A trapped-ion quantum computer for the Munich Quantum Valley

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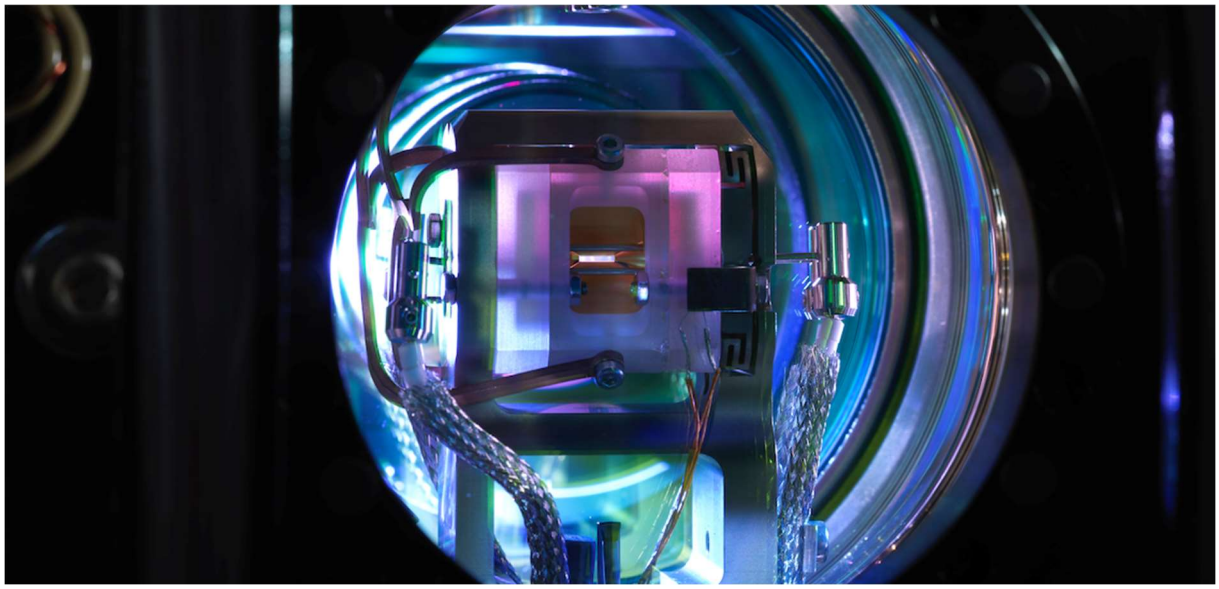
In cooperation with Munich Quantum Valley, the Leibniz Supercomputing Centre is procuring a quantum computer based on trapped-ion technology.



AQT ion trap © AQT | D. Kühl

Quantum technology for research and development: Together with Munich Quantum Valley (MQV), the Leibniz Supercomputing Centre (LRZ) of the Bavarian Academy of Sciences and Humanities (BAdW) is procuring another quantum computer for its Quantum Integration Centre (QIC). The computer, which uses 20 qubits implemented in an ion trap, was developed by the Austrian-based start-up Alpine Quantum Technologies (AQT). The new system will be made available to the seven member organizations of MQV, primarily for conducting research in system software. AQT's new ion-trap system is funded by the Bavarian State Ministries for Science and the Arts (StMWK) and for Economic Affairs, Regional Development and Energy (StMWi) with around 9.8 million euros as part of the Hightech Agenda Bavaria.

The new quantum computer offers MQV and the LRZ a wide range of possible application options and supports the development of new software. The objective is to implement new system software and programming environments and evaluate them with the help of practical applications in cooperation with partner companies from MQV's network. In addition, the quantum computer will be integrated into the LRZ's high-performance and supercomputers to accelerate them. Also, efficient workflows for supercomputing will be developed. Additional development projects are expected to result from the cooperation between AQT and MQV, for example in the areas of control electronics and laser technologies.

Ion-trap-based qubits controlled by laser beams

Even though research teams around the world have already started using quantum computers and are programming the first applications for them, the new technology still leaves a lot of room for development. For example, it is still uncertain which hardware will prevail in terms of scalability, economic efficiency and, in particular, reliability when it comes to computing. It is equally unclear which type of quantum computer is best suited for which tasks. The LRZ is already experimenting with systems in which quantum bits are realized using superconducting circuits. These can only be operated at temperatures close to absolute zero (-273 degrees Celsius or −459,67 degrees °F) and are sensitive to disturbances. Controlled by microwaves, systems with a large number of qubits can be scaled.

In contrast, the AQT system works with qubits made of electrically charged atoms (ions) that are captured in traps and manipulated by laser beams. Although the operations on these qubits are slower, the error rates are also smaller due to better shielding and insensitivity. In addition, the system can be operated at room temperature. AQT's quantum system therefore needs no special cooling, water or energy infrastructure and requires only about two kilowatts of electrical power during operation – less than a kettle. Its quantum register of 20 ions is controlled by two laser beams measuring 729 nanometers; for computing operations, the qubits can thus be made to entangle in pairs in a targeted manner.

The entire AQT quantum system, consisting of ion trap, laser and camera unit plus control electronics, fits into two 19-inch racks such as those commonly used in computer centers. The start-up delivers its quantum computer, which was developed and validated in collaboration with the University of Innsbruck, together with software libraries that are compatible with common platforms such as Qiskit, Cirq, Pennylane, Project Q or Qoqo, which simplifies programming.

Enriching the Munich Quantum Software Stack through technological diversity

The ion-trap system will be located in the QIC of the LRZ, which is the research center where quantum systems are integrated into supercomputers. The partner organizations of MQV and LRZ can access the AQT quantum computer via a cloud connection. At a later stage, the system will be integrated into the LRZ's high-performance computing resources, complement classical supercomputing and accelerate scientific simulations. The main goal is to develop interfaces to traditional computers and between the different quantum technologies. These efforts are being pursued as part of Q-DESSI, a research program of MQV, and other projects at the LRZ, and will culminate in the platform-independent Munich Quantum Software Stack. It is now also possible to take into account ion-trap system conditions, which makes the programming environment more versatile, flexible and universal.

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Statements from the partners involved

“The next innovation kick on the way to a quantum computer made in Bavaria: With the integration of an ion-trap system at the LRZ, we are broadening our internationally leading research environment in the field of quantum computing. This opens up additional opportunities for the members of Munich Quantum Valley in the development of system software for this key technology of the future. As the State Government of Bavaria, we are pleased to support this technological openness with almost 10 million euros as part of our Hightech Agenda – turning Bavaria more and more into a global quantum hotspot!”

Markus Blume, Bavarian State Minister for Science and the Arts

“With AQT's new ion-trap quantum system, we are significantly expanding the spectrum of quantum computers available in Munich Quantum Valley. The LRZ is making this technology available to all MQV members so they can test quantum computing applications. We are pleased that in this way we can provide many users with easy access to quantum computers and thus pave the way for their widespread use in research and industry.”

Prof. Dr. Rudolf Gross, scientific director Munich Quantum Valley (MQV)

“The fact that the Leibniz Supercomputing Centre has chosen our new ion-trap quantum system is an acknowledgment of the wealth of experience we have gained and all the development work we have done in this field. We are now looking forward to getting to know the Munich Quantum Valley’s many different requirements with regard to our 20 qubit system, so that we can develop it further.”

Dr. Thomas Monz, co-founder AQT, Innsbruck

“We are looking forward to exploring this new quantum technology and integrating it into our software development work at the LRZ and MQV. The AQT’s ion-trap system is an asset for the Q-DESSI project – its technical features provide diversity and lead to a broader set-up of the programming environment and system software of the Munich Quantum Software Stack."

Prof. Dr. Martin Schulz, Technical University of Munich (TUM), Member of the Board of Directors at the LRZ, and Head of the Q-DESSI Consortium of MQV

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About AQT, LRZ and MQV

The Alpine Quantum Technologies (AQT) was founded in 2018 by professors Rainer Blatt (experimental physicist) and Peter Zoller (theoretical physicist) and Dr. Thomas Monz. The company develops hardware for quantum computing and focuses on technologies based on ion traps and lasers. https://www.aqt.eu/

For more than 60 years, the Leibniz Supercomputing Centre (LRZ) has been providing innovative computer technologies and reliable IT services to the universities and colleges in Munich and to the scientific community in Bavaria. It is also one of three supercomputing centers in Germany and conducts basic research into new IT technologies such as artificial intelligence (AI) and quantum computing. https://www.lrz.de

Munich Quantum Valley (MQV) advances research into quantum science and technology in Bavaria focusing on the primary goal of developing and operating competitive quantum computers. It connects different stakeholders from science, industry, funding and the public and it supports the transfer of knowledge from research to industry. MQV is establishing a network of international reach and offers educational services for schools, universities and companies. It is supported by the Bavarian State Government with funds from the Hightech Agenda Bavaria. https://www.munich-quantum-valley.de/

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AQT ALPINE QUANTUM TECHNOLOGIES GMBH

Building on decades of experience in experimental and theoretical quantum information processing, AQT develops and builds quantum computers. The company's goal is to offer ion trap-based quantum computers that fit seamlessly into conventional IT infrastructure and can be operated from any PC or laptop, regardless of location. AQT already enables its customers to install quantum computers on site or to use them via a convenient cloud solution. AQT supports research customers with quantum hardware components and complete solutions that significantly accelerate the development of quantum optics experiments.