Munich Quantum Valley

Public Annual Report

2024

www.munich-quantum-valley.de

Munich Quantum Valley

Public Annual Report 2024

April 2025

Welcome address of the Bavarian Minister for Economic Affairs, Regional Development and Energy

– *Hubert Aiwanger*

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As part of our Hightech Agenda, Bavaria proudly supports the Munich Quantum Valley initiative. Leveraging our exceptional scientific expertise, this ambitious project positions us at the forefront of scientific discovery and ensures that Bavaria emerges as a key player in the evolving quantum economy. It will attract investment and talent, driving innovation and growth within Bavaria's quantum industry.

Munich Quantum Valley is committed to fostering the development of dynamic, high-performing start-ups. Additionally, it will assist industries in exploring potential applications of quantum computing and quantum technologies. By creating an ecosystem that nurtures innovation and collaboration, Bavaria aims to empower businesses and researchers to harness the transformative potential of quantum technologies.

Reflecting on the successful interim evaluation conducted in 2024, I commend the remarkable progress achieved by the Munich Quantum Valley. This evaluation highlighted significant advancements in scientific and technological development, the emergence of numerous innovative start-ups, and the establishment of strong partnerships with industry. These achievements not only showcase the capabilities of our region but also reinforce our commitment to technological independence and resilience in a rapidly changing global landscape.

Looking ahead, I wish the Munich Quantum Valley great success in its mission to develop and operate cutting-edge quantum computers. The path forward is filled with exciting possibilities, and I encourage continued collaboration and networking among scientists and industry partners in the fields of quantum computing and quantum technologies. By working together, we can unlock new frontiers of knowledge and application, ensuring that Bavaria remains at the cutting edge of the quantum revolution.

HIGHTECH Agenda Bavaria

Bavarian Ministry of Economic Affairs, Regional Development and Energy

Welcome address of the Bavarian Minister for Science and the Arts

– Markus Blume

2025 marks a very special scientific anniversary: One hundred years ago, Werner Heisenberg and others established the theory of quantum mechanics, laying the foundations for a new science of physics. Now, a century later, Munich Quantum Valley is following in Heisenberg's footsteps and helping to shape the second quantum revolution.

Quantum technology is a key technology of the 21st century. And with Munich Quantum Valley, Bavaria and Germany are excellently prepared to play a leading role in this field. As part of the Hightech Agenda Bavaria, MQV is creating the biggest multi-faceted quantum ecosystem in Europe. A successful evaluation and the high level of interest in quantum studies and in the Doctoral Fellowship confirm its scientific excellence and its attractiveness.

Complemented by a vibrant start-up scene and strong industry partners that testify to the economic potential of quantum technologies, Bavaria has become the place to be for everything that will be possible in the field of quantum science and technology. Our goal is to create the quantum computer of tomorrow here in Bavaria today!

I would like to congratulate all of the members of Munich Quantum Valley on their scientific and technological progress of the last year. Thanks to you, this unique ecosystem remains successful, dynamic and highly visible. I am convinced: In the Quantum Year 2025, MQV will shine even brighter! For the coming years, I wish you all continued success and sustained momentum for your projects.

HIGHTECH Agenda Bavaria

Bavarian State Ministry of Science and the Arts

Foreword of the Munich Quantum Valley Director General

– Joachim Ullrich

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2025 is the UNESCO International Year of Quantum Science and Technology commemorating the consistent mathematical formulation of quantum mechanics by Heisenberg, Born, and Jordan in Göttingen in 1925. Since then, quantum mechanics has permeated many areas of our lives, technology and economy.

We have even learned how to control and manipulate individual quantum systems, such as atoms, ions, or superconducting circuits, so that we can now encode the basic units of quantum information, the qubits. A worldwide race has begun to exploit these technologies and, in particular, to build quantum computers, which are expected to revolutionize fields such as material science, chemistry and logistics.

The Munich Quantum Valley (MQV) e.V., an association of seven strong partners, was inaugurated in 2022 to meet this challenge. Since then, MQV has become one of the largest and most successful quantum ecosystems in the world. In 2024, new start-ups emerged and outstanding scientific results were achieved, some of which are proudly presented in this report. In parallel, MQV's mission has been sharpened and its governance structure has been rethought to further develop MQV into an innovative and agile deep-tech system enabler at the interface between research, start-ups and industry.

I have had the great privilege to accompany this exciting journey since May 2024, interacting with enthusiastic and visionary scientists, entrepreneurs and industry partners, universities and research institutions, the two very supportive Bavarian ministries, and being assisted by our utmost-motivated MQV Office staff.

Munich Quantum Valley

Building a quantum future

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About Munich Quantum Valley

Our mission

Munich Quantum Valley (MQV) aims to create the world's foremost ecosystem for industrializing quantum technologies. It combines research, technology development, graduate training, and educational outreach in quantum science and technology (QST) by establishing a tight network of research institutions, industry, incubators, funding agencies, and the public. By uniting public and private efforts in a shared enterprise and attracting the world's best scientists and engineers, MQV aims to develop and operate competitive quantum computers and achieve breakthroughs in QST that will transform our future. It will accelerate technological disruption by promoting knowledge transfer between science and industry to foster quantum applications and push Bavaria and Germany to the forefront in QST. MQV will build on the most promising hardware platforms and technologies developed within MQV and by European partners to realize full-stack scalable quantum computers. On a medium-term basis (5–10 years), MQV will fabricate systems with up to 1,000 qubits, integrate them into the powerful Bavarian high-performance computing (HPC) infrastructure, and make them available to users via cloud access. The long-term goal is to develop fault-tolerant quantum computers, which can solve a wide class of practical problems and hence are of broad use for both the economy and society.

Organizational structure

To reach its primary goal of developing and operating competitive quantum computers, Munich Quantum Valley (MQV) follows a "full-stack" approach: Multidisciplinary consortia develop all layers of a quantum computer, from hardware and control to software and applications. On the hardware side, MQV's quantum-computing research encompasses three different platforms: superconducting qubits, neutral-atom qubits, and trapped-ion qubits – each with different characteristics and advantages for different use cases. This MQV approach ensures that the mutual benefits cross-fertilize when it comes to developing scalable platforms.

The Superconducting Qubit Quantum Computer (SQQC) consortium provides superconducting quantum systems known for their design versatility and excellent controllability. The Trapped Atom Quantum Computer (TAQC) consortium provides neutral-atom systems known for their potential to scale qubit registers and their high fidelity of entanglement. Trapped-ion systems have already demonstrated excellent performance and capability for integration into classical computing setups. MQV leverages the many years of experience of its scientists with these hardware technologies to use them as a testbed for integrating a quantum computer into a supercomputing environment. This task of integrating quantum computing into high-performance computing (HPC) environments is led by the Quantum Development Environment, System Software & Integration (Q-DESSI) consortium, which also develops a full software stack and creates a comprehensive programming and runtime environment. The Scalable Hardware & System Engineering (SHARE) consortium provides the classical control technology needed for device scalability, such as the fabrication of scalable integrated chip technology (superconducting quantum devices for SQQC, chip traps for TAQC, and fast electronic control for both). The Quantum Algorithms for Application, Cloud & Industry (QACI) consortium provides the tools, services and resources necessary for user training and integration. At the theoretical level, the Theoretical Quantum Computing (THEQUCO) consortium develops hardware-independent theoretical foundations of quantum computing, while the Hardware Adapted Theory (HAT) consortium is tasked with platform-level quantum control and platform-level quantum error mitigation and quantum error correction. Thus, a holistic approach is taken where software engineering interfaces with the hardware-related tasks and connects them to the high-level application.

Beyond the scope of the individual consortia, different consortia work together on cross-sectional topics. The SHARE consortium collaborates closely with the SQQC and the TAQC consortium, respectively, to develop tailored platform technologies for superconducting and neutral-atom quantum hardware. The HAT consortium collaborates with the hardware consortia on quantum control and co-design. The Munich Quantum Software Stack (MQSS) is being developed by the Q-DESSI consortium in close collaboration with the hardware consortia to ensure seamless integration from systems to end users. The two theory consortia HAT and THEQUCO combine efforts with the QACI consortium on developing quantum algorithms as well as potential use cases. The task of determining the suitability of current and future quantum devices for realistic quantum computing applications involves all of the seven research consortia.

In addition to the seven research consortia, there are two other MQV consortia covering aspects beyond research and development. The QTPE consortium provides an infrastructure with state-of-the-art technological tools and engineering know-how as well as an entrepreneurial pipeline to translate the scientific research into innovative businesses and accelerated commercialization of quantum technologies for the society. The QST-EB consortium educates and supports future generations of researchers and users of quantum technologies and quantum computing in Bavaria.

The consortia are funded by the Hightech Agenda Bavaria and collaborate not only internally but also with matching associated projects funded by the German Federal Ministry of Education and Research (BMBF) and the European Union.

MQV association

Munich Quantum Valley e.V. was founded on 27 January 2022 as a registered association to manage and coordinate the efforts in MQV to develop and operate competitive quantum computers in Bavaria and to promote quantum technology and quantum science. Listed below are the seven founding members:

BAdW BAYERISCHE AKADEMIE DER WISSENSCHAFTEN	Bavarian Academy of Sciences and Humanities (BAdW)
Fraunhofer	Fraunhofer-Gesellschaft (FhG)
FAU Friedrich-Alexander-Universität Erlangen-Nürnberg	Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)
DLR Deutsches Zentrum für Luft- und Raumfahrt	German Aerospace Center (DLR)
LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN	Ludwig-Maximilians-Universität München (LMU)
MAX PLANCK GESELLSCHAFT	Max Planck Society (MPG)
Technical University of Munich TUM	Technical University of Munich (TUM)

Executive Board

Each of the seven founding institutions of Munich Quantum Valley e.V. nominates one member of the Executive Board. As of 31 December 2024, the members of the Executive Board were:

Prof. Dr. Claudia Felser, Chairwoman
Max Planck Society (MPG)

Dr. Robert Axmann
German Aerospace Center (DLR)

Prof. Dr. Arndt Bode
Bavarian Academy of Sciences and Humanities (BAdW)

Prof. Dr. Gerhard Kramer
Technical University of Munich (TUM)

Prof. Dr. Jürgen Schatz
Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)

Dr. Sigmund Stintzing
Ludwig-Maximilians-Universität München (LMU)

Dr. Hannah Venzl
Fraunhofer-Gesellschaft (FhG)

Director General

The Director General is responsible for the strategic positioning of MQV to foster close collaboration with strong industrial partners and visionary start-ups, as well as to promote cutting-edge research, technology and knowledge transfer and to create a corresponding ecosystem. The Director General also represents MQV to policy makers and funders.

As of May 2024, Prof. Dr. Joachim Ullrich started as Director General of MQV, also tasked with defining and establishing the future strategic direction and positioning of MQV post-2026.

Prof. Dr. Joachim Ullrich
Munich Quantum Valley

Scientific Advisors

MQV actively seeks the advice and feedback of top international experts, both in the form of a Scientific Advisory Board and through individual outstanding scientists, in its pursuit of excellence.

Scientific Advisory Board

The Scientific Advisory Board (SAB) of MQV consists of internationally recognized external experts. The results of the SAB meetings are used by the Executive Board, the Director General, the Scientific Director and the Bavarian State Ministries for strategic decisions regarding current and future MQV projects.

Independent evaluation by the SAB ensures the quality of MQV projects and public accountability for the appropriate and effective use of funds. As of 31 December 2024, the members of the SAB were:

Prof. Markus Aspelmeyer, Chairman
University of Vienna

Dr. Michael Bolle
Carl-Zeiss-Stiftung

Prof. Per Delsing
Chalmers University of Technology

Prof. Dietmar Harhoff
Max Planck Institute for Innovation and Competition

Dr. Bettina Heim
NVIDIA

Dr. Sebastian Luber
Infineon

Prof. Roee Ozeri
Weizmann Insititute of Science

Dr. Carsten Polenz
designated member, SAP

Prof. Anita Schöbel
Fraunhofer Institute for Industrial Mathematics ITWM

Prof. Christine Silberhorn
Paderborn University

Prof. Philipp Slusallek
Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

Dr. Sabine Wölk
German Aerospace Center

Prof. Peter Zoller
University of Innsbruck

Further scientific advisors

In addition to the SAB, MQV is pleased to have further renowned researchers in the field of quantum technologies as scientific advisors. As of 31 December 2024, these included:

Prof. Dr. Rainer Blatt
University of Innsbruck

Prof. Dr. Rudolf Gross
Walther Meißner Institute

MQV Office

The MQV Office provides administrative, fundraising and application support to the Executive Board, the Director General, the Scientific Director and all members and partners. It gives Munich Quantum Valley (MQV) a unified voice in communications with the press, funding agencies, investors, industry partners, policy makers and the general public.

The MQV Office is the first point of contact for all internal and external inquiries from MQV members, industry partners, ministries and funding agencies. Together with the MQV Director General and the MQV Scientific Director, it is responsible for managing and coordinating the overall strategic direction of MQV. It supervises and directs the MQV research program, including monitoring project progress against deliverables and milestones, periodic reporting, and budgeted expenditures. It also prepares annual reports and makes recommendations to the Scientific Advisory Board and the Bavarian State Ministries involved.

It also coordinates and conducts central public engagement activities to create a broad public understanding of quantum technologies and their benefits to society, and to raise national and global awareness of MQV and its research and development program. It develops educational, social media and online content, works with the media, and organizes events for a wide range of audiences.

Munich Quantum Valley in numbers

15
Academic partners

7
Ecosystem start-ups

27
Industrial partners

1
Network partner

9
Patents

330+
Scientific publications

7 Public events

7 Talks within MQV Colloquium

290+ Scientific talks

17 Research institutes

Social Media Follower
(31 Dec 2024)

LinkedIn	Instagram	Threads	Mastodon
10576	914	173	151

≈ 400 Scientists

2

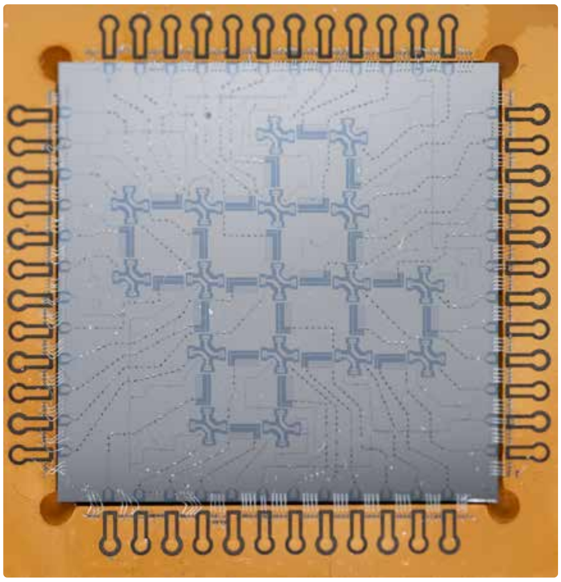
Research highlights

The field of quantum computing continues to advance at a rapid pace, with significant progress being made in the development of quantum computing theory, hardware, and applications. This chapter highlights some of the most notable research accomplishments in the MQV ecosystem in 2024, showcasing the innovative work being done by MQV researchers and their partners. From improvements in quantum error correction, to advances in various quantum hardware approaches, to the identification of use cases of quantum computing with real-world implications, these research highlights demonstrate the rapid pace of progress being made in this ever-evolving field.

Unveiling a 17-qubit transmon-based processor

In a pioneering effort within MQV's superconducting qubit research, the Walther Meißner Institute (WMI) and the Technical University of Munich (TUM) have increased the number of qubits on their largest chip from six qubits in 2023 to 17 qubits in 2024. As the largest superconducting qubit chip developed by a German research group to date, this achievement represents a significant milestone towards the project's goal of operating larger quantum systems.

Superconducting qubits are controlled by applying carefully designed microwave pulses to a chip cooled to almost absolute zero temperature. The superconducting qubit chip itself features a scalable architecture with transmon-type qubits and tunable coupling elements. Tests on dedicated devices have confirmed that this design can perform two-qubit operations with world-leading low error rates around 0.1%. The current quantum processor features a median qubit lifetime of 60.4 μs, a median two-qubit gate error of less than 2.3%, and fast readout and repetition rates that allow it to perform one million experiments per second. To address all individual qubits on the chip, a multi-layer air-bridge fabrication technology has been developed, that allow circuit elements to cross over one another.



The 17-qubit chip fabricated and operated in the laboratories of WMI. Fixed-frequency qubits (cross-shaped) are linked by tunable couplers (edges) in a shape particular suitable for error correction. © MQV | Mikka Stampa

These achievements, made in close collaboration with the quantum computing projects GeQCoS and MUNIQC-SC, lay the foundation for further improvements and algorithm-based benchmarking of this 17-qubit quantum processor in 2025. In an internal demonstration, the WMI has opened the device via its internal cloud interface to students to perform quantum experiments as part of a lecture on superconducting quantum computers. This marked the first step towards providing access to the device via the Munich Quantum Software Stack developed within the Q-DESSI consortium, ultimately enabling research on applications and algorithms on MQV hardware.

References:

N. Glaser et al., Sensitivity-adapted closed-loop optimization for high-fidelity controlled-Z gates in superconducting qubits.

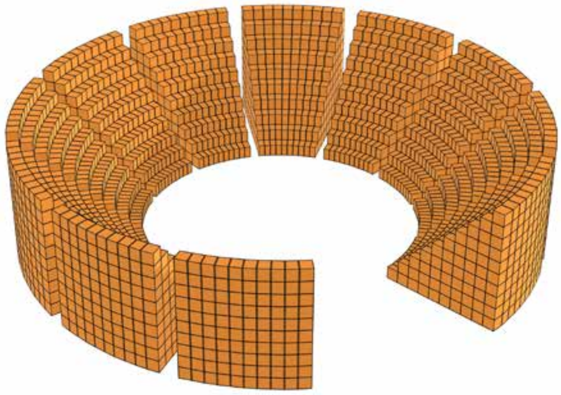
F. Roy et al., Parity-dependent state transfer for direct entanglement generation.

Demonstrating quantum advantage: a new complexity-theoretic separation

In the race to build practical quantum computers, a key open question is often overlooked: What is the evidence that quantum devices can outperform classical ones at computational tasks? In complexity-theoretic terms, the promise of and hope for quantum computers rests on the unproven conjecture that polynomial-time quantum computation is more powerful than polynomial-time classical computation. Unfortunately, a proof is beyond the techniques of current complexity theory. Instead, proposals and experiments demonstrating "quantum supremacy" typically rely on complexity-theoretic hardness assumptions.

Focusing on a more imminent problem closer to near-term devices, MQV researchers have studied the computational power of noisy shallow quantum circuits whose gates are between neighboring qubits in a 3D architecture. They give the first rigorous proof that such circuits provide a quantum advantage, even compared to powerful classical circuits: They identify a concrete computational task which can be solved by the considered quantum devices. The task is beyond the reach of shallow (ideal) classical circuits including those that have (so-called unbounded fan-in) gates involving arbitrarily many input bits. The result strengthens the case for the pursuit of quantum devices with limited error correction capabilities.

While building on prior works, the result gives a stronger separation by considering more powerful classical circuits, taking into account realistic noise in the quantum setting and imposing locality of operations in 3D. This makes the result the strongest unconditional separation between classical and quantum computing known to date.



The 3D-local architecture (arrangement of qubits) of the shallow quantum circuit resembles the Colosseum. It is designed to tolerate noise and is appropriate for computation on near-term quantum devices.

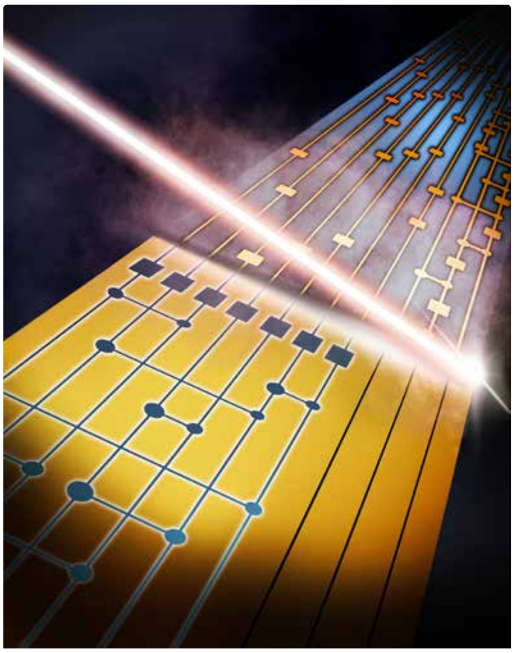
References:

L. Caha, X. Coiteux-Roy, and R. Koenig. A colossal advantage: 3d-local noisy shallow quantum circuits defeat unbounded fan-in classical circuits.

Calculating error-free more easily with two codes

Computers also make mistakes. These are usually suppressed by technical measures or detected and corrected during the calculation. In quantum computers, this involves some effort, as no copy can be made of an unknown quantum state. This means that the state cannot be saved multiple times during the calculation and an error cannot be detected by comparing the copies. Inspired by classical computer science, quantum physicists have developed a different method in which the quantum information is distributed across several entangled quantum bits and stored redundantly in this way. How this is done is defined in so-called correction codes.

Various methods are used to correct errors in quantum computers. Not all operations can be implemented equally well with different correction codes. Therefore, MQV researchers, together with external collaborators, have developed a method – and implemented it experimentally for the first time – with which a quantum computer can switch back and forth between two correction codes and thus perform all computing operations under protection against errors. With this method, a quantum computer is able to switch to the second code whenever a logic gate that is difficult to realize appears in the first code, making it easier to implement all the gates required for computing.



The Innsbruck quantum computer calculates with algorithms that switch back and forth between two different quantum error-correction codes to realize error-corrected computing operations. © Helene Hainzer

References:

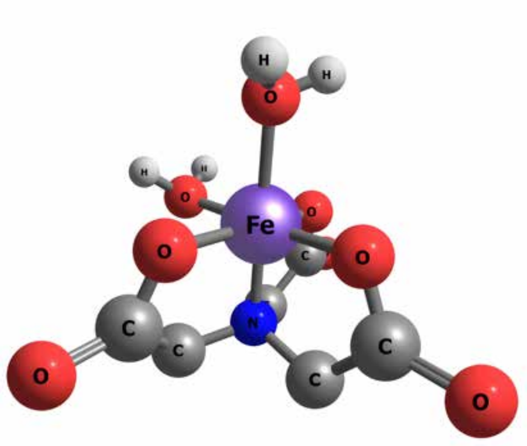
I. Pogorelov et al., Experimental fault-tolerant code switching.

Solving an industry-relevant quantum chemistry problem

One particularly promising area for applications of quantum computers is in chemistry, where they can help simulate complex molecules that are challenging for traditional computers and therefore could have a significant impact on the chemical, materials, and pharmaceutical industries.

As an example for industry-relevant quantum chemistry problems, MQV researchers calculated the low energy states of a complex metal-containing molecule (Fe(III)-NTA). These types of molecules find applications in water softeners, as ligands for catalysts, or antioxidants, and they are difficult to study with classical computers because their electrons interact strongly with each other in complex ways. The team developed a variational quantum algorithm, a hybrid method that combines quantum computing with classical computing techniques. By running the algorithm on a trapped-ion quantum processor, they successfully determined key energy values with high accuracy. To reduce the number of quantum-circuit executions, a main bottleneck for variational algorithms, they combined it with a classical diagonalization step using only the quantum-measured data. As a result, the approach required only 600 measurements per computation, making it highly efficient for today's limited quantum hardware.

The results showed that the quantum algorithm could achieve chemical accuracy, meaning the errors were within a margin useful for real-world chemistry applications. This study demonstrates a major step toward practical quantum chemistry, showing that quantum hardware can already provide valuable contributions to industrial problems. As quantum technology advances, these techniques will become even more powerful, paving the way for breakthroughs in materials science, drug discovery, and beyond.



Geometry of Fe(III)-NTA. The geometry of the Fe(III)-NTA complex [Fe(NTA)(H2O)2] in its low-spin state is shown. Six hydrogen atoms are hidden for visual clarity.

References:

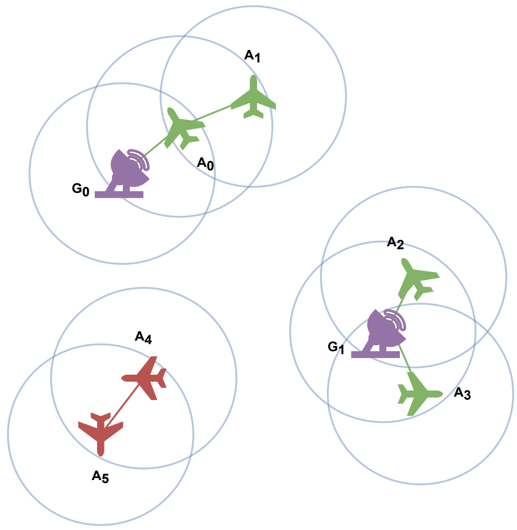
L. Nützel et al., Solving an industrially relevant quantum chemistry problem on quantum hardware.

Driving real-world impact: aerial-network optimization and quantum anomaly detection

In a joint project with Airbus, researchers at Fraunhofer IKS developed a potential analysis for the future use of quantum computing to improve communication between aircraft. In this dynamic optimization problem, the target is to optimize the connection between aircraft and a ground station to ensure the continuous availability of a communications network, such as providing internet in the air.

This extremely difficult optimization problem is currently solved manually in the industry. The researchers proposed solutions based on classical and quantum multi-agent reinforcement learning algorithms. The potential of quantum computing could be demonstrated for small problem sizes with a small number of aircraft by showing that the quantum-assisted solution strategy is able to solve this challenge with fewer or comparable probes to the environment than an equivalent classical solution strategy.

In another project, researchers at Fraunhofer AISEC and SAP are investigating the potential of quantum-computer-assisted anomaly detection for time series data. The use case considered is cloud monitoring, where sudden failures and their causes need to be identified quickly and reliably in order to restore normal operations. Different quantum-machine-learning approaches suitable for NISQ and fault-tolerant hardware are being developed, evaluated for their advantages and scalability, and visualized. So far, benchmarking has been implemented for two promising candidates.



Problem sketch – connecting aircraft to a ground station to optimize communication networks.

References:

T. A. Drăgan et al., Quantum Multi-Agent Reinforcement Learning for Aerial Ad-hoc Networks.

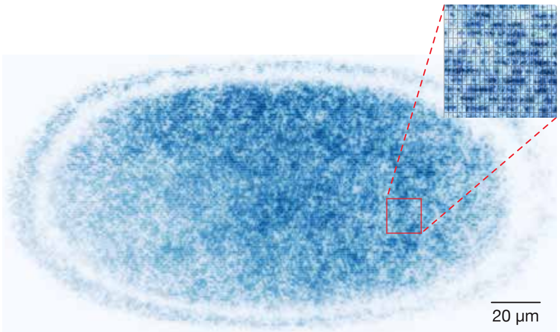
Detecting 10,000+ trapped strontium atoms and operating large-scale atomic arrays

In a groundbreaking achievement, researchers from the Max Planck Institute of Quantum Optics have successfully demonstrated the unique prospect of scaling neutral-atom quantum registers to more than 10,000 atoms.

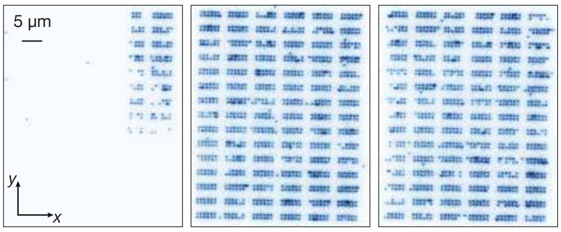
In their experiment, the researchers directly loaded and then imaged over 10,000 strontium atoms with less than one percent loss and exceptional classification fidelity exceeding 99%. This breakthrough in scalability was made possible by using a novel power-efficient bow-tie optical lattice to trap strontium atoms, directly demonstrating the scalability potential of optical lattices as compared to other approaches.

Using the optical lattice architecture, the MQV researchers subsequently demonstrated the ability to repeatedly assemble and continuously operate large-scale sorted arrays of more than 1,000 optically trapped strontium atoms. Such large sorted arrays hold immense potential for applications in quantum computing, quantum metrology and quantum simulation. A key innovation driving this success was the discovery of a highly selective atom-removal feature that ensures that each experimental cycle replenishes only the loading zone, while preserving atoms stored in the dedicated zone. This work builds on a unique architecture in which atoms are continuously trapped in a storage array and then moved one by one to replenish lost atoms from a storage zone. The setup is thereby particularly simple and, unlike competing architectures, does not require long-distance atom transport.

The demonstrated architecture establishes an entirely new approach to scaling neutral-atom arrays and lattice systems assembled bottom-up and overcomes a major scaling bottleneck of neutral-atom arrays.



A single-shot image of more than 10,000 single atoms directly loaded into the bow-tie lattice from the magneto-optical trap. The smaller red box is an enlargement which shows well-resolved single atoms.



Exemplary single shots at various instances in time of an iteratively assembled array exceeding 1,000 atoms on average. The first image on the left shows the initial gradual loading of the array.

References:

R. Tao et al., High-fidelity detection of large-scale atom arrays in an optical lattice.

F. Gyger et al., Continuous operation of large-scale atom arrays in optical lattices.

3

Fostering excellence in quantum science and technology

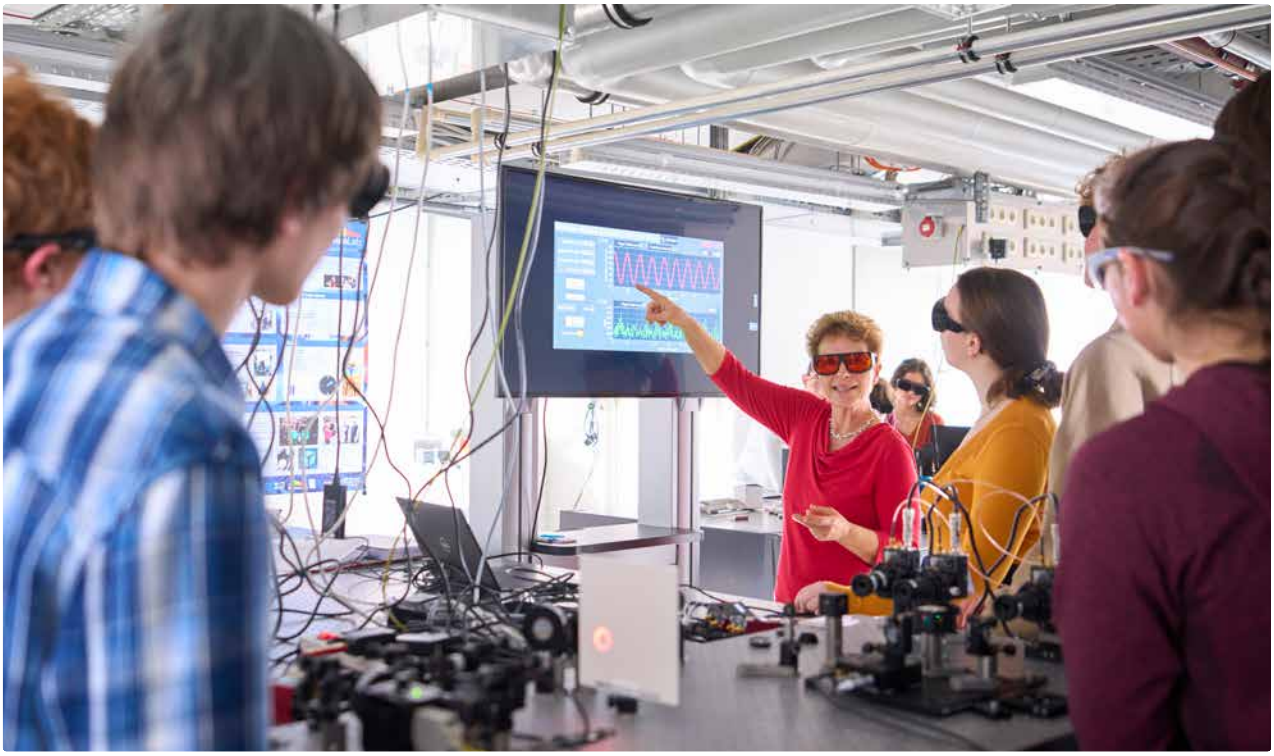
The overarching mission of Munich Quantum Valley (MQV) is to create the world's foremost ecosystem for industrializing quantum technologies. Beyond the research and development program of the consortia developing full-stack quantum computers, MQV fosters various exchange and partnership formats to link research with industry, sets up a Quantum Technology Park providing tailored high-tech infrastructure for developing and producing quantum devices, and supports dedicated entrepreneurial activities as well as the education of the next generation of quantum experts and actively reaches out to attract top talents to the MQV ecosystem. At the very well attended annual Spring Meetings of the German Physical Society (DPG), namely of the Atoms, Molecules, Quantum Optics and Photonics Section (SAMOP) and the Condensed Matter Section (SKM), MQV presented Bavarian quantum research in particular to prospective Ph.D. candidates who took the opportunity to have a personal, in-depth talk with MQV representatives about possible career opportunities within the MQV ecosystem. MQV's presence at a variety of fairs, such as the Hannover Messe or Quantum Effects, and conferences like the International Conference for High Performance Computing, Networking, Storage, and Analysis or the IEEE Quantum week gave room to exchange ideas with companies and to highlight opportunities for scientific and industrial cooperation.

Quantum education in Bavaria

An important goal of Munich Quantum Valley (MQV) is to provide and support educational programs for schools, universities, and companies in order to raise the next generation of researchers, engineers, integrators, and users of quantum technology and quantum computing in Bavaria and beyond. This is implemented within the Quantum Science and Technology Education in Bavaria (QST-EB) consortium as part of MQV on different levels.

Bringing quantum physics into the classroom

The overall goal of the educational offers is to inspire curiosity for quantum science and technology from a young age and to attract the world's top talents to the MQV sites and train them in quantum technology and quantum computing. That already starts with making the topic accessible to a very young audience through MQV's active support of the PhotonLab, a laboratory for pupils located at the Max Planck Institute of Quantum Optics (MPQ). In 2024 the mark of 3,000 yearly visitors was broken for the first time, coincidentally at the same day as the team welcomed its 22,000th visitor over all. The on-site program is complemented by digital, interactive books, that give students and teachers the opportunity to learn about quantum technologies and quantum computing from their own classrooms or at home. With quantum physics becoming part of the syllabus in Bavarian high schools in the next term, MQV also broadened its offers in training teachers.



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Various support for Master's students

At the university level, the Ludwig-Maximilians-Universität München and the Technical University of Munich have joined their forces to establish the interdisciplinary Master's study program "Quantum Science & Technology" (QST). Through QST-EB, MQV offers the students of the QST-program dedicated support in the form of a variety of fellowships and internships to foster a diverse and thriving Bavarian quantum ecosystem. Master's level fellowships include a program for outstanding women and a program for exchange students. The Fellowship for Women yearly supports up to five female students of the QST master's program, based on study achievements, quantum-technology activities and individual interviews. The MQV exchange fellowship supports the exchange of Master students with foreign partner universities. The scholarships can be either used for international students of selected partner universities visiting one of the MQV partners for a period of four weeks or longer or for students of the QST Master's program visiting a partner university. MQV, in cooperation with the Fraunhofer-Gesellschaft, also provides a platform for students to get in touch with quantum-technology companies through application-oriented and industrial internships. The internship portfolio is open to students from all Bavarian universities. The goal of these internships is to connect students with companies developing, integrating, deploying and using quantum technologies and quantum computing, providing the students with insights into possible career paths and helping them to create a career network to foster knowledge transfer between research institutes and industry.

Bavarian-wide doctoral fellowship program

The excellence-focused doctoral fellowship program awards highly prestigious doctoral fellowships to outstanding young researchers. The MQV doctoral fellows, selected through an annual international competition, receive a three-year ad personam fellowship which offers them the flexibility to join research groups at any Bavarian university. Being fully funded for three years, the holders of the fellowship are welcome in many groups and can then join the graduate program of their host institution. In 2024, the call was answered with over 190 applications. After a multi-stage selection process by a jury of MQV members, 23 candidates participated in interviews. In the end, seven candidates accepted the MQV doctoral fellowship while 13 further candidates were strongly recommended for special consideration to MQV colleagues seeking to hire doctoral students using other funds, as they also made an excellent impression.

Michelle Lienhart

MQV doctoral fellow of the 2022 cohort at the Walter Schottky Institute (TUM)

Michelle is researching quantum-dot molecules, which consist of two coupled quantum dots, also known as artificial atoms. Her goal is to entangle spins in the quantum dot molecules with photons and thus come one step closer to the combination of quantum computing and quantum communication

Tim Harris

MQV doctoral fellow of the 2022 cohort at the Chair of Theoretical Nanophysics (LMU)

Tim researches theoretical models that describe certain classes of materials. By reducing the theoretical description of real materials to the essentials, he aims to identify the relevant microscopic mechanisms that are responsible for the physical behavior of these materials. Furthermore, he develops proposals on how these “minimal models” can be implemented in quantum simulator experiments.

Offers for professional development

Complementary to the MQV-funded educational programs that focus on the support at the university level in Bavaria, the “Quantum LifeLong Learning” (QL3) project offers training and education for industry professionals. The training courses are intended to reach specialists and managers from a wide variety of industries and combine the latest research results with practical challenges.

Quantum Technology Park

A key initiative of the Munich Quantum Valley (MQV) is the establishment of a high-tech infrastructure providing state-of-the-art fabrication tools for quantum technologies.

The most significant addition to this infrastructure in 2024 was the opening of the Max Planck Semiconductor Laboratory (MPG-HLL) on the Garching Research Campus. Since its inauguration on 7 October 2024, the MPG-HLL has added 1,400 m^2 of state-of-the-art clean-room space to the ecosystem. Its strategic location on the Garching Research Campus makes it easily accessible for most researchers within MQV.

Taking advantage of this proximity and the continuous collaboration between the QTPE stakeholders, an official cooperation agreement between MPG-HLL and TUM/WMI was negotiated and signed in 2024. The aim of this agreement is to join forces to improve the infrastructure for superconducting technologies. Moving forward, this collaboration will enable MQV to distribute key process steps across the infrastructure at WMI and the clean room at MPG-HLL, forming the basis for a pilot line for superconducting quantum circuits.

At the same time, other infrastructure projects are progressing according to plan. The renovation of the clean room at LMU is progressing well while remaining open to the research community. In addition, planning for the new Fraunhofer EMFT site on the Garching research campus is well underway, with operations expected to begin in 2029.

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Entrepreneurship

Turning world-class research into economic success and building a globally competitive quantum tech industry in Bavaria is one of the core goals of Munich Quantum Valley (MQV). Technology transfer is therefore a central issue. Entrepreneurship plays a key role in overcoming the bottleneck of translating scientific research into commercial products. Within MQV, the entrepreneurial efforts are driven by the Venture Lab Quantum/Semicon (VLQS), MQV's innovation center for quantum technologies.

Since the start of MQV and even the months before, founder teams across various maturity stages have been supported by VLQS. With three new incorporations in the making in 2024, a total of seven incorporated local start-ups are now part of the Munich Quantum Valley ecosystem. The Munich Quantum Software Company (MQSC), Peak Quantum and Qoro Quantum are the newest additions, joining Munich Quantum Instruments, planqc, Qlibri and Quantum Diamonds.

At the university level, the Venture Lab Quantum/Semicon also also provides various educational formats at the intersection of quantum technology and entrepreneurship to support the next generation of founders and inventors. In 2024, the VLQS began its first batch of the Quantum Fellowship Program, a one-year entrepreneurship education program within the quantum tech industry for ten students from a variety of backgrounds. After starting with an internship as a founder's associate at one of the quantum technology related start-ups in the MQV and TUM Venture Lab Quantum/Semicon start-up ecosystem, the program then continues with a four-month entrepreneurship project. Additionally, the students are given regular expert sessions and access to networking opportunities through the VLQS.

After its great success in 2023, the IdeaLab was continued in 2024. The entrepreneurial education program tailored for Ph.D. students and postdocs in quantum-related disciplines supports researchers with identifying and evaluating commercial applications of their academic work in a two-day workshop. The IdeaLab framework was also adapted in the Ammersee Venture School that was organized and run by the Venture Lab Quantum/Semicon in cooperation with the TUM Venture Lab Chemspace. The Ammersee Venture School was an entrepreneurship-focused summer school in which five teams of researchers ideated and developed start-up ideas and learned from established founders and experts, which has kicked off three further start-up projects, including one in the realm of quantum computing.

© VLQS

Start-up class of 2024

In 2024, three new start-ups made their way to incorporation, adding to the ever-growing list of start-ups in the Munich Quantum Valley ecosystem:

Munich Quantum Software Company

The Munich Quantum Software Company (MQSC) is a spin-off of Robert Wille's Chair for Design Automation at the Technical University of Munich. The MQSC aims to create industry-grade software tools and services that provide for quantum computing what is already commonplace in conventional IT, answering the demand for software capable of handling complex design tasks that is provoked by the rapid development of market-ready quantum computing hardware.

→ www.munichquantum.software

Peak Quantum

Peak Quantum is building high-quality quantum processors (QPUs) based on superconducting qubits. Launched by a team of world-class researchers from the Walther Meißner Institute (WMI), the spin-off is pioneering a novel qubit architecture with built-in error protection, aiming to accelerate the development of fault-tolerant and application-ready quantum computing.

→ www.peakquantum.de

Qoro Quantum

Qoro Quantum aims to provide a classical network stack for scalable, distributed quantum computing, and integration within HPC. Qoro Quantum was incorporated in July 2024 and operates in Germany and the UK.

→ www.qoroquantum.net

Start-up voices

A vibrant start-up community is one of the key components of the MQV ecosystem. The following brief interviews with three of the more established companies from this entrepreneurial ecosystem highlight the innovative work being done, with each start-up tackling unique challenges and opportunities in the field.

Alpine Quantum Technologies (AQT)

AQT builds Europe's most powerful trapped-ion quantum computer. Customers can access them via our cloud service ARNICA or install entire systems on-site. Researchers are supported with quantum hardware components and complete solutions that accelerate the development of quantum optics experiments.

What was AQT's biggest success in 2024?
Delivering and installing the first trapped-ion quantum computer to LRZ in Garching. It will support the development of a wide range of applications with industrial, scientific and societal relevance for Europe.

What challenges are coming up next?
Scaling our technology to higher numbers of ions, better throughput and higher gate fidelities. Our main goal is to build the next generation of machines, which will feature processor register sizes too large to describe on even supercomputers.

What does it mean for AQT to be part of the MQV ecosystem?
As part of MQV, we have access to a world-class network of experts, including high-level users, application scientists and software engineers. We greatly appreciate the collaboration with the LRZ, which ensures seamless integration into the HPC environment.

→ www.aqt.eu

© MQI

Munich Quantum Instruments

At Munich Quantum Instruments, we develop innovative photonic quantum sensors that can be applied in break-through discoveries and disruptive applications such as optical quantum computers, quantum sensing, deep space optical communication, and quantum communication.

What was Munich Quantum Instruments' biggest success in 2024?
One achievement was to get accepted into a prestigious accelerator program offered by QAI ventures (Basel, CH). That helped us to strengthen our team. Also we won two tenders from the European Space Agency which also helps tremendously to grow our company.

What challenges are coming up next?
This year, our main challenge is to find and hire new experienced and motivated staff and to increase our sales.

What does it mean for Munich Quantum Instruments to be part of the MQV ecosystem?
MQV is a very valuable network for us. As an example, it gives us excellent contacts to other startups but MQV also increases the visibility of Munich Quantum Instruments in the quantum community.

→ www.munich-quantum-instruments.com

© SPRIND | Mattia Balsamini

Quantum Diamonds

Quantum Diamonds develops and deploys first-of-a-kind metrology tools based on innovative quantum sensing technology to localize and analyze defects and failures within microelectronics. The Quantum Diamonds tech is becoming an invaluable testing solution for yield improvement and ramp-up for advanced chips.

What was Quantum Diamonds' biggest success in 2024?
In 2024, we deployed the world's first commercial quantum sensing tool for failure analysis of microelectronics. We are pioneering advanced semiconductor testing globally with further interest from key players in Taiwan and the US.

What challenges are coming up next?
We aim to scale our tech to the fabrication-level testing of chips and expand globally. These require significant hardware and software improvements, as well as robust business development, which we are tackling in 2025 and beyond.

What does it mean for Quantum Diamonds to be part of the MQV ecosystem?
Being a part of the MQV ecosystem accelerated our lab-to-market substantially by both financial support and excellent infrastructure. This allowed us to scale from a spin-off to commercial delivery within 1.5 years. We are happy to be a part of MQV!

→ www.quantumdiamonds.de

Partner Network

The Partner Network of Munich Quantum Valley e.V. brings together stakeholders from research institutions, universities and companies with the common goal of promoting quantum science and quantum technologies in Bavaria. This includes the development and operation of quantum computers, the identification and evaluation of possible application scenarios as well as the support of an efficient knowledge transfer from research to industry and the development of educational offers for schools, universities and companies.

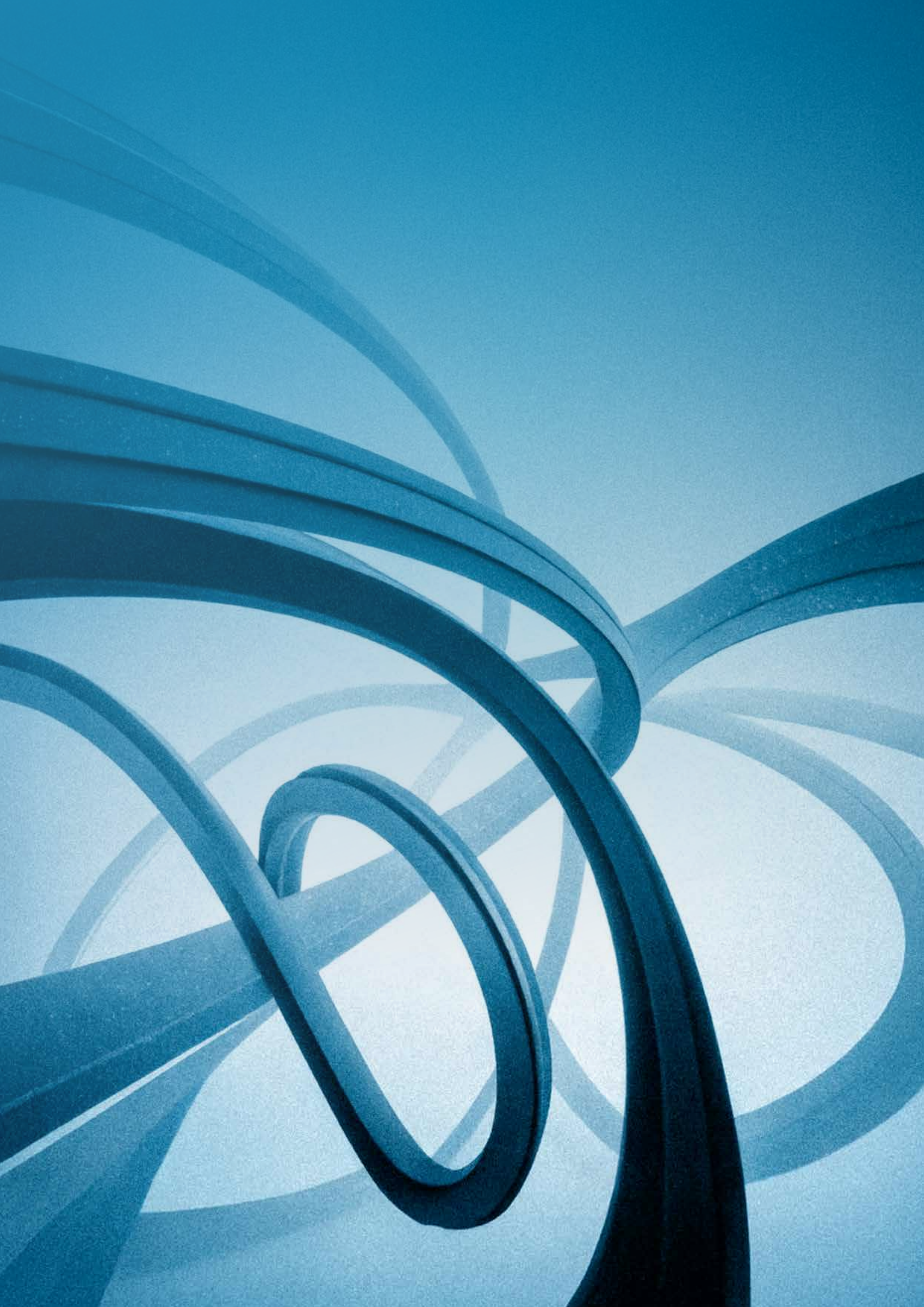
The network continued to grow and by the end of 2024 included 27 industry partners, 15 academic partners, and one network partner. With so many partners collaborating and successfully working together on quantum technologies and applications, it has become one of the leading quantum ecosystems in Europe. The partners benefit from the network by having exclusive access to special workshops and events, by connecting them with skilled workforce and early-career researchers, by getting up-to-date information from the MQV ecosystem and the opportunity to cooperate in outreach activities and through the exchange with scientists to explore teaching possibilities for the staff or other collaborative projects.

Representatives from industry and academia within the MQV ecosystem had the opportunity to connect at dedicated events. In June 2024, the first MQV supplier workshop took place which was primarily aimed at the MQV Partner Network and highlighted the requirements and needs of both industry and science with the goal to strengthen the quantum community. In November 2024, the symposium "Towards applications of quantum computing", organized by Munich Quantum Valley (MQV) together with the Fraunhofer Institute for Cognitive Systems IKS and supported by Bayern Innovativ and QUTAC, took place. The symposium brought together representatives from industry and science working on quantum computing applications with hardware and software developers to explore the key question of where a practical quantum advantage could lie in industry and what the challenges are that need to be overcome.

Industry

Academic

Networks



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Public engagement

Munich Quantum Valley (MQV) sees it as an important task to communicate the fascination for quantum science and technology (QST) to the public and to moderate the discussion about expectations, hopes, and possible fears.

To create a basic understanding of quantum technologies and their benefits for society, and to provide insights into its research, MQV hosted its own and participated in various external public events. The monthly portrait series "MQV In Persona", launched in 2023, was successfully continued in 2024. It highlights the research of young postdocs and doctoral students, gives personal insights, and shows the diversity of research within MQV. As a new format, the monthly video series "Quick Quantum Questions", in which MQV experts answer various questions about QST in short video clips, was launched in July 2024. In addition, MQV is actively involved in federally-funded projects, like GALaQSci and Quanten(t)räume, to develop an educational smartphone game as well as other outreach formats.

Public events

By participating in various public events, MQV was able to make direct and personal contact with the interested public, where visitors could ask questions about the basics of quantum physics, specific technological details, questions about the economic or social relevance of quantum technologies, or specific questions about the work of MQV. With formats such as open days or science festivals, an audience of all ages could be reached.

A day as a microtechnologist

MQV Girls'Day at the Fraunhofer EMFT

With its Girls'Day offer on 25 April, MQV specifically addressed girls from high school. 15 students aged 14 and 15 took part in the MQV Girls'Day program, which was held in collaboration with and at the Fraunhofer Institute for Electronic Microsystems and Solid State Technologies (EMFT).

With its Girls'Day offer on 25 April, MQV specifically addressed girls from high school. 15 students aged 14 and 15 took part in the MQV Girls'Day program, which was held in collaboration with and at the Fraunhofer Institute for Electronic Microsystems and Solid State Technologies (EMFT). With a lecture that clarified the questions of what exactly quanta are and how researchers want to exploit their extraordinary properties for quantum computers, the students dived straight into the fascinating world of quanta. How the Fraunhofer EMFT makes practical use of tiny technologies, such as ultrathin cables or smallest sensors, was illustrated during a tour of the institute with its numerous laboratories and exhibits. A group of four girls were allowed to take a look inside the cleanroom laboratory. Of course, this included putting on full-body protective clothing, from overshoes to headgear, before the girls were allowed to handle the tools in the cleanroom themselves. The schoolgirls were able to try out how much precision it takes to work with the incredibly thin materials that are processed in the cleanroom. Another highlight during the lab tour was the cryo lab, with its sparkling golden cryostat. The girls continued with hands-on workshops organized by female scientists from Fraunhofer EMFT, who also gave them a personal insight into their work as researchers.

A whole weekend full of quantum

MQV at FORSCHA and Island Festival

Another highlight was the participation in the science festival FORSCHA from 28 to 30 June, that was part of the Munich Science Days in the Verkehrszentrum of the Deutsches Museum, and the Island Festival, a street festival that took place on the Museumsinsel the same weekend.

At FORSCHA, MQV member Prof. Jens Eisert from Freie Universität Berlin took attendees on an exciting journey from the beginnings of computers to the development of high-tech quantum computers in his talk “Of cats, quanta and computers”. At both events, MQV was on site with experiments, exhibits and “magic tricks” – prepared for all ages, from kindergartners, high school students and their parents to interested retirees. For the adults, the exhibits from various MQV member institutes were of particular interest, demonstrating that there are different hardware technologies for building quantum computers, while also focusing on questions of concrete implementations, thus making the abstract topic more tangible.


Munich

Huge number of visitors at the Open Day

A very special success was the campus-wide Open Day at the Garching research campus on 3 October, where MQV played a key role in the central organization, in particular by creating and maintaining the overarching event website.

During the Open Day, MQV was present at the Leibniz Supercomputing Centre (LRZ) with talks and a booth. Three MQV members gave introductory talks on quantum computing and all lectures were very well attended. Guided tours of the computer building were also offered to the guests, to give them an idea of what is involved in combining supercomputers such as the SuperMUC-NG with quantum computers. At the booth, again the exhibits from various MQV member institutes were of particular interest. From 10 am until the end of the event at 5 pm, the flow of visitors never stopped and there was always a large crowd at the MQV booth.

In addition to the LRZ, many other MQV member institutes and partners took part in the Open Day: At the Max Planck Institute of Quantum Optics (MPQ), everything revolved around the question of how light and matter interact and visitors were able to take part in hands-on experiments as well as guided tours of the quantum optics labs. At the Walther Meißner Institute, guests were immersed in the world of low-temperature physics and learned why quantum computers with superconducting circuits have to be operated close to absolute zero. At the Walter Schottky Institute, visitors learned about the role of semiconductors in quantum sensor technology, and at the booth of the Munich Center for Quantum Science and Technology, guests could learn about the various fields of research in quantum science and take VR tours of various laboratories.

The large traffic jam that formed on the main street of the research campus after the event was over was evidence of the large number of visitors.

In Persona

Munich Quantum Valley follows a full-stack approach in developing quantum computers. In practice, this means an enormously diverse group of researchers and engineers with different backgrounds working on a huge variety of topics and problems. Here are some of the young scientists' journeys into and within the field of quantum computing to show how different the personal stories of quantum scientists can look like and to highlight the wide range of research perspectives in the advancement of quantum computing in the MQV network.

That the way into quantum science really doesn't need to be straightforward shows the path of Barbora Hrdá. Despite her preference for mathematical subjects, the Ph.D. student first completed a Bachelor's degree in Slavic Studies and Theater Studies. As an obvious next step, Barbora applied to LMU's elite graduate program in Eastern European Studies. "Thank god they didn't take me," she says and laughs, her laughter tinged with relief. Her detour gave her the necessary confidence to pursue a career in STEM and so she also applied to the "Computing in the Humanities" master's program – which she got in and finished successfully. After a few years as a software developer at an insurance company, she was looking for a new challenge, leading her to the Fraunhofer Institute for Applied and Integrated Security (AISEC). "I try to make calculations on quantum computers more secure", Barbora sums up her work there. As part of her doctoral research at Fraunhofer AISEC, she is investigating what IT security standards like those in classical computing could look like for quantum computing and what options there are to use quantum computers securely today, both on the software and on the hardware level. When this topic was brought up to the computer scientist, quantum computing was once again new territory for her. But, "if I don't know something, I can learn it", says Barbora, now confidently pursuing the profession she is passionate about.

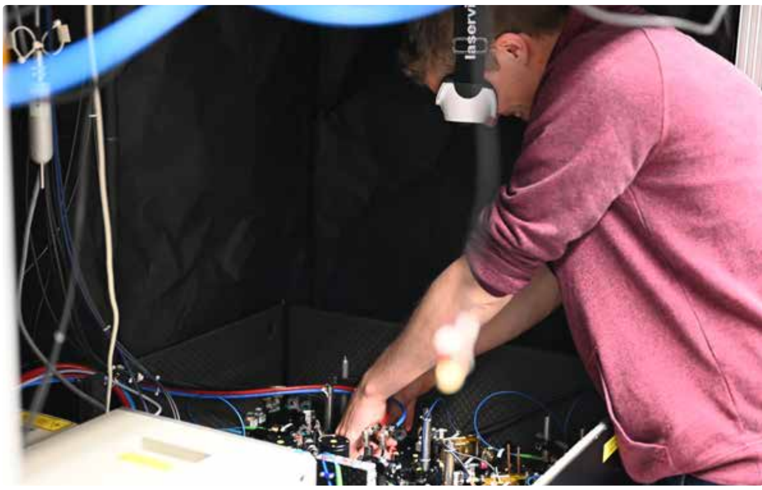
"I try to make calculations on quantum computers more secure"

Barbora Hrdá

Fraunhofer Institute for Applied and Integrated Security (IIS)

In her research, Barbora is investigating what IT security standards for quantum computing could look like and what possibilities there are to use quantum computers securely today. To this end, she is looking at concepts at both software and hardware level

Someone who always knew he wanted to go into physics is Kevin Mours. That is why he began his studies while still at high school, giving him a head start to his technophysics degree, a combination of mechanical engineering and physics with a stronger focus on application and an engineering perspective. Today he is back to basic research as a doctoral student at the Max Planck Institute of Quantum Optics (MPQ), where his work focuses on the construction of a digital quantum computer with neutral atoms. Using powerful lasers, he traps single atoms in optical tweezers to be able to encode and control them as individual qubits. The moment as Kevin and his colleagues were able to see the atomic signal in their experiment



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> We shoot however many lasers at atoms until they do what we want

Kevin Mours

Max Planck Institute
of Quantum Optics

Kevins' research is focussed on the construction of a digital quantum computer with neutral atoms. Using powerful lasers, he traps single atoms in optical tweezers to be able to encode and control them as individual qubits.

for the first time he describes as one of his proudest moments: “Seeing that blue line in the glass cell was just amazing. It is the moment we know we have atoms exactly where we want them to be”. A moment that was in the making for months – setting up the numerous individual components and adjusting them again and again until everything is set up perfectly. The possibility of being involved in the experiment from the very beginning, getting to know every single little screw and the function of every controller, was one of the main factors for Kevin to come to the MPQ for his Ph.D. and the experience he brought were a perfect fit for this MQV project.

That she wants to pursue a career in research was also clear pretty quickly for Alexandra Schewski. After studying physics in Erlangen, she made a conscious decision to pursue a Ph.D.: “Understanding interrelationships and delving deeper into a topic is something I really enjoy.” That is what led her to the Fraunhofer Institute for Electronic Microsystems and Solid State Technologies (EMFT), where she is developing so-called through-silicon vias (TSVs) – conductive connections from the top to the bottom of a chip through the silicon substrate – that are compatible with superconducting qubits. They are needed to place as many qubits as possible on a processor using 3D integration. “For the TSVs to be qubit-compatible, they have to be superconducting themselves. In addition, they must have low microwave loss, that is they must be designed in such a way that the microwaves used to control the qubits can, so to speak, flow through them unhindered,” explains the physicist. Alexandra’s day-to-day work can be best described as process development, finding out which process parameters influence her result to obtain certain properties for her TSVs. For the material itself there are very high requirements. Even the smallest impurities can disturb the sensitive qubits on the chip and lead to a loss of quantum information. This is why the young researcher spends much of her time in the clean room, covered from head to toe in in her cleanroom suit.

> Our task is to make many qubits usable at the same time

Alexandra Schewski

Fraunhofer Institute for Electronic
Microsystems and Solid State
Technologies

Alexandra is developing through-silicon vias that are compatible with superconducting qubits. These are superconducting connections from the top to the bottom of a chip. They are needed to place as many qubits as possible on a processor using 3D integration.

Santana Lujan on the other hand never expected to work in science at some point in his life. "When I started my Master's degree, I didn't even know what a quantum computer was," he says and laughs. His path to his Master's in computer science was also rather unusual – from secondary school over aborted Computer-Science studies, a successfully completed training as an IT specialist and a Bachelor's degree in Electrical Engineering to finally getting his Master's degree in his dream subject. Driven by his curiosity to try out new things, he now works at the DLR Quantum Space Operations Center, investigating how the hardware of quantum computers can be optimally controlled. In his research, Santana models pulse sequences using control theory for the optimal control of quantum systems. The purpose of this is to avoid possible errors made by a quantum computer. "Control theory is a necessary step in the development of almost all quantum computing platforms," emphasizes the scientist. You can only get so far with the mere calibration of gates: "Then the system parameters change a little and the next day your gate no longer works well. You can combat many of these things with control theory."

"At heart, I simply love developing software"

Santana Lujan

Quantum Space Operations Center (DLR)

In his research, Santana models pulse sequences using control theory for the optimal control of quantum systems. The purpose of this is to avoid possible errors made by a quantum computer.

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Emily Wright was studying Applied Mathematics and Engineering when she first came into contact with the field of quantum computing by chance. During an internship at the Bank of Canada, she attended a talk by the quantum hardware company D-Wave. "It was the first time that I heard of the idea of quantum information and how we can have this new way of thinking about information and new ways of doing computation," she recounts. "And I was really fascinated by that." So fascinated, in fact, that after her Bachelor's degree in Applied Mathematics and Engineering she decided to switch it up a bit and go for a Master's degree in Physics. Afterwards, she moved from Canada to Munich so start her Ph.D. at the Walther Meißner Institute. There, Emily is working on the development of fast quantum gates. She uses machine learning to optimize microwave signals so that they perform exactly the desired operation in a superconducting quantum circuit. Solving exciting engineering problems, as Emily puts it, is one of the main motivators for physicist. When she first got into quantum computing, she found it interesting that everything can be defined with "relatively simple linear algebra" – her background in Mathematics clearly showing. "To go from this theory, that is really contained and easy to work with, to the reality of such a huge engineering problem is what keeps me going", she says.

> “Building a quantum computer is not a solo task”

Emily Wright

Walther Meißner Institute (BAdW)

Emily is working on the development of fast quantum gates. She uses machine learning to optimize microwave signals so that they perform exactly the desired operation in a quantum circuit.

Find all portraits of our ‘In Persona’ series in full length on our website!

Available in English and German

Similar to Emily, Stefan Huber was initially most interested in the mathematical framework of quantum information theory. After his degree in Physics, he moved from Zurich to Munich for his Ph.D. at the chair of Mathematical Physics at the Technical University. Since after completing his Ph.D., there were no postdoctoral positions available in the research groups he found interesting, Stefan initially took a position at the Leibniz Supercomputing Centre (LRZ) that was not directly related to his previous studies. He has always been interested in working with computers and before he seriously considered returning to research, it was already clear that there would be a quantum department at the LRZ. “And in the 1.5 years in between, it didn't hurt to learn how to manage big computers,” he says. He then became the first member of the quantum group at the LRZ – at 31 years old, Stefan is already one of the old hands in his department. Now, the goal is to expand quantum computing as a general service and enable scientists to access the new technology via a cloud. For the work of the scientist this involves very specific issues, such as the costs that arise when using this computing resource. Stefan also advises scientists on which of the various hardware technologies available at the LRZ is best suited for their particular research project. Looking into the future of quantum computing, Stefan has a down-to-earth assessment: “There is no reason to be pessimistic.”

> “I play with big and exotic computers”

Stefan Huber

Leibniz Supercomputing Centre (BAdW)

Stefan is developing solutions to enable quantum computing as a new service at the Leibniz Supercomputing Centre. This involves very specific issues, such as the costs that arise when using this computing resource.He also advises scientists on which of the various hardware technologies available at the LRZ is best suited for their particular research project.

Quick Quantum Questions

In the video clips of the series "Quick Quantum Question", experts from Munich Quantum Valley (MQV) answer questions on quantum science and quantum technologies. The videos cover fundamentals such as superposition and entanglement, as well as specific technologies and challenges, and provide deeper insights into the quantum landscape that MQV is building.

Find all video clips of our 'Quick Quantum Questions' series on YouTube!

Available in English and German


quick quantum questions
Q³
entanglement
What is entanglement?
Munich Quantum Valley
Abonnieren
Teilen
Speichern

GALaQSci

The GALaQSci (Game-based and AI-assisted Learning about Quantum Science) project is a collaboration of quantum scientists and physics educators from the following partner institutions: Ludwig-Maximilians-Universität München, Technical University of Munich, Max Planck Institute of Quantum Optics, the Cluster of Excellence Munich Center for Quantum Science and Technology (MCQST), and MQV. Its goal is to make the abstract and counterintuitive concepts of quantum technologies accessible and understandable for a broad audience through an immersive and educational experience in the form of a smartphone game – bringing the world of quantum technology right into the hands of the player! The quantum scientists and physics educators are working closely together with professional game developers to create a game, in which the player needs to solve riddles by effectively using features of quantum objects and technologies. An AI-based non-player character is designed to individually help understand the principles and concepts.

← www.galaqsci.de

Quanten(t)räume

The Quanten(t)räume (quantum dreams/quantum spaces) project addresses the challenges of communicating the application potential of quantum technologies (QT) with new approaches and bringing science, industry and society into a dialog. The diverse formats and expertise of the network partners from research, industry and education create a combination of broad impact (museums, future dialogs) and in-depth impact (student labs, specialist expertise). The close integration of the formats through cooperation between the various partners ensures that ideas, questions and suggestions are developed and reflected on from different perspectives across a broad target and stakeholder group.

In 2024, two new formats of the project started. The "Quantenfreitage" (Quantum Fridays) in the PhotonLab of the Max Planck Institute of Quantum Optics give visitors of all ages the opportunity, after a short introduction, to conduct experiments themselves. The two-hour workshops in small groups, which take place once a month, are a good opportunity to get a first glimpse into quantum physics. The weekly "Quantendienstage" (Quantum Tuesdays) at the Deutsches Museum and other project partners are an open forum for everyone to participate in discussions, presentations and games with the goal of making quantum science and technology accessible to everybody.

← More information online

List of principal investigators

Adel	Hans	FhG-IIS	SHARE
Aidelsburger	Monika	LMU-PH	TAQC
Alberti	Andrea	MPQ	TAQC
Bhatotia	Pramod	TUM-IN/CS	Q-DESSI
Blatt	Sebastian	MPQ	TAQC
Bloch	Immanuel	MPQ + LMU-PH	TAQC
Boche	Holger	TUM-EE	THEQUCO
Brandt	Martin	TUM-WSI	SHARE
Burgarth	Daniel	FAU	HAT
Caldwell	Allen	MPG-HLL	QTPE
Carlowitz	Christian	FAU-EEI	SHARE
Cirac	Ignacio	MPQ	THEQUCO
Debus	Pascal	FhG-AISEC	QACI
von Delft	Jan	LMU-PH	THEQUCO + QST-EB
Eisert	Jens	FUB	HAT
Efetov	Dmitri	LMU	QTPE
Filipp	Stefan	WMI	SQQC
Finley	Jonathan	TUM-WSI	SHARE
Fölling	Simon	LMU-PH	TAQC
Fürlinger	Karl	LMU-IN	Q-DESSI
Glaser	Steffen	TUM-CH + WMI	THEQUCO + HAT
Gross	Rudolf	WMI	SQQC
Hartmann	Michael	FAU-PH	SQQC + HAT + QACI
Holleitner	Alex	TUM-EI + TUM-WSI	SQQC + SHARE + QST-EB
Huebl	Hans	WMI	SQQC
Iapichino	Luigi	LRZ	Q-DESSI
Isa	Erkan	FhG-EMFT	SHARE
Jirauschek	Christian	TUM-EI	SQQC
Knap	Michael	TUM-PH	THEQUCO
Knolle	Johannes	TUM	SQQC + THEQUCO
Koch	Robert	FhG-IIS	SHARE
König	Robert	TUM-MA	THEQUCO
Kraus	Barbara	TUM-PH	THEQUCO
Kranzlmüller	Dieter	TUM-IN/CS	Q-DESSI + QACI
Kutter	Christoph	FhG-EMFT	SHARE + QTPE
Linnhoff-Popien	Claudia	LMU-IN	QACI
Lorenz	Jeanette	FhG-IKS	QACI
Marquardt	Florian	MPL + FAU-PH	THEQUCO + HAT + QST-EB
Marx	Achim	WMI	SQQC
Mayer	Thomas	FhG-EMFT	SHARE
Mendl	Christian	TUM-IN/CS	Q-DESSI + QACI + HAT
Müller	Markus	FZJ	HAT

Nagy	Roland	FAU-EEI	SHARE
Ninkovic	Jelena	MPG-HLL	QTPE
Nötzel	Janis	TUM-EE	THEQUCO
Pernice	Wolfram	eHEI	TAQC
Pollmann	Frank	TUM-PH	THEQUCO
Pollet	Lode	LMU-PH	THEQUCO
Pomplun	Nikolas	DLR	HAT
Rabl	Peter	TUM	HAT
Roßkopf	Andreas	FhG-IISB	QACI
Schellenberger	Martin	FhG-IIS	QACI
Schilling	Christian	LMU-PH	THEQUCO
Schmidt	Kai Philipp	FAU-PH	THEQUCO
Schulz	Martin	LRZ + TUM-IN	Q-DESSI
Schulz	Laura	LRZ	Q-DESSI + QACI
Schollwöck	Ulrich	LMU-PH	THEQUCO
Schulte-Herbrüggen	Thomas	TUM-CH	THEQUCO
Seidl	Helmut	TUM-IN/CS	Q-DESSI + QACI
Thönes	Thomas	FhG-IIS	SHARE
Tornow	Marc	TUM-EI	SQQC + SHARE
Trummer	Christopher	TUM + WMI	QTPE
Ufrecht	Christian	FhG-IIS	QACI
Weissenbäck	Markus	FhG-IIS	QACI
Wilk	Tatjana	MCQST + MPQ	QST-EB
Wille	Robert	TUM-IN	Q-DESSI + QACI
Zahn	Daniela	FhG-EMFT	SHARE
Zeiher	Johannes	MPQ	TAQC

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