WACQT - Wallenberg Centre for Quantum Technology Newsletter #9, 2022

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Dear reader,

Right now, many things are happening in quantum technology (QT) and this newsletter is packed with information that I hope you will nd interesting. A very important point is the bilateral agreement on collaboration on QT that was recently signed between Sweden and the US. This will hopefully lead to a national strategy for QT and promote international collaboration. In late March, the US ambassador also visited WACQT. Another important visit in March was that by members from the board of the KAW foundation.

WACQT researchers are doing well: as you can read below, professor Anne L'Huillier, PI in WACQT, was awarded the Wolf Prize together with two other researchers for her work on attosecond physics. In addition, assistant professor Simone Gasparinetti, also WACQT PI, was recently awarded an ERC starting grant. We congratulate them both.

I wish you happy reading.

Per Delsing
Director of WACQT

WACQT news

Anne L'Huillier wins the Wolf Prize in Physics

Anne L'Huillier, professor of atomic physics at Lund University and principal investigator in WACQT, has been awarded the Wolf Prize in Physics 2022 "for pioneering contributions to ultrafast laser science and attosecond physics". The Wolf Prize is awarded annually since 1978 by the Israeli Wolf Foundation to outstanding scientists and artists from around the world. In physics, it is considered the most prestigious award next to the Nobel Prize.

Read more at chalmers.se, including an interview with Anne, and on the homepage of the Wolf Prize.

Simone Gasparinetti receives ERC Starting Grant

Simone Gasparinetti, assistant professor in experimental quantum physics at Chalmers and principal investigator in WACQT, has been selected by the European Research Council (ERC) to receive a prestigious ERC Starting Grant of 2 million euros. His project is about combining thermodynamics and quantum mechanics in experiments, for example to improve the performance of an engine or the charging of batteries. "This grant presents me with a nice opportunity to carry out fundamental research complementary to the more applied one that my group is pursuing in the context of WACQT and other EU-funded projects," says Simone Gasparinetti.

Read more at chalmers.se and at the website of Simone Gasparinetti's group.

SSF funds programming of the quantum computer with 35 MSEK

A team of researchers from WACQT and the Department of Computer Science and Engineering (CSE) at Chalmers have been awarded 35 million SEK from the Swedish Foundation for Strategic Research (SSF) in the call Future Software Systems. The project, led by professor Devdatt Dubhashi at CSE and WACQT, is called QuantumStack. Its aim is to develop a full software stack for programming a quantum computer, covering the whole pipeline from algorithms, compilation, and programming languages down to implementation on physical hardware. "Quantum computing is a potentially revolutionary technology with major e orts around the world in academia and industry. Close collaboration between computer scientists, physics, and other areas is crucial in all these e orts. This grant enables us to add a powerful computer-science arm to the Swedish national e ort in quantum computing, wherein we will leverage expertise from many world-leading research groups in the CSE department at Chalmers," says Devdatt Dubhashi.

Read more in the press release from SSF (in Swedish).

NordIQuEst connects WACQT quantum

computer with Finnish supercomputer

The Nordic-Estonian Quantum Computing e-Infrastructure Quest (NordIQuEst), led by WACQT senior advisor professor Göran Wendin (on the right in the picture), is an e ort to integrate quantum computers and supercomputers in the Nordic countries and Estonia. Just before the formal start of NordIQuEst on April 1, the rst connection was made: the QAL9000 quantum computer at Chalmers can now be run remotely by accessing the Finnish supercomputer LUMI.

“Believe it or not, it worked on the rst try,” says Miroslav Dobsicek (third from the right in the picture), senior research engineer in WACQT at Chalmers who oversees the quantum-computing software stack. “The next connectivity proof-of-concept will be with the Norwegian eX3 high-performance computing (HPC) system.”

On June 8-9, NordIQuEst will arrange an online workshop together with EuroCC National Competence Centre Sweden (ENCCS). The aim of the workshop is to introduce quantum computing to people from the HPC community.

Giulia Ferrini named Outstanding Referee by American Physical Society

The American Physical Society (APS), which publishes the scienti c journals in the Physical Review family, has named associate professor Giulia Ferrini, principal investigator in WACQT, one of their Outstanding Referees. Only about 150 of the more than 80 000 active APS referees receive this award each year for their excellent work on reviewing manuscripts submitted to the APS journals. In 2022, Giulia Ferrini was the only awardee based in Sweden, as can be seen in the full list of recipients.

“I am honoured and pleased by this award. I will continue to strive to assist APS and the broad quantum physics publishing mission to the best of my ability,” says Giulia Ferrini.

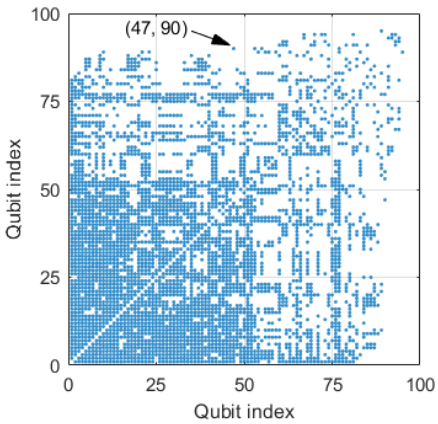
KAW visits WACQT

On 22 March, a delegation from WACQT’s funders Knut and Alice Wallenberg Foundation, including its chairman Peter Wallenberg Jr, visited the WACQT laboratories at Chalmers. During the visit, WACQT director professor Per Delsing presented the centre and its recent progress, and showed the latest quantum processors being measured at Chalmers. “We are always happy to welcome our sponsors. They show great interest in what we do and are always very supportive,“ says Per Delsing.

US ambassador visits WACQT

On 31 March, the US ambassador to Sweden, Erik D. Ramanathan, visited the WACQT facilities at Chalmers to discuss quantum technology and US-Sweden ties in this area. One week later, a joint statement was released by the US and Sweden on cooperation in quantum technology, as described in a news item below.

WACQT researchers investigate quantum computing with rare-earth ions

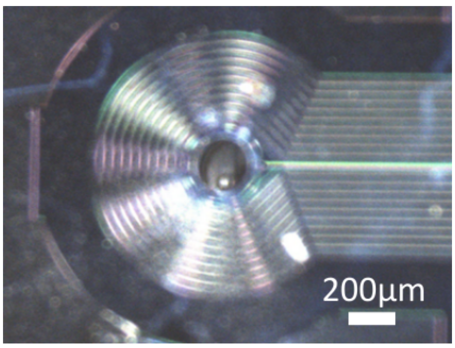


There are many hardware platforms being tried for quantum computing, including the superconducting qubits used in the core project of WACQT. A platform that has received somewhat less attention is ions of so-called rare-earth metals put inside a solid crystal. These ions can maintain their quantum states for a long time and can be densely packed. Recent progress in being able to detect and address single ions in such a setup has made the platform seem more promising than before. In a series of papers, WACQT researchers led by professor Stefan Kröll at Lund University have now analyzed in detail how a quantum computer based on rare-earth ions would work.

“The most remarkable result was that 100-1000 qubits with single-qubit gate delities better than 99.7% could be obtained within a sphere of a radius of a few tens of nanometres, and that each qubit on average could control around 50 other qubits. This opens up for extensive multi-qubit gate operations,” says Stefan Kröll. The picture shows a simulation of a 100-qubit system. Blue dots show which qubits can control each other. For example, the arrow points at the blue dot indicating that qubits 47 and 90 can control each other.

Read more in the three publications in Physical Review A: 1, 2, 3.

Levitating superconducting microparticles for investigating large-scale superposition states



Why do we not observe “weird” quantum phenomena like superposition (being in di erent states simultaneously) in our daily lives? To answer this question, researchers are pushing the limits on the size and weight of objects that can be put into superposition states. The group of associate professor Witlef Wieczorek in WACQT at Chalmers is using levitated superconducting microparticles for this purpose. They have now performed a proof-of-concept demonstration where they levitated a particle with the diameter of a human hair using a magnetic trap on a chip.

“We are excited that we can now levitate micrometre-sized superconducting particles fully on chip. This experiment is the first step along the long road ahead towards preparing superposition states of macroscopic objects,“ says Witlef Wieczorek.

Read more in IEEE Transactions on Applied Superconductivity.

Slow light stabilizes lasers

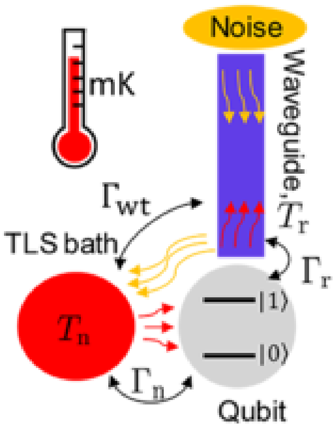
Lasers are used to measure time and distance with extreme precision. To ensure this precision, the frequency of the laser light needs to be kept stable. The key to the stabilization is to maintain a fixed length between two mirrors that the laser light bounces between. If the distance between the mirrors is long, small fluctuations of the mirror positions will matter less. By using techniques to slow down the light as it flies between the mirrors, WACQT researchers led by professor Stefan Kröll and associate professor Lars Rippe at Lund University have now demonstrated in experiment that they can increase the effective distance between the mirrors in their setup from 6 millimetres to more than 60 metres. This increased effective distance yielded a corresponding decrease of more than four orders of magnitude in the sensitivity of the laser frequency to fluctuations of the mirror positions.

“Interestingly, these extreme slow-light effects can have applications in such diverse areas as medical diagnostics (see the quantum-sensing techniques used in Deep Light Vision AB reported on in the previous newsletter) and high-precision metrology,” says Stefan Kröll.

Read more in New Journal of Physics.

Heat transport for a superconducting qubit

Superconducting qubits need to be cooled down to a temperature of just a few millikelvin to function well in a quantum computer. In an experiment performed by WACQT researchers at Chalmers with theory support from RIKEN in Japan, it was found that a qubit that had been cooled down remained hotter than the waveguide it was coupled to. Through careful measurements and modelling, the researchers were able to pinpoint the source of excess heat to systems in the qubit vicinity that were excited by high-frequency noise. The results both help design better protection from noise for superconducting qubits and provide a way to measure heat transport at very low temperatures and powers.



Read more in PRX Quantum.

Interview with Steven Girvin

Since the start of WACQT in 2018, the centre's scienti c advisory board has been chaired by professor Steven Girvin from Yale University. In this interview for the Oral Histories program at the American Institute of Physics, he recounts his life and illustrious career in physics.

WACQT featured in Dagens Industri

The Swedish business newspaper Dagens Industri published a long article on WACQT and the building of the quantum computer at Chalmers in March. The article and video, which include interviews with WACQT principal investigator associate professor Jonas Bylander and scienti c coordinator Anton Frisk Kockum, are available (in Swedish) without any subscription required.

Selected Swedish news

US and Sweden will cooperate on quantum technology

On April 8, the Swedish minister for education, Anna Ekström, and the US ambassador to Sweden, Erik D. Ramanathan, signed a joint statement on cooperation in quantum information science and technology. The joint statement aims to speed up development of quantum technologies and strengthen the exchange between the two countries. "We are delighted that Sweden and the US now have signed this agreement. This will strengthen already ongoing collaborations and hopefully result in extended collaborations," says Per Delsing, director of WACQT.

Read the full statement on cooperation.

Swedish quantum start-up Scalinq launches first product

In the previous newsletter, we reported on the rst round of funding for quantum technology from the Swedish Innovation Agency, Vinnova. One of the companies that received funding then, Scalinq, founded by WACQT research scientist Robert Rehammar and colleagues at Chalmers, has now launched their rst product. The product is a sample holder for superconducting quantum-computing chips, enabling up to 300 connections to a chip.

“We are very excited about this launch. There is a large interest from the market, and we are talking to several potential customers. Our solution was designed from start to be scalable, and this is readily proven by the fact that we already have a second member available in the product family, suitable for smaller samples,” says Robert Rehammar.

Read more on Scalinq’s homepage.

Selected world-wide news

Quantum sensors gain tunnel vision. Considering how much we can observe when looking out into space, we know surprisingly little about what hides beneath the surface of Earth itself. Now quantum sensors are becoming able to tackle that challenge. Writing in Nature, a research team from the UK report that they have re ned a quantum sensor based on so-called atom interferometry. In this technique, a cloud of atoms is created and falls freely, interfering with itself along the way. From the detected signal at the bottom of the device, one can read out minute changes in the gravitational eld that a ected the fall. The research team demonstrated that their device could rapidly and accurately detect an underground tunnel measuring 2 metres by 2 metres.

Read more in Nature News & Views and in Nature.

Optical clocks measure gravity at small scales. Einstein’s general theory of relativity predicts that time passes more slowly close to heavy objects, such as the Earth. This phenomenon was measured with highly accurate clocks already in 1976, when it was found that a clock on a satellite orbiting 10 000 kilometres above the Earth ticks faster than one on the surface. This di erence needs to be taken into account for GPS systems to work correctly.

In two papers published back-to-back in Nature, research teams from the US now report that they have achieved record-high stability in atomic clocks, where lasers probe certain transitions between energy levels in a cloud of atoms trapped in a grid of laser light. The accuracy of these new clocks is so great that they now can detect the difference in gravity on a millimetre scale; an increase in precision over the measurements from 1976 by more than ten orders of magnitude.

Read more in Nature News & Views and in the two papers in Nature: 1, 2.

NATO centre for quantum technology to be established in Denmark. The NATO alliance has made technological development one of its top priorities. Therefore, they have decided to establish a centre with test facilities for quantum technology at the Technical University of Denmark (DTU) with initial funding of 150 million DKK. The interest from NATO spans all areas of quantum technology: quantum computing for faster calculations, quantum-communication devices for safe communications, and quantum sensing.

“Denmark has always been very strong in quantum technology. WACQT and NordIQuEst welcome DTU to collaboration and competition to develop the Nordic quantum information ecosystem,” says Göran Wendin, senior advisor in WACQT.

Read more at DTU’s homepage.

Post-quantum cryptography implemented by OpenSSH. One of the most well-known potential applications of quantum computing is to break encryption. The security of modern encryption schemes is mostly based on it being hard for ordinary computers to find out from a large number (the public key, visible to everyone and used to encrypt messages) what the two prime numbers are that multiplied together yield the large number. These two prime numbers are the private key, which can decrypt messages encrypted with the public key. In 1994, Peter Shor at IBM showed that a quantum algorithm can find the private key from the public key exponentially faster than the best known classical algorithms.

In anticipation of large-scale quantum computers of the future becoming able to crack the encryption used today, new encryption algorithms called post-quantum cryptography are being developed. In the latest release of OpenSSH, a widely used tool for remote login on computers, the default encryption was changed to one of these new algorithms. In the release notes for version 9.0 of OpenSSH, the developers write “We are making this change now (i.e. ahead of cryptographically-relevant quantum computers) to prevent ‘capture now, decrypt later’ attacks where an adversary who can record and store SSH session ciphertext would be able to decrypt it once a sufficiently advanced quantum computer is available.”

Alphabet spins out quantum startup Sandbox AQ. Alphabet, the parent company of Google, has spun out a quantum-computing company called Sandbox AQ. Unlike Google’s Quantum AI team that builds a quantum computer, Sandbox AQ appears to focus on software, both classical and quantum, including solutions for post-quantum cryptography. The company currently employs more than 50 people and is set to expand after having raised several hundred million dollars in funding.

Read more from Reuters.

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