WACQT - Wallenberg Centre for Quantum Technology Newsletter #11, 2023

WACQT | Wallenberg Centre for Quantum Technology

Dear Reader

WACQT has now been running for more than five years and we have reached a steady state operation. A recent and important development is the planning and operation of the new quantum technology testbed that will allow industry and researchers in Sweden to test their quantum algorithms on a WACQT quantum computer. The first version will have a 25-qubit quantum processor and it will later be upgraded to 40 qubits.

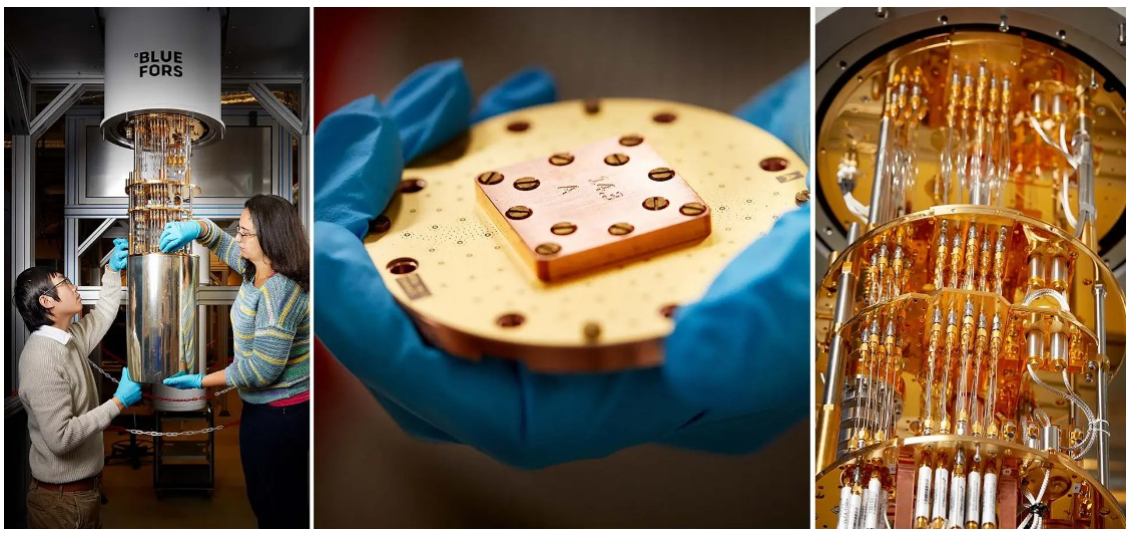
People is the most important asset for WACQT and we have recently recruited two new assistant professors. Alexandru Gheorghiu will work with quantum software at Chalmers and Armin Tavakoli will work with theory of open quantum systems at Lund University. We wish them welcome to WACQT.

We are very happy to congratulate WACQT researchers Ville Maisi at Lund University and Witlef Wieczorek at Chalmers who both have been awarded ERC consolidator grants.

We are also very happy to welcome Giovanna Tancredi as a new Principal Investigator in WACQT.

Per Delsing
Director of WACQT

WACQT news



New Swedish quantum computer to be made available to industry

The quantum computer developed at Chalmers is rarely available for use, as researchers are constantly working to develop it. But now, with funding from Knut and Alice Wallenberg Foundation, a copy of the quantum computer will be built. The new computer, accompanied by a quantum helpdesk, will allow Swedish companies and researchers to solve problems using quantum technology.

“The purpose is to raise Sweden’s competence level in quantum technology and lower the threshold for using quantum computers,” says Per Delsing, director of WACQT.

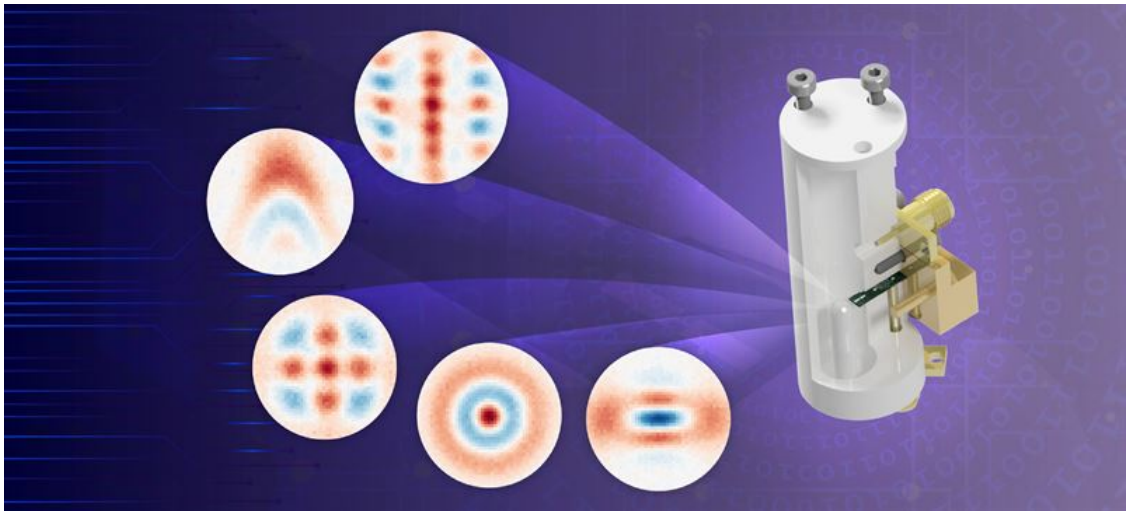
Read more

Using the power of symmetry for new quantum technology

By taking advantage of nature’s own inherent symmetry, WACQT researchers have found a way to control and communicate with the dark state of atoms. This finding opens another door towards building quantum computing networks and quantum sensors to detect the elusive dark matter in the universe.

“The foundation of our experiments is an innovative engineering trick where we control and make use of the available symmetries in a system which otherwise is very challenging to tame,” says Aamir Ali, primary author of the study.

Read more at chalmers.se and in Physical Review Letters.

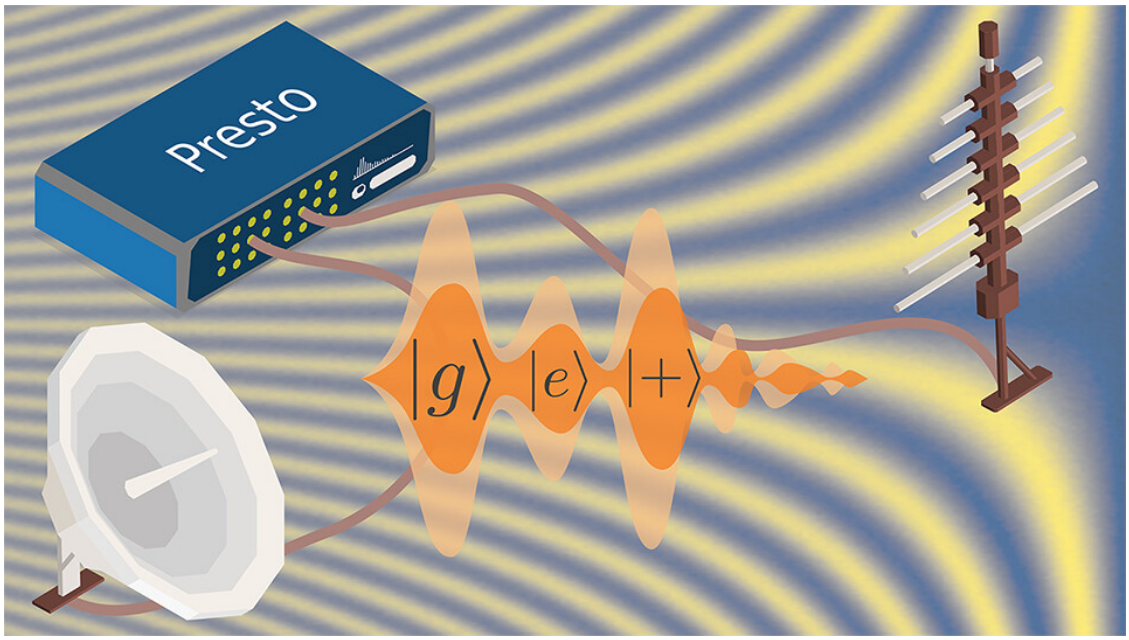


Unprecedented control over captured light

A team of WACQT researchers have succeeded in developing a technique to control quantum states of light in a three-dimensional cavity. In addition to creating previously known states, the researchers are the first ever to demonstrate the long-sought cubic phase state. The breakthrough is an important step towards efficient error correction in quantum computers.

“We have shown that our technology is on par with the best in the world,” says Simone Gasparinetti, one of the study’s senior authors.

Read more at Chalmers website and in PRX Quantum.



Digital microwave control platform improves scalability of qubit systems

A main impediment to scaling up a quantum computer is the cost and complexity of its classical control system. WACQT researchers at KTH and Chalmers have addressed this issue by developing an all-digital microwave control platform. The platform, named Presto after a very fast musical rythm, is based on the third-generation radio-frequency system on a chip and has been demonstrated to achieve very high fidelity for readout and gate operations on a sample consisting of two superconducting qubits.

"The power of our instrument lies in its high density of channels that will enable more accurate control of larger, multi-qubit circuits," says David Haviland, professor at KTH.

Read more in the AIP Scilight article and in the scientific publication.

Entanglement-assisted quantum communication with simple measurements

Dense coding is the seminal example of how entanglement can boost quantum communication, allowing one to transmit two bits of classical information while sending only one qubit. This is made possible by the sender and the receiver pre-sharing an entangled pair of particles. WACQT researchers at Stockholm University has investigated entanglement in more general communication tasks, in both theory and experiment. Their results reveal that there are scenarios in which the power of entanglement in enhancing quantum communication can be harvested in simple and scalable optical experiments.

"Conceptually, our results motivate a research effort into general entanglement-assisted correlations based on product measurements for the receiver side and importantly show crucial practical advantages since such protocols circumvents the need for implementing highly demanding entangled measurements," says Mohamed Bourenanne who led the work.

Read more in the publication in Nature Communications.

Ministry of Enterprise and Innovation eager to learn

Doctoral student Christopher Warren shows the quantum computer and explains its working in more detail.

On November 30th, a 20-person delegation from the Swedish Ministry of Enterprise and Innovation visited the Wallenberg Centre for Quantum Technology at Chalmers.

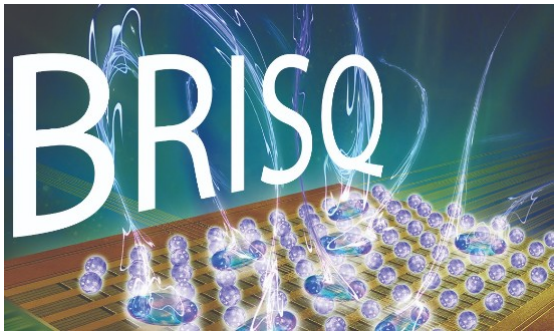
"We see the potential of quantum computers in very many areas of application. And as we know that the research environment here is fantastic, we wanted to come here and listen to the experts," says Fredrik Sandberg, digital and tech expert at the Ministry of Enterprise and Innovation. Read more

European quantum computer project expands

The EU Flagship project of building a superconducting quantum computer, OpenSuperQ, has been approved to enter a second phase. The project is expanded from 10 to 30 partners and renamed OpenSuperQPlus100 as it targets functional 100-qubit quantum computers.

"The project is entirely aligned with the quantum hardware and software goals of WACQT," says Jonas Bylander, one of the principal investigators for Chalmers. Read more

European collaboration to realise quantum computer based on Rydberg ions



A new EU-funded collaboration project – BRISQ – has started with the goal to realise a prototype of a scalable quantum computer based on trapped Rydberg ions. The advantage of the trapped Rydberg ion platform is coherence times of up to a minute together with entangling gate times on the order of 100 nanoseconds.

These two factors are key for achieving an unprecedented circuit depth and thus computational complexity. WACQT principal investigator Markus Hennrich and his group at Stockholm University are one of the partners in the project.

“I am looking forward to a fruitful collaboration with the excellent research groups in Tübingen, Jülich and Innsbruck, as well as our industry partners Infineon and HQS Quantum Simulations,” says Hennrich. Read more

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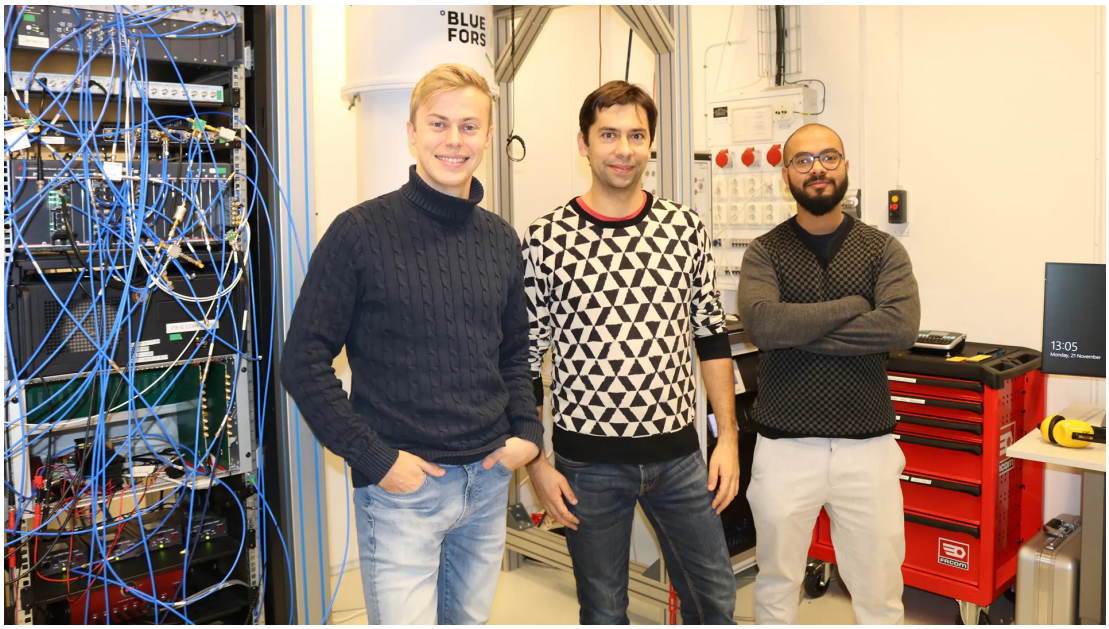

Pinpointing the energetic cost of timekeeping

Five research groups across Europe, among them WACQT researchers at Chalmers, are now joining forces in uncovering the ultimate limitations of timekeeping to assess whether precision measurements can become more energy efficient. The project, named ASPECTS, is part of the EU Quantum Technologies Flagship. Read more

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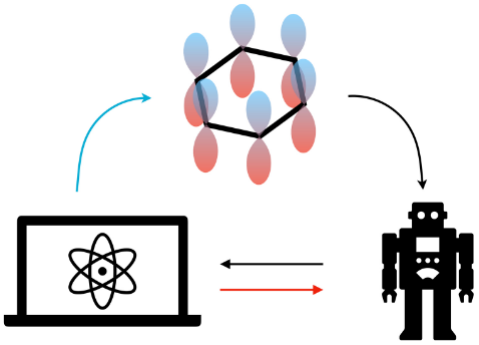
Machine learning and quantum computing to advance chemistry



A new, interdisciplinary project – jointly funded by WACQT and the Wallenberg AI, Autonomous Systems and Software Program (WASP) – combines expertise in machine learning, quantum algorithms, and chemistry to advance the abilities to calculate properties of molecules. In the long run, it could lead to speed-up of materials and drug design. Read more

Strengthening undergraduate education in quantum technology

Göran Johansson, WACQT PI and head of the Swedish Graduate School in Quantum Technologies, has received SEK 13 million from Marianne and Marcus Wallenberg Foundation for EDU-WACQT – a three-year programme for shaping and strengthening Swedish undergraduate education in quantum technology. The programme comprises three parts:

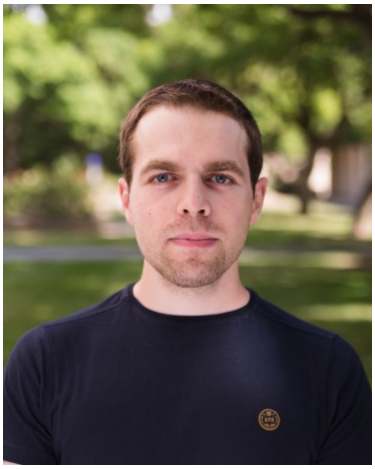
- financing of student summer jobs at WACQT universities, (read more and apply)
- scholarships covering tuition fees for students from outside the EU, and
- coordination and development of undergraduate education at the WACQT universities.

Giovanna Tancredi appointed research leader and principal investigator

Giovanna Tancredi, research scientist within WACQT since 2019, has been appointed one of the research leaders of WACQT´s core project of building a quantum computer. Giovanna Tancredi takes over many of Jonas Bylander's responsibilities, as he will work part-time for the spin-out company Atlantic Quantum during 2023. Giovanna has also been appointed WACQT principal investigator and is now a part of the Management group.

"I am very happy to take the new role and I will do my best to guide and help the research team achieve our ambitious goals," says Tancredi.

New assistant professors



Computer scientist Alexandru Gheorghiu has been hired as an assistant professor in quantum software at the Department of Computer Science and Engineering at Chalmers. His main focus is quantum complexity theory and quantum algorithms for the current state of quantum computing, that is noisy intermediate-scale quantum (NISQ) devices. He also studies proofs of quantumness, that is methods for provably demonstrating that a quantum device can perform computational tasks that a classical device with comparable resources cannot.

Armin Tavakoli from Vienna University of Technology and the Institute of Quantum Optics and Quantum Information in Vienna has been hired as assistant professor in theory of open quantum systems for quantum technology at the Department of Physics at Lund University. His research plans include for example topics within entanglement detection, quantum networks, quantum communication, and quantum thermal machines.

WACQT researchers receive prestigious grant

Two WACQT researchers have been granted the prestigious Consolidator Grant by the European Research Council:

Ville Maisi, Lund University, with the project QPHOTON which is about building a microwave detector which can count microwave photons and hence probe their statistics. The photon counters will be a new experimental tool that can be used

Witlef Wieczorek, Chalmers, whose project aims to realize quantum entanglement between objects of microgram mass. An array of superconducting microparticles magnetically levitated on a chip lies at the heart of the project. Combining that

extensively throughout quantum technology since a majority of the solid-state quantum technologies use microwave signals. Read more

technology with the world-leading expertise of superconducting quantum circuits available at Chalmers enables the curiosity-driven research. Read more

Save the date!

- WACQT's yearly general meeting – the May meeting – will take place 10–12 May in Gothenburg. The meeting is for the WACQT board, the scientific advisory board, the industrial advisory board and all members of WACQT.
- WACQT Summer School 21–25 August at the Swedish south coast, mainly for PhD students.

Selected world-wide news

IBM has announced a 433-qubit quantum computer. In November, IBM announced its new, 433-qubit superconducting quantum processor called 'Osprey'. It more than triples the number of qubits of their 127-qubit Eagle processor launched in 2021. According to IBM, 'Osprey' will have the potential to run complex quantum computations well beyond the computational capability of any classical computer.

"It is really impressive to see that IBM is continuing to deliver according to their ambitious roadmap. However, to benefit from the large number of qubits, we need to see gate fidelities of 99.9 % or above. It will be extremely interesting to see what performance they will get from this chip when it is tuned up," says Göran Johansson, WACQT principal investigator in quantum computing.

Read more in IBM's press release and in IEEE Spectrum

Neutral-atom computer made publicly available. The quantum computing start-up QuEra in Boston builds quantum computers based on neutral Rydberg atoms. Now they have made their first-generation quantum computer, a 256-qubit machine named Akila, publicly available via Amazon Braket. Access can be granted for free for academics via Amazon's credits for researchers.

"QuEra uses the neutral Rydberg atom technology for quantum computing and quantum simulations. It is great news that this machine is accessible for research," says Markus Hennrich, leader of WACQT's efforts in Rydberg ion quantum computing.

Read more at QuEra's website.

Quantum computing programme launched in Denmark. The Danish Novo Nordisk Foundation has launched an ambitious quantum computing programme in collaboration with the Niels Bohr Institute at the University of Copenhagen. The goal is to have Denmark's first fully functional, generally applicable quantum computer available in 2034.

The programme has a grant from the Novo Nordisk Foundation of DKK 1.5 billion (around SEK 2.2 billion) and will run for 12 years. The first seven years will be spent exploring different platforms and identifying the platform that offers the greatest opportunity to build

a usable quantum computer, and during the last five years the researchers will scale up the selected platform, make it usable, and run some relevant problems.

“This is a strong competitor to us. It starts a bit later, but has focus and good opportunities to advance internationally,” says Jonas Bylander, WACQT principal investigator in quantum computing.

Read more

Nobel laureate’s quantum computing startup raises €100 Million. Pasqal, a Paris-based quantum computing startup, announces having raised €100 Million to advance neutral atoms quantum computing. Pasqal’s technology builds upon the Nobel Prize-winning research of company co-founder Alain Aspect. The company will use the funding to further develop its neutral atoms quantum computing platform, which it believes will deliver major commercial advantages over classical computers by 2024.

“Quantum simulations with more than 200 qubits have been demonstrated on the Rydberg atom platform. With Pasqal’s excellent financial support for the Rydberg atom technology I expect more impressive results soon,” says Markus Hennrich, leader of WACQT’s efforts in trapped-ion quantum computing.”

Read more in Pasqal’s press release

Over 200 M€ to trapped-ion quantum computing startups. The German Aerospace Centre (DLR) has awarded contacts to five start-up companies with the aim of creating qubits based on trapped ions. The contracts amount to a total of 208.5 million euros. After four years the goal is to have prototype quantum computers with at least 50 qubits, built in a modular way that allows for scale up to thousands of qubits.

“Trapped ions are impeccable qubits with highest fidelity quantum operations demonstrated. This funding supports start-up companies working on modular ion trap chips with integrated microwave-based qubit control, a technique inspired by NMR. This is a promising route for scaling trapped ions quantum computers to large number qubits,” says Markus Hennrich, leader of WACQT’s efforts in Rydberg ion quantum computing.

Read more

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