circuitry onto a single Indium Phosphide chip, the project entirely eliminates the need for complex optical alignments and reduces environmental vulnerabilities. This innovative integrated design will produce highly pure, indistinguishable single photons on-demand at exceptionally fast rates of over 1 GHz. Furthermore, because the device operates in the telecom C-band and is fibre-packaged, it guarantees full compatibility with standard telecommunications infrastructure.

A further key objective of the project is to validate this groundbreaking technology outside the laboratory. The consortium will deploy the newly packaged, multi-channel chip on the live, fibre-based Geneva Quantum Network to test its ability to distribute and process quantum information in a real-world setting.

Ultimately, DEMAND provides an essential hardware blueprint for scalable quantum networks, moving these vital communication tools from experimental testbeds towards robust, commercial deployment.

Areas of research



Duration

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- **Robert Thew**
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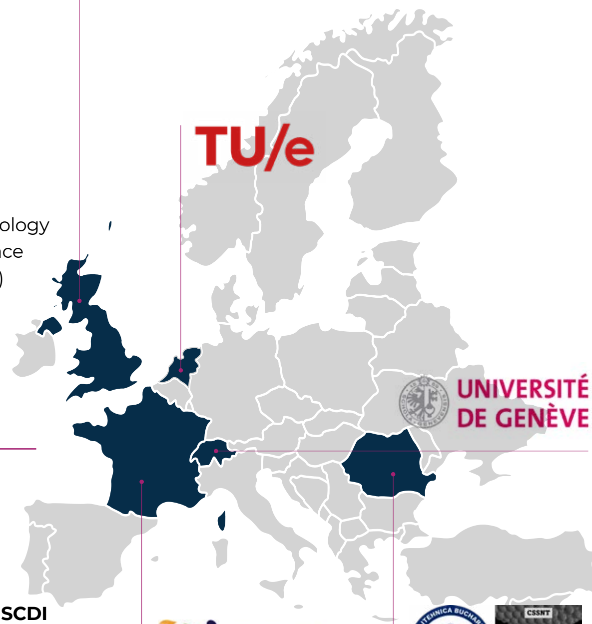


Funding organisations

- **United Kingdom: EPSRC**
- **France: ANR**
- **Netherlands: QDNL**
- **Romania: UEFISCDI**
- **Switzerland: SNSF**

DISQO

DISorder-tailored Quantum Optical Sensor

Modern biology and chemistry rely on advanced imaging and sensing techniques to study delicate systems like living cells, fragile tissues, and sensitive chemical reactions. However, standard microscopes and sensors often require bright light that can permanently damage or alter these fragile samples.

While “quantum sensing” offers a solution by using non-classical optical sources at extremely low, safe intensity levels, current quantum devices are rigid, difficult to tune, and struggle to perform outside of ideal laboratory conditions.

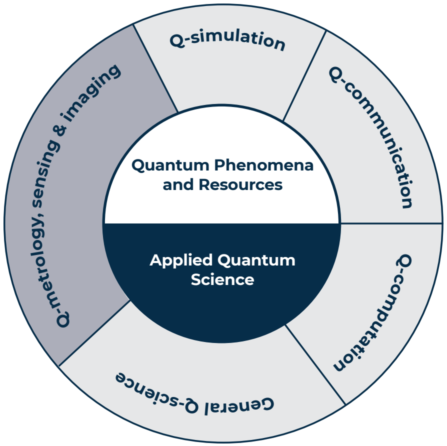
The DISQO project will solve this by building a practical, next-generation quantum sensor that actually adapts to the real world. Instead of relying on traditional, fixed light sources, the international research team will develop innovative “disorder-tailored” light sources.

By passing lasers through specially engineered, complex materials (e.g. advanced optical fibers and crystals), the system will generate tunable pairs of photon pairs perfectly matched to the specific sample being studied.

Combined with an ultra-fast and sensitive camera to detect entangled photons, this adaptable system will allow scientists to measure microscopic structures and chemical concentrations with unprecedented precision.

Ultimately, DISQO will deliver a working prototype capable of non-invasively imaging highly sensitive biological tissues - such as the retina or living bacteria - and delicate chemicals, opening new frontiers in science without destroying or altering the things we are trying to observe.

Areas of research



Duration

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Funding organisations

- **France: ANR**
- **Germany: BMFTR**
- **United Kingdom: EPSRC**
- **Czechia: TACR**

EXCEL-QKD

Exploration of Cell-free Quantum Key Distribution

As our society becomes increasingly dependent on digital technologies, protecting sensitive information is more important than ever. Quantum Key Distribution (QKD) is one of the most promising technologies for future-proof cybersecurity because it uses the laws of quantum physics to create encryption keys that cannot be secretly intercepted. However, current QKD systems have an important limitation: they usually rely on a single transmitter and a direct optical link, making them vulnerable to obstacles, movement, or misalignment. The EXCEL-QKD project aims to overcome these limitations by developing the world's first cell-free quantum key distribution system. Instead of relying on a single transmitter, several distributed quantum transmitters will work together to communicate with a receiver. If one communication path becomes blocked, others can continue operating, making the system far more reliable and resilient.

To achieve this, the project will combine:

- advanced quantum light sources,
- highly sensitive single-photon detectors,
- and innovative communication protocols that use both the location and timing of detected photons.

These new methods will allow the system to identify and reconstruct signals coming from different transmitters while maintaining strong security guarantees.

Over three years, researchers from Spain, the Czech Republic, and Luxembourg will design, build, and test a laboratory demonstrator of this new architecture. The project will evaluate its performance under realistic indoor conditions, including situations where communication links are partially blocked or deliberately attacked.

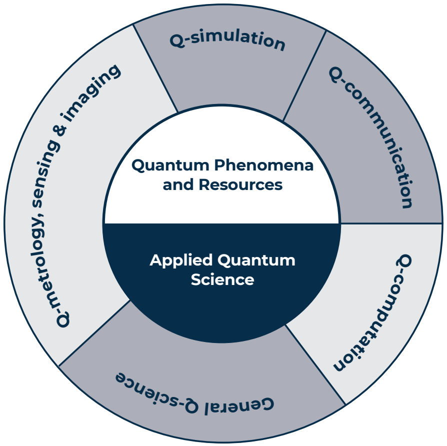
The expected outcome is a new generation of quantum communication systems that are more robust, scalable, and practical than current solutions. In the long term, EXCEL-QKD could support secure communications in hospitals, industrial facilities, smart buildings, Internet of Things environments, and future 6G networks.

By establishing the foundations of distributed quantum communications, the project will contribute to Europe's strategic goals in cybersecurity, digital sovereignty, and advanced quantum technologies.

www.linkedin.com/company/excel-qkd/

excel-qkd.vercel.app/

Areas of research



Duration

September 2026 → August 2029

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Funding organisations

- **Spain: AEI**
- **Luxembourg: FNR**
- **Czechia: TACR**

FALCON

Fault tolerant control of warm ions

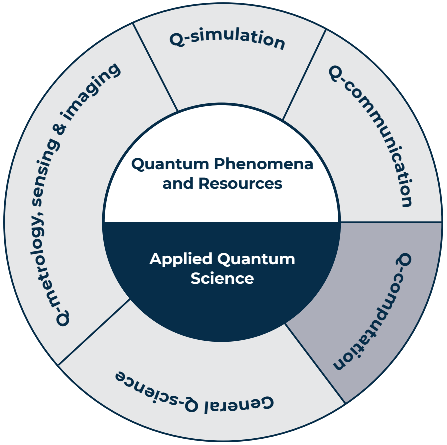
Quantum information processing promises to tackle challenges in fundamental physics as well as support novel solutions in industry ranging from chemistry to material sciences. Different technologies such as neutral atoms, superconducting circuits, trapped-ions, and other approaches look highly promising.

Here, trapped-ions promise to offer the lowest native error rates. Lower error rates reduce the resource overheads for large-scale fault-tolerant quantum computing, and thus demonstrations of a quantum benefit over classical solutions may be achieved earlier.

Within this project, the performance of trapped-ion systems will be improved and their sensitivity to both systematic and stochastic error sources will be reduced through a combination of control signal modulation and dynamical decoupling.

The targeted low error rates will facilitate quantum error correction, scaling, and demonstrating quantum benefits at an accelerated pace.

Areas of research



Duration

September 2026 → August 2029

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- **Kaloyan Zlatanov**
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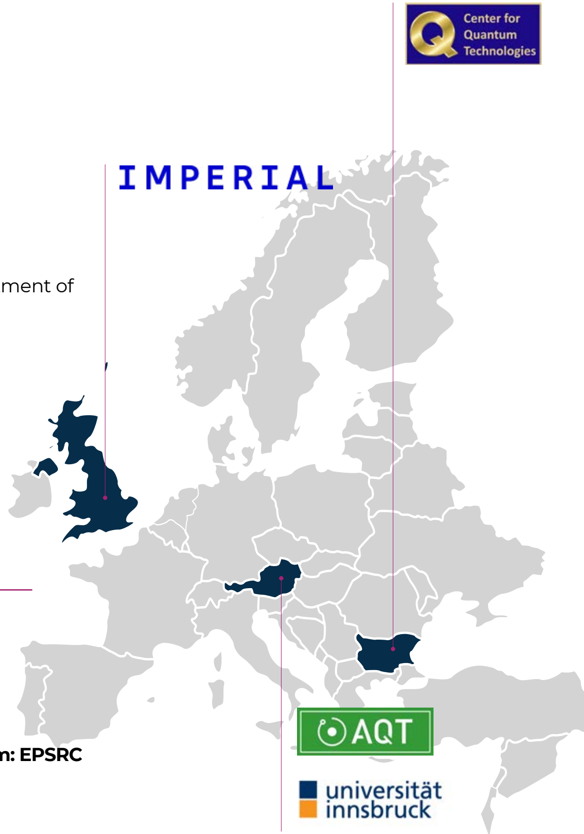
  Imperial College London (UK)



Funding organisations

- **Austria: FFG**
- **Bulgaria: BNSF**
- **United Kingdom: EPSRC**

ICON

Hollow Core Fibers for Quantum Communication with Quantum Dots

Secure communication is a cornerstone of modern society. Financial transactions, healthcare records, and critical infrastructure all rely on encryption to protect sensitive information. However, the emergence of quantum computers threatens to undermine many of the cryptographic methods currently used to secure digital communications.

The main objective of ICON is to develop a practical and scalable quantum communication platform for the future. Quantum communication offers a fundamentally different approach to security: instead of relying on mathematical complexity, it uses the laws of physics to ensure that any attempt to intercept information can be detected.

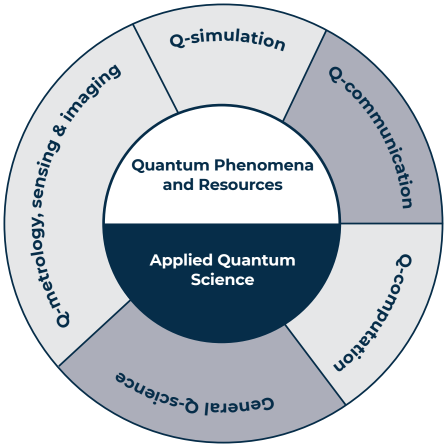
Current quantum communication technologies face a major challenge. The most promising quantum light sources operate at wavelengths not well suited to conventional optical fibers, requiring complex and inefficient conversion processes that increase cost and reduce performance. ICON turns the problem around: rather than adapting the quantum devices to existing fiber technology, the project develops optical fibers designed specifically for the quantum light sources themselves.

These advanced hollow-core fibers guide light through air instead of glass, optimized for the wavelength where semiconductor quantum-dot sources perform best. They also support quantum and classical communication channels simultaneously — essential for coordinating real-world networks. A dedicated effort develops ultra-low-loss connectors to standard fibers already installed in cities worldwide, ensuring integration into existing infrastructure. Together, these advances allow the use of simple silicon-based detectors rather than the expensive cryogenic detectors required by conventional systems, significantly reducing cost and complexity.

To demonstrate the technology, the project will build a three-user quantum-secured network distributing entangled photons over kilometer-scale hollow-core fiber, showcasing protocols where no single participant can access the complete secret alone.

ICON brings together leading academic and industrial partners from Austria, the United Kingdom, and the Czech Republic, combining expertise in quantum photonics, fiber technology, fiber engineering, and quantum cryptography to lay the foundations for secure communication in the quantum era.

Areas of research



Duration

September 2026 → August 2029

Consortium

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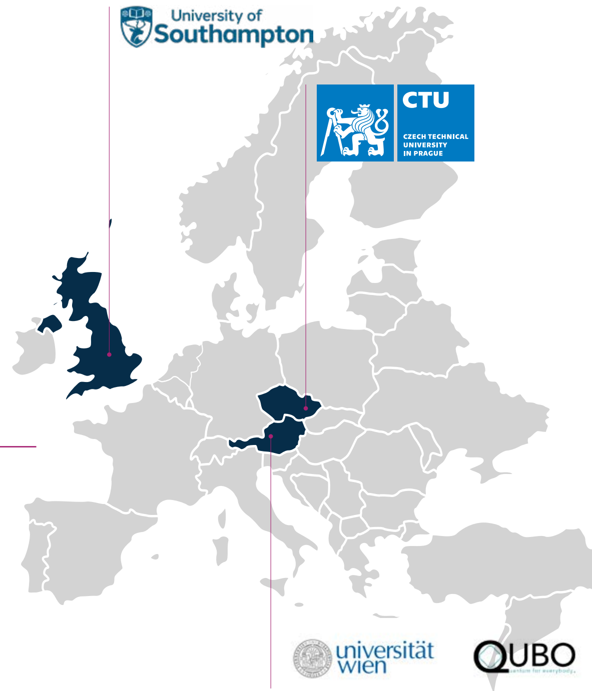


Funding organisations

- **Austria: FFG**
- **Czechia: TACR**
- **United Kingdom: EPSRC**

IgnisQNC

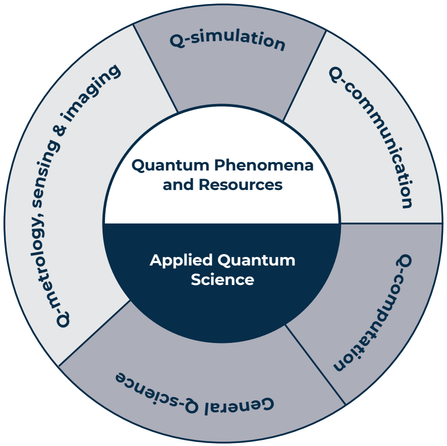
Harnessing Quantum Uncertainty for Trustworthy Quantum Neural Computing

The project develops Quantum Neural Computing (QNC), a new approach to quantum-powered AI that exploits quantum probabilistic information processing to build uncertainty-aware intelligent systems. By integrating quantum representations into machine learning, QNC investigates whether quantum-generated probabilistic structures can improve learning robustness, computational expressivity, and adaptability on emerging quantum hardware.

IgnisQNC combines quantum physics, machine learning, and explainable AI to develop intelligent systems that are not only powerful but also transparent and interpretable. The team will evaluate these approaches on real quantum computing platforms, including IBM, Google, D-Wave, and European quantum infrastructures, targeting applications such as biometrics, medical diagnostics, and financial forecasting.

By rethinking how quantum computers can learn and process information, IgnisQNC aims to establish new principles for quantum-enhanced artificial intelligence, enabling future intelligent systems that can better represent, quantify, and reason with uncertainty in complex real-world environments.

Areas of research



Duration

September 2026 → September 2029

Consortium

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Funding organisations

- **United Kingdom: EPSRC**
- **Spain: AEI**
- **Germany: BMFTR**

IQNoVa

Interconnected Quantum Nodes Benchmarking and Validation

Quantum networks, which connect quantum processors over distance, are a key enabling technology for secure communication, distributed quantum computing, and advanced sensing applications. While individual quantum systems have demonstrated impressive capabilities, the scalability of standalone quantum processors is fundamentally limited by noise, device imperfections, and limited protocols. Distributed quantum computing, in which modular quantum processors are interconnected through quantum links, offers a practical path to overcoming scalability limitations by enabling collaborative processing across multiple quantum nodes and increasing computational power beyond those of single processors.

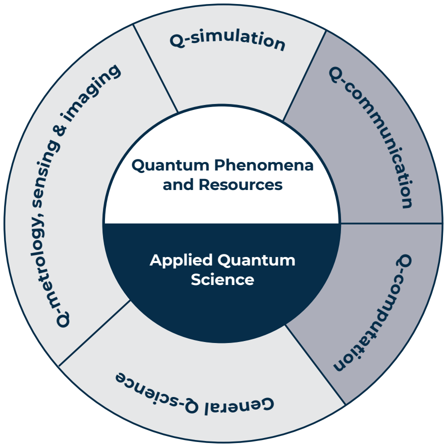
Despite rapid experimental and theoretical progress, the development of robust and scalable quantum processor networks remains a key challenge. Network performance is constrained not only by physical losses in quantum channels but also by local operational errors, suboptimal link protocols, and imperfect node integration. Existing methods for evaluating quantum networks focus mainly on individual links between two nodes, while the performance of larger, interconnected systems remains difficult to assess. Similarly, benchmarking approaches for multi-node quantum systems are still in their early stages. Reliable benchmarking and validation are essential for building scalable, resilient, and interoperable quantum infrastructures across multiple nodes.

This project addresses this challenge by developing a comprehensive framework for benchmarking and validating interconnected quantum nodes. The framework will enable both layer-specific assessments and end-to-end evaluation of quantum information flow between nodes. Performance metrics will quantify entanglement distribution fidelity, error propagation, and distributed computational throughput, while utility-based measures will evaluate the network's ability to support multi-node tasks, including distributed quantum computing and quantum-secure communication.

The project will also develop a software suite for standardizing and benchmarking distributed quantum computing systems. It will define unified metrics and evaluation workflows for multi-node quantum systems. These methods will be tested experimentally on optically connected spin-based quantum nodes.

The resulting quantitative performance data will support the development of practical distributed quantum applications.

Areas of research



Consortium

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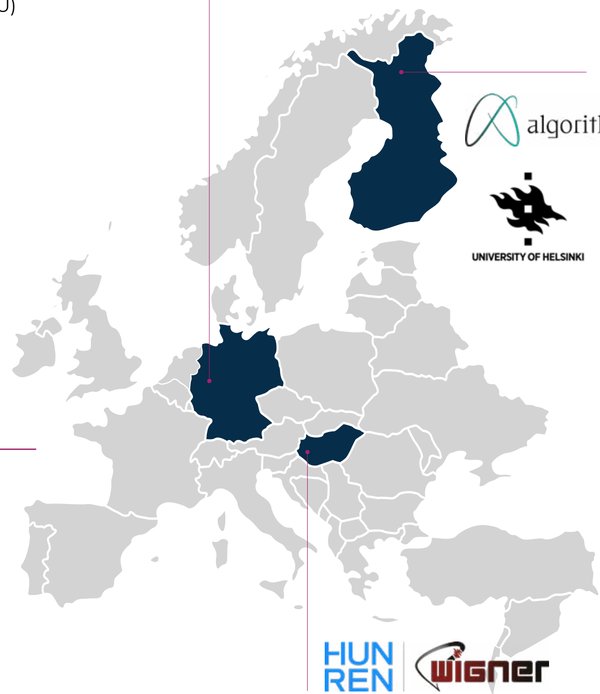


Duration

December 2026 → November 2029

Funding organisations

- **Hungary: NKFIH**
- **Germany: BMFTR**
- **Finland: AKA**

LINQSENS

Loss-tolerant INtegrated Quantum SENSors based on nonlinear interferometry

Tracking the greenhouse gases driving climate change – such as carbon dioxide and methane – requires extreme precision. From enforcing environmental regulations to monitoring industrial leaks, detecting microscopic fluctuations in gas concentrations is vital. Yet the optical sensors we currently rely on hit a fundamental physical wall. No matter how well they are engineered, they are ultimately limited by classical noise, a baseline level of background interference that masks the faintest chemical signatures.

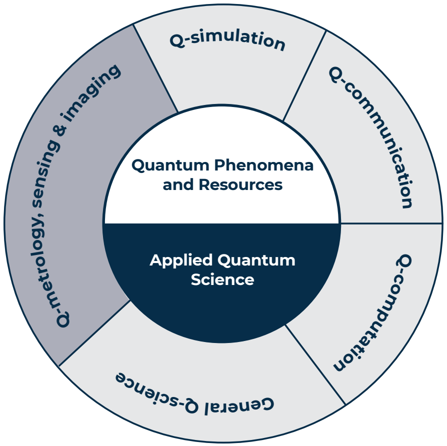
To push past this barrier, researchers are turning to quantum physics. LINQSENS aims to harness quantum states of light to achieve unprecedented sensitivity. However, bringing quantum technology out of the lab and into the real world is notoriously difficult. Quantum states are inherently fragile; in traditional setups, losing even a fraction of the light particles, or photons, causes the entire measurement to collapse.

LINQSENS is circumventing this fragility by engineering resilient quantum sensors based on quantum optical circuits and novel photon detection. Rather than relying on delicate setups that fail when light scatters, targeted phase-sensitive optical amplification is used. Paired with novel detectors that allow more information to be extracted from rich quantum correlations, these sensors achieve sub-shot-noise sensitivity even in the presence of the inevitable photon loss that occurs in real-world environments. This allows them to maintain their extreme precision where earlier quantum sensors would fail.

Crucially, this technology will not be confined to a sprawling laboratory bench. LINQSENS will shrink these quantum circuits onto compact, integrated photonic chips made from a specialised material called thin-film lithium niobate. As a proof of concept, the project will develop two deployable prototypes tailored specifically to detect carbon dioxide and methane. When target gases drift across the chip, they subtly alter the phase of the light travelling through it. The quantum-enhanced photons can measure these microscopic shifts with an accuracy that far surpasses standard devices.

By benchmarking these advanced chips against classical technology, the LINQSENS project aims to prove that quantum sensing can survive—and thrive—in imperfect conditions. It will lay the groundwork for a new generation of rugged, ultra-precise sensors, fundamentally transforming metrology and environmental monitoring.

Areas of research



Duration

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Funding organisations

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- **Switzerland: SNSF**
- **Spain: AEI**

Q-SPEC3D

Quantum-enabled SPECtral 3D imaging and estimation

Q-SPEC3D develops a new generation of imaging technologies capable of extracting more information from light than conventional cameras and microscopes . The project exploits fundamental properties of light – spatial coherence and photon correlations – to overcome long-standing limitations in image quality, sensitivity, and information content. Its most groundbreaking output is the world's first class of scan-free spectrally resolved 3D imaging devices based on photon correlations.

Current advanced imaging techniques rely on massive data collection, long acquisition times, and complex reconstruction procedures. Q-SPEC3D addresses these challenges by developing theoretical and experimental tools that identify and exploit only the most informative components of the optical signal. This reduces measurement complexity while preserving – or improving – imaging performance, yielding faster acquisition, enhanced image quality, and greater robustness under low-light conditions.

Another objective is to develop optimal methods for extracting physical information from light. By unifying quantum optics, statistical inference, and computational imaging, the consortium will design measurement and reconstruction strategies capable of estimating spatial, spectral, and depth information with unprecedented precision.

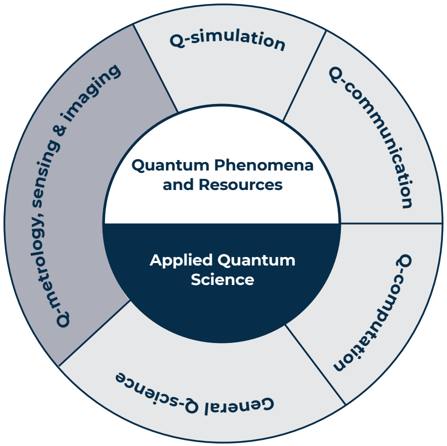
Building on these advances, Q-SPEC3D will realise the first imaging systems capable of simultaneously acquiring three-dimensional and spectral information without mechanical scanning. A single measurement will reveal position, depth, and spectral signatures of objects and materials — overcoming a fundamental bottleneck, since current systems require multiple acquisitions or moving components to obtain equivalent information.

Target applications span:

- biomedical imaging,
- fluorescence diagnostics,
- environmental monitoring,
- remote sensing,
- precision metrology,
- cultural heritage analysis.

By combining fundamental advances in quantum-enabled measurement with practical demonstrators, Q-SPEC3D will strengthen Europe's leadership in quantum sensing and imaging while opening new horizons for scientific discovery and industrial innovation.

Areas of research



Duration

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Funding organisations

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- **France: ANR**
- **United Kingdom: EPSRC**

Quanti-PEP

multi-modal Quantum Imaging of cellular metabolism for high throughput screening for peptide-based cancer vaccines

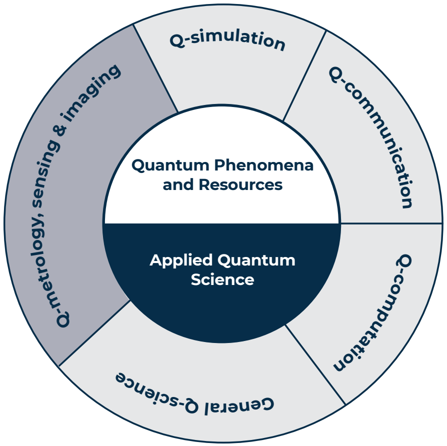
Cancer immunotherapies, particularly personalized cancer vaccines, represent a major breakthrough in modern medicine. These vaccines work by training a patient's own immune system to recognize and destroy tumors using tumor-specific „peptides" tiny protein fragments found on cancer cells that act like a genetic fingerprint. When the correct peptides are introduced, they trigger immune cells (T cells) into action. However, a major bottleneck in developing these treatments is the testing phase. Current laboratory methods are slow, complex, and require millions of patient cells just to screen a fraction of potential candidates. Furthermore, they only capture delayed "snapshots" of immune responses, routinely missing crucial dynamic changes in cell behavior.

The Quanti-PEP project aims to revolutionize this process by creating a pioneering, high-speed screening platform that uses advanced quantum technology to monitor immune cell activation in real time. Instead of waiting days for results, this new platform will detect the very first chemical and metabolic signs of an immune cell engaging with a cancer peptide within seconds to hours. It achieves this by tracking nanodiamonds and specialized single-photon cameras to simultaneously measure vital signs inside cells such as calcium spikes and energy shifts with nanoscale precision.

Additionally, the platform integrates wireless "smart" magnetic nanorods. Using external magnetic fields, these nanorods can physically nudge immune cells and release peptides exactly when and where they are needed, creating a highly controlled test environment. By providing a comprehensive footprint of cell activation using up to 10-fold fewer cells, Quanti-PEP will dramatically accelerate the timeline and reduce the costs of discovering effective cancer vaccines. The consortium will initially validate this technology on glioblastoma, a highly aggressive brain tumor with an urgent need for better treatments.

Ultimately, Quanti-PEP will establish a faster, more accurate pathway toward personalized therapies, paving the way for next-generation cancer care in Europe and beyond.

Areas of research



Duration

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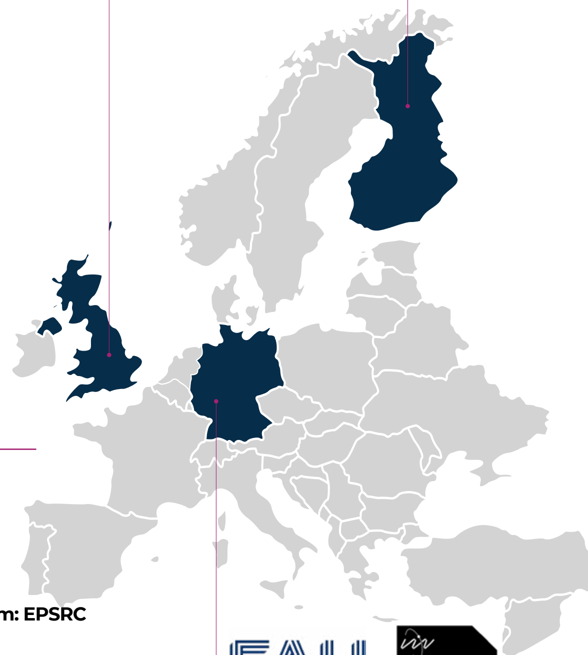
Funding organisations

- **Germany: BMFTR**
- **Finland: AKA**
- **United Kingdom: EPSRC**



QuantLIGs

Quantum Tuning of “Laser Induced Graphene” for Sensing

QuantLIGs project will explore sustainable and green graphene functional materials for flexible electronics for sensing, wearables and implants by exploiting small footprint, portable ultrafast turnkey laser technology, and laser inscription of conducting structures. The project consortium will create processes that translate quantum applications into devices, products and industrial applications.

QuantLIGs is an interdisciplinary collaboration between the Polymer Photonic Research Group at University of Galway, the Laser Engineering Research Group at University of Liverpool, UK and the Measurement Science Group at NORCE Research in Norway.

The project will harness collaborative advanced interdisciplinary science and cutting-edge engineering, to transfer Quantum Technology from the lab, to industry, and position Europe as a leader in promising future technology areas for materials and devices.

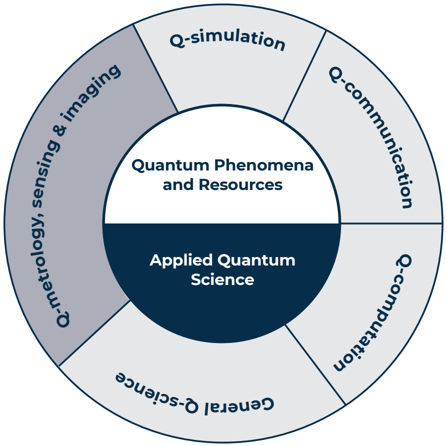
The project will use laser light to optically tune the bandgap of Graphene for sensor applications by:

- Using a digitally controlled ultrafast laser to inscribe 3D porous Graphene inside flexible polymers such as polyimide, to create conducting carbon structures.
- Using digitally controlled adaptive optics and holographic inscription to programme the beam profile and determine the polarisation state of the inscribing laser beam, to tune the bandgap to digitally control semiconductor properties of Graphene.
- Inscribing conducting vias and sensor structures, and characterise them to form building blocks for devices.
- Demonstrating quantum operation of laser-inscribed graphene devices for applications in flexible electronics and thin conformable coatings including:
- Carbon quantum dots for emission and fluorescence at designed wavelengths.
- Transparent photovoltaic carbon structures to detect light.

These tailored graphene and carbon dot materials will be applied to medical, environmental sensors, and photovoltaics. The structures generated can be used as medtech sensors for medical diagnostic tools, carbon quantum dots for light emission at defined wavelengths, photovoltaics for solar cells, and quantum devices in medical wearable and implant sensors, using bendable nanomaterials. They can also be used in environmental applications such as sea-water pH sensing.

www.linkedin.com/groups/29190003/

Areas of research



Duration

September 2026 → September 2029

Consortium

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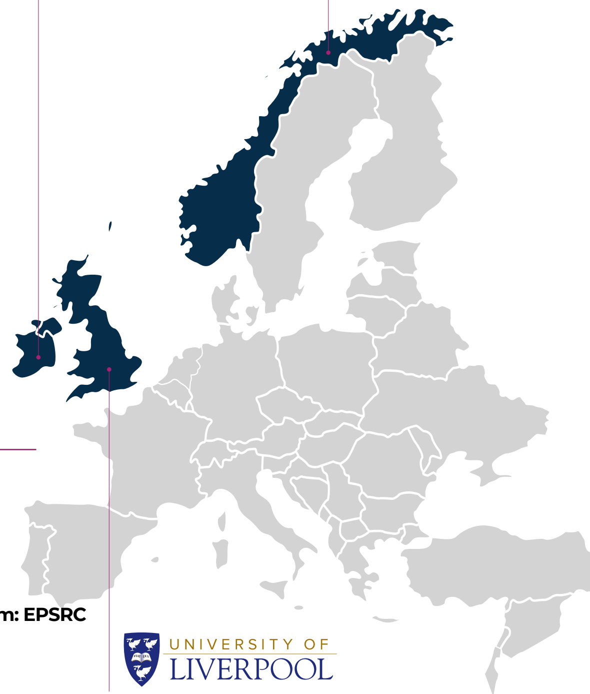
Ollscoil na Gaillimhe University of Galway

NORCE



University of Liverpool

Funding organisations

- **Ireland: TÉ - RI**
- **Norway: RCN**
- **United Kingdom: EPSRC**

Quantum4Health

Quantum Imaging System for Intraoperative Highly Effective Diagnostics Allowing Gentle Tumor Surgery and High Impact for Healing

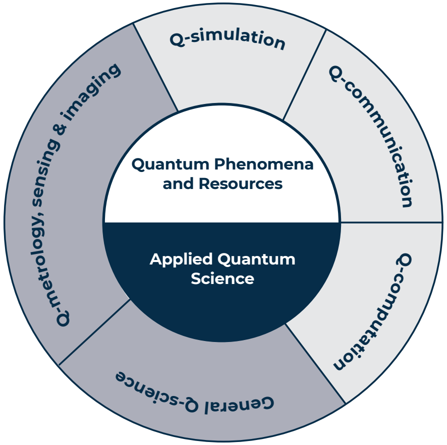
The project Quantum4Health aims to develop a diagnostic medical device based on mid-infrared spectrally-resolved quantum imaging with undetected photons, employing correlated near-/mid-infrared (NIR/MIR) photon-pair sources enabled by a novel Orientation--Patterned Gallium Phosphide (OP-GaP) material platform.

This diagnostic tool will enable the margins of skin tumors on the face to be diagnosed during surgery, ensuring their complete removal from healthy tissue. This enables a minimally invasive surgical procedure and at the same time ensures that the tumor has been completely removed during the operation. This avoids the need for repeat surgery, which is necessary in 15% of all cases operated on when the pathologist diagnoses the presence of residual tumor in healthy tissue postoperatively.

Intraoperative detection is made possible by a quantum light source that generates entangled NIR/MIR photon pairs – signal photons in NIR, and idler photons in the MIR wavelength range between 5.7 μm and 9 μm, where healthy and tumor tissue have different characteristic absorption peaks (fingerprinting). Exploiting the quantum entanglement between the NIR and MIR photons, the absorption of MIR idler photons can be measured indirectly via the detection of NIR signal photons using low-noise and cost-effective semiconductor detectors.

Based on deep learning algorithms, spectral information can be evaluated in real time and used to distinguish between tumor and healthy tissue. The principle of attenuated total reflection (ATR) is used to examine the tumor margins. The cross-sections of the resection margins are brought into contact with a high refractive index prism, on the surface of which part of the incident MIR light, which is irradiated at the angle of total reflection, interacts with the tissue. The unabsorbed MIR radiation is reflected back and brought into quantum interference with the entangled photons and the pump light. The absorbed MIR photons can be quantified as a change in modulation in the interference spectrum.

Areas of research



Duration

November 2026 – October 2029

Consortium

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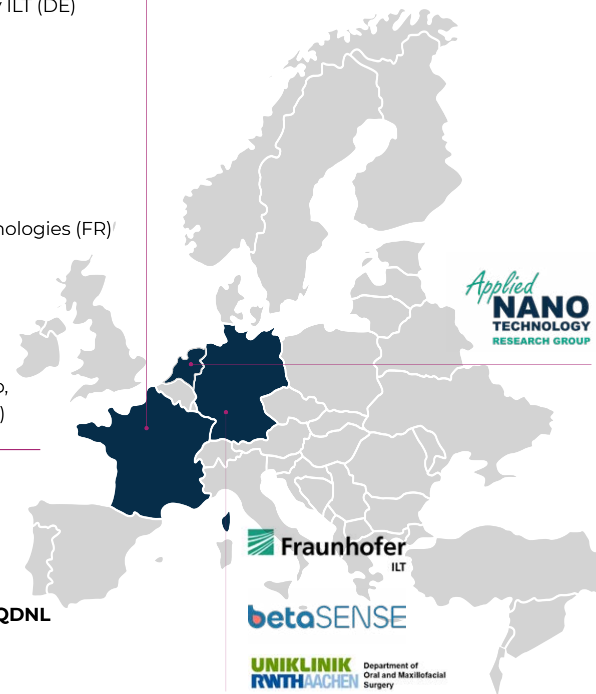
Funding organisations

- **Germany: BMFTR**
- **France: ANR**
- **Netherlands: QDNL**



QUICFIRE

QUantum Internet Components in all-FIbre REalisation for low-loss entanglement distribution

The future quantum internet, where users can share quantum information, access remote quantum computers, and securely exchange messages or business transactions, will rely on one crucial resource: high-fidelity quantum entanglement shared between users which can be generated and distributed at high rates over large distances. Single photons are the ideal carrier for the distribution of entanglement because of their weak interaction with the environment, propagation at the speed of light, and their compatibility with the existing fibre-optical communication networks.

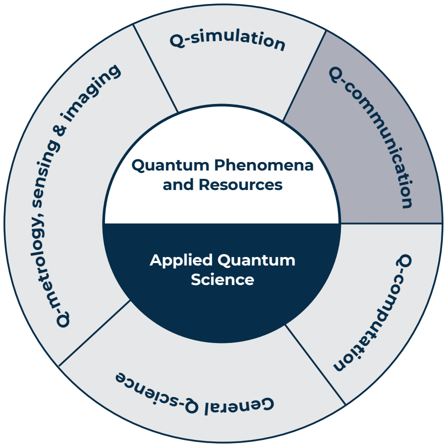
However, a new generation of fibre-integrated components is required that avoids the losses incumbent in current technology, since classical amplifiers cannot be used in single-photon quantum communication without destroying the entanglement carried by the photons.

This is what QUICFIRE will address:

- **fast, efficient and fibre-integrated heralded sources of entangled photon pairs,**
- **fast and low-loss fibre switches,**
- **a novel architecture featuring frequency-multiplexing for the distillation of high-purity, high repetition rate distribution of quantum entanglement across a fibre network.**

The project team consists of researchers from the Universities of Bath and Southampton (UK), the University of Warsaw (Poland), the Technical University of Vienna and industrial partner qtlabs (Austria). The consortium combines expertise in fibre technology, microfabrication, optical communications, nonlinear and quantum optics, photonics simulation, quantum information theory, and the input of two commercial quantum technology partners to bring about this step change in quantum internet capability.

Areas of research



Duration

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Consortium

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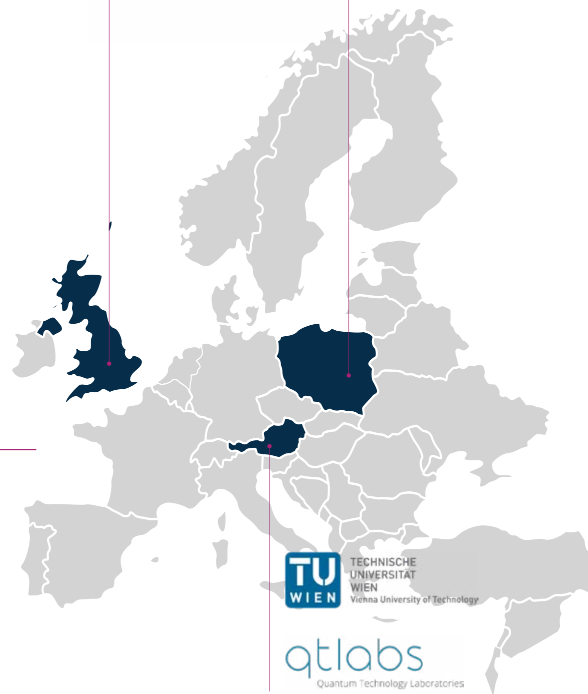


Funding organisations

- **United Kingdom: EPSRC**
- **Poland: NCBR**
- **Austria: FFG**

SINPHONI

On-chip Moiré Single-Photon Emitters for Quantum Communications

The key ingredient for future quantum technologies is a source of single particles of light, called single photons. These photons must be generated one by one, with high quality and in a controlled way, so that they can be used to carry and process information in future quantum communication protocols.

SINPHONI will explore a new strategy based on atomically thin materials, known as two-dimensional transition-metal dichalcogenides. When two of these materials are stacked with a small twist between them, they form a moiré pattern: a periodic landscape where tiny quantum light sources can appear in nanometer-sized regions, similar to artificial atoms embedded in an ultra-thin material.

A key goal of SINPHONI is not only to create these light sources, but also to control them in a reversible and programmable way. To achieve this, SINPHONI will use small piezoelectric actuators integrated on a chip. These actuators can gently stretch the material and thereby tune the colour of the emitted single photons while controlling their polarization state. This approach will make it possible to adjust individual emitters independently, while keeping their quantum-light emission properties intact.

The project will also improve the brightness of the emitters by coupling them to microscopic optical cavities, which help collect the emitted photons more efficiently. At the same time, advanced optical experiments and theoretical modelling will be used to understand how local strain, the moiré landscape and the quality of single-photon emission are connected.

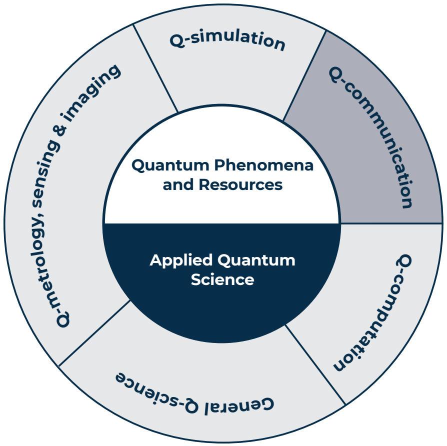
SINPHONI brings together nine partners from six European countries, combining expertise in 2D materials, nanofabrication, optical characterization, theoretical modelling and industrial reliability assessment.

By the end of the project, SINPHONI will aim to demonstrate a compact chip hosting multiple, independently tunable moiré single-photon emitters. This would represent an important step towards practical and scalable quantum light sources for future quantum communication and quantum information technologies.

www.linkedin.com/in/sinphoni-quantera-228880415/

www.sinphoni-quantera.eu

Areas of research



Duration

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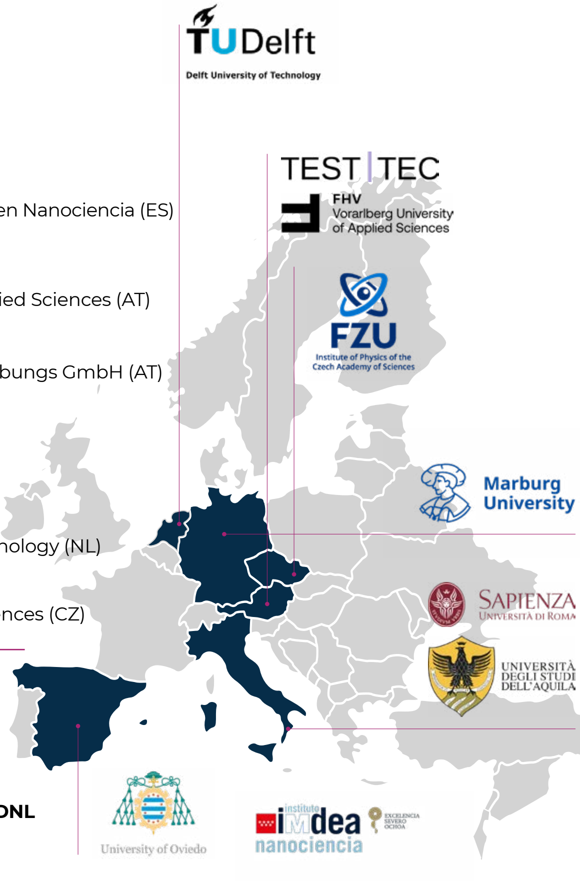


Funding organisations

- **Spain: AEI**
- **Germany: BMFTR**
- **Austria: FFG**
- **Italy: MUR**
- **Netherlands: QDNL**
- **Czechia: TACR**

TeRaRy

Precision terahertz-radiation detection with Rydberg atoms

Electromagnetic radiation in the gigahertz to terahertz frequency range (centimetre to millimetre waves) is notoriously difficult to detect at the single-photon level. This is due to the small photon energy, which implies that cryogenic cooling is required in solid-state sensors to reach single-photon sensitivity.

The available technologies – such as transition-edge sensors and superconducting nanowire single-photon detectors – must be operated at extreme cryogenic temperatures, are barely tunable in their sensitivity window, and cannot operate in high magnetic fields. This limits their use both in industrial applications, such as high-sensitivity imaging for material characterisation, and in fundamental research, such as particle detection and dark-matter searches.

TeRaRy will aim to overcome all these limitations by developing non-linear atomic sensors that work in non-thermal regimes. For this, Rydberg states will be utilised – highly excited atomic states – that are not populated at room temperature, and that are long-lived, spectrally tunable, highly susceptible to gigahertz and terahertz radiation, and strongly interacting.

Two complementary strategies will be pursuit to reach single-photon sensitivity:

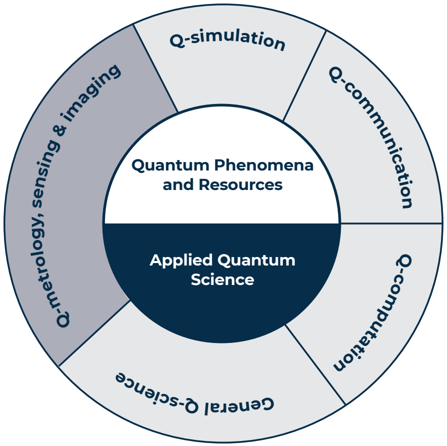
- An avalanche amplification scheme, in which a single absorbed photon triggers a cascade of thousands of Rydberg excitations that are easily detected.
- An interferometric scheme, in which a photon stored as a Rydberg polariton in a cold atomic ensemble is read out optically with high sensitivity.

Because the sensing frequency can be tuned by selecting different atomic states, and because the sensors rely on well-known atomic properties, they are inherently tunable and self-calibrating.

In a multi-national collaboration between academic and industrial partners in Germany, Italy, the United Kingdom and France, the project team will:

- demonstrate the fundamental capabilities of these novel sensors,
- characterise their performance against the state of the art,
- explore pathways towards practical, deployable devices.

Areas of research



Duration

September 2026 → September 2029

Consortium

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Funding organisations

- **Germany: BMFTR**
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- **Italy: MUR**
- **United Kingdom: EPSRC**

µQOC

Microcombs for Quantum Optical Clocks

Atomic clocks underpin much of the technology that defines the modern world, from the internet, finance and GPS to cutting-edge experimental physics and astronomy. They work by shining electromagnetic waves onto a collection of identical, isolated atoms to excite them into a higher energy state. This can only happen if the waves precisely match the atomic transition frequency, which is proportional to the energy difference between the two states. As the atoms are simple, identical quantum systems, their transition frequencies are also equal and highly insensitive to the environment. We can thus realise an extremely precise clock by constantly fine-tuning the wave's frequency to excite the most atoms, and counting its cycles.

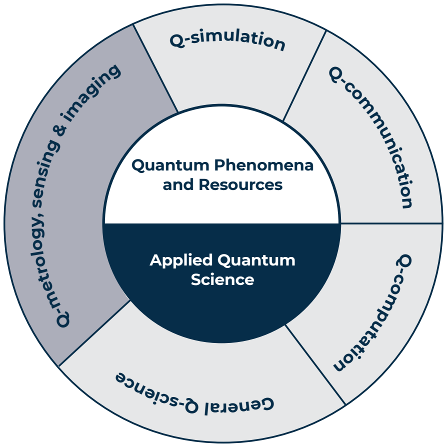
Almost all current commercial atomic clocks are microwave clocks, so-called because they use atomic transitions with frequencies of a few GHz. The best are stable to around one second in 300 million years. Over the last 2-3 decades however, a new generation of atomic clocks has been in development, which instead use optical transition frequencies. At hundreds of THz, these high frequencies allow optical clocks to reach stabilities 100 times greater than microwave clocks, enabling them to be used to detect gravitational potential differences equivalent to 1 cm in height at the Earth's surface, thanks to General Relativity.

Unlike microwaves however, optical frequencies cannot be counted electronically, so they must first be divided down to a microwave frequency. This is done using optical frequency combs, which are pulsed lasers that output up to around a million exactly equally spaced frequencies of light simultaneously. By making these combs span a factor of two in frequency, or an octave (a term borrowed from music), it is possible to use them like gears to measure frequency ratios via a technique known as self-referencing.

Recently, portable optical clocks have begun to emerge, whose greater precision for a given size compared to microwave clocks could transform existing applications and unlock many new ones. Currently however, frequency combs are expensive hand-built devices with volumes of a few litres or more, which could prevent optical clocks becoming truly miniature or mass-market.

In this project, we will get around this limitation by developing a robust, mass-producible, self-referenced frequency comb with a volume of just a few cm^3, based on an entirely different physical mechanism realised in ultra-low-loss on-chip optical waveguide ring resonators.

Areas of research



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Funding organisations

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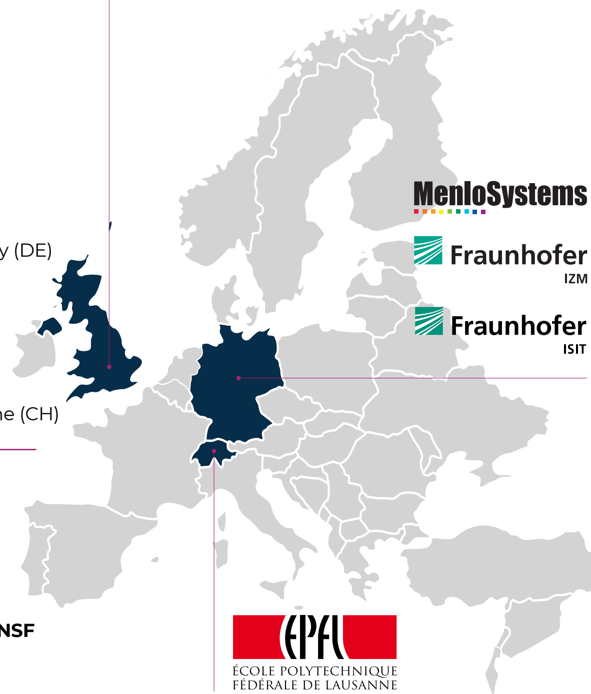

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