WACQT - Wallenberg Centre for Quantum Technology Newsletter #12, 2023

WACQT | Wallenberg Centre for Quantum Technology

Dear Reader

On October 3rd we received the fantastic news that WACQT principal investigator Anne L'Huillier has been awarded the Nobel prize in physics 2023. We are super happy for her and extremely proud to have her as a colleague in WACQT. You can read more below.

In this newsletter we also report on the Swedish Quantum Agenda that was written by the stakeholders from several organizations including WACQT. The WACQT quantum computer was also successfully demonstrated at the Digital assembly in Stockholm in June.

The international news also includes new UK and Danish governmental efforts on quantum technology as well as new results from the IBM quantum computer.

Happy reading,

Per Delsing, director of WACQT

WACQT news

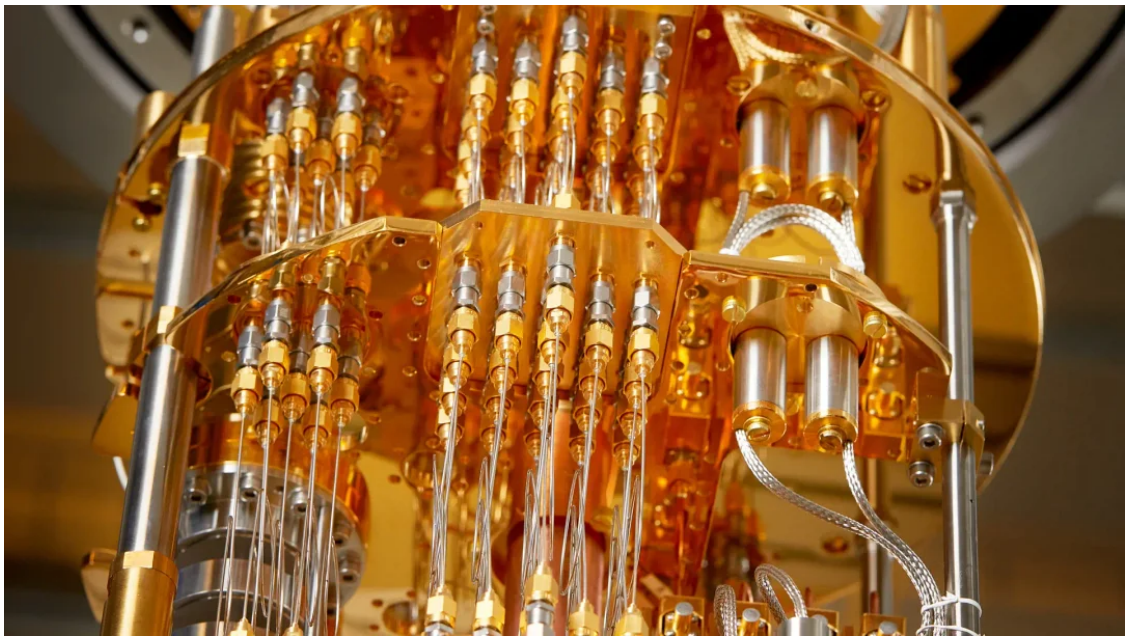
Anne L'Huillier is awarded the Nobel prize

WACQT principal investigator Anne L'Huillier, professor in atomic physics at Lund University, is one of this year's recipients of the Nobel Prize in physics. She is awarded the prize for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter. The prize is shared with two other pioneers in attosecond physics, Pierre Agostini at the Ohio State University, USA, and Ferenc Krausz at the Max Planck Institute for Quantum Optics in Germany.

Over years, Anne L'Huillier has been awarded many prizes for her research, for example the prestigious Wolf Prize, the Banco Bilbao Vizcaya Argentaria Foundation Frontiers of Knowledge Award, the Lise Meitner Award, and the Max Born Award. And now the most prestigious price there is in science – the Nobel prize.

"Anne is amazing and a role model for so many of us. We are super happy for her and immensely proud to have her as a colleague," says Per Delsing, director of WACQT.

Nobel prize press release
News article at the Lund University website
WACQT interview from 2022



A Swedish agenda for quantum technology

Sweden has strong research in quantum technology, much thanks to private funding from Knut and Alice Wallenberg foundation, but now needs national coordination and investments to maximize the benefits of this emerging area of technology. WACQT has been part of writing a Swedish quantum agenda which has been handed over to the Minister of Education.

"Quantum technology has the potential to affect many areas of society in the future and it is important that Sweden is 'quantum ready'," says Per Delsing, director of WACQT.

News article at the WACQT website
A Swedish quantum agenda (English version)
En svensk kvantagenda (Swedish version)

Some other countries' quantum agendas and strategies:

Australia: An Australian strategy for the quantum revolution
Canada: National Quantum Strategy Consultations: What We Heard Report

Denmark: Danish Quantum Agenda
Finland: Finnish Quantum Agenda
Netherlands: National agenda for quantum technologies
UK: National quantum strategy
USA: National strategic overview for quantum information science

One step closer to a European quantum computing community

At the end of June, nine European parties, including Chalmers, signed a hosting agreement for the acquisition and operation of a EuroHPC quantum computer within the framework of the LUMI-Q consortium. The collaboration is expected to link WACQT and other Nordic ecosystems for quantum computing users to a broad EU community and accelerate research and development in quantum technology in the coming years.

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Celebrating the centennial of Einstein's Nobel lecture

A hundred years ago, Albert Einstein delivered his Nobel lecture in the amusement park Liseberg in Gothenburg. To celebrate the anniversary, four distinguished Nobel laureates visited the Liseberg theatre and Chalmers to shed light on the fascinating world of physics, during the two-day conference *Einstein '23*. On the agenda, were also several other enlightening and entertaining program items that shed light on Einstein's visit to Gothenburg and his influence.

"We had the pleasure of listening to the two founding fathers of quantum technology, Serge Haroche and David Wineland. The title of Haroche's presentation was *Quantum physics: Einstein's rebellious child*. Here he reminded us about the photoelectric effect, the photon and other important contributions Einstein made to quantum physics, although he never really came to terms with it, as illustrated by the well-known debates with Niels Bohr," says Göran Johansson, co-director of WACQT and one of the organizers of Einstein '23.

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“Now we’re in a steady state”

Why do we need a Swedish quantum agenda? How do you best deal with the current quantum hype? And how is the construction of the quantum computer at WACQT coming along? These were a few of the topics that were up for discussion as the PhD students, researchers, partners, advisors, and board members of WACQT met up to review the centre's activities during their annual May meeting.

“Of course, it’s a really nice feeling to see that things are moving forward, and to be able to meet everyone in WACQT. We are now almost halfway through the centre's funding. We have had a significant ramp-up phase, but now we are in a steady state,” says Per Delsing, director of WACQT.

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WACQT Summer school 2023

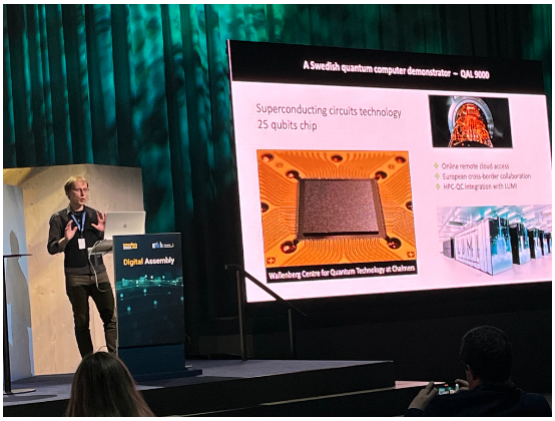
The third edition of WACQT’s biannual summer school was held in August at the Swedish south coast. It was mainly for PhD students, but some postdocs also attended. The week included lecturers from around the world – for example Anne L’Huillier who was awarded the Nobel prize some weeks later – , a panel discussion on motivation, work-life balance and much more.

“It was great to be back in person for the summer school, two years ago the school was online. Interesting and engaging lectures in combination with a beautiful venue gave perfect conditions for the participants to learn, discuss and interact,” says Peter Samuelsson, professor in theoretical physics at Lund University and new director of studies for WACQT Graduate school.

Read more about the summer school

Several meetings with WACQT participation

Several meetings have taken place since the previous WACQT Newsletter. In June, the European Commission held its annual Digital Assembly, this year in Stockholm. The event was a lunch-to-lunch event, of which one hour was devoted to quantum technology. Miroslav Dobsicek, leader of the software team in WACQT's quantum computer project at Chalmers, demonstrated calibration and a computation using twelve qubits on to the WACQT quantum computer which he accessed via the cloud. Katia Gallo, WACQT principal investigator, was involved in organizing a demonstration of quantum communication – a quantum secured video conference. The Digital Assembly can be watched on Youtube, the WACQT demonstrations start at 5h 9min.



Miroslav Dobsicek, WACQT

In March, the EuroHPC Summit – the annual meeting of the European High Performance Computing Joint Undertaking – was held in Gothenburg. WACQT director Per Delsing was one of the speakers, and members of EuroHPC visited Chalmers and WACQT at two occasions.

The EuroNanoForum 2023 took place in Lund in June. The event comprised a session on quantum technology, which was organized by Anton Frisk Kockum and Göran Wendin from WACQT.

At the end of August, the four-day workshop Frontiers of near-term quantum computing took place at Chalmers. The aim was to bring together researchers from the fields of computer science, quantum information and chemistry to discuss theoretical and computational aspects of near-term quantum computing, the capabilities and limitations of current approaches, and strategies towards utilizing near-term hardware for solving practical problems.

"The high-quality speakers and the broad range of topics of the workshop attracted many participants, making it a great success. We have received positive feedback and comments highlighting how the event facilitated establishing collaborations and scientific discussions among attendees," says Laura García-Álvarez, researcher at WACQT and one of the organizers of the workshop.

Sweden builds its quantum communication infrastructure as part of EuroQCI

Sweden has received EU funding, with Swedish co-funding from Vinnova and WACQT, to design, develop and deploy a National Quantum Communication Infrastructure in Sweden (NQCIS), as part of the larger and long-term European effort to grant quantum-secured communications across all Europe, through the European Quantum Communication Infrastructure (EuroQCI) programme. The NQCIS, coordinated by KTH, involves teams at Ericsson, Chalmers, Stockholm University, and Linköping University as well as emerging quantum companies in Sweden. It will build a multi-node testbed and deploy a national infrastructure for quantum key distribution, with metropolitan links in Stockholm and long-distance links between Stockholm and Linköping, tailored to the specific needs of public and industrial stakeholders in Sweden.

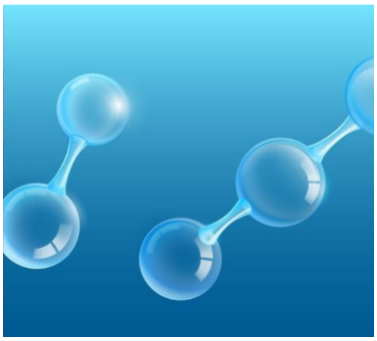
"Through this project, Sweden and all EU Member States will build secure quantum communication opportunities in order to strengthen shared capacity in quantum

communications, cyber security, and industrial spearhead capacity and expertise," says Katia Gallo, principal investigator for quantum communication in WACQT and leader of the NQCIS project.

NQCIS runs for 30 months and has a budget of SEK 100 million.

Read more about NQCIS
Read more about EuroQCI

Swedish quantum computer applied to chemistry



Quantum computers are expected to facilitate the development of new pharmaceuticals and materials in the future. WACQT researchers at Chalmers have, for the first time in Sweden, used a quantum computer to undertake calculations within a real-life case in chemistry.

"We see good possibilities for further development of our method to allow calculations of larger and more complex molecules, when the next generation of quantum computers are ready," says Martin Rahm, associate professor in chemistry at Chalmers.

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Seeking to verify quantum advantage with bosonic quantum computers

Research teams in Gothenburg, Paris, and Milan have joined forces with the aim to demonstrate and verify quantum advantage in bosonic quantum computing architectures based on superconducting circuits. The four-year project, named VeriQuB, is funded through the EIC Pathfinder programme.

In Gothenburg, experimentalists at Chalmers, led by Simone Gasparinetti, will mainly work on realizing the planar superconducting resonators and coupler that will serve as the basic building blocks in the bosonic quantum computing architecture.

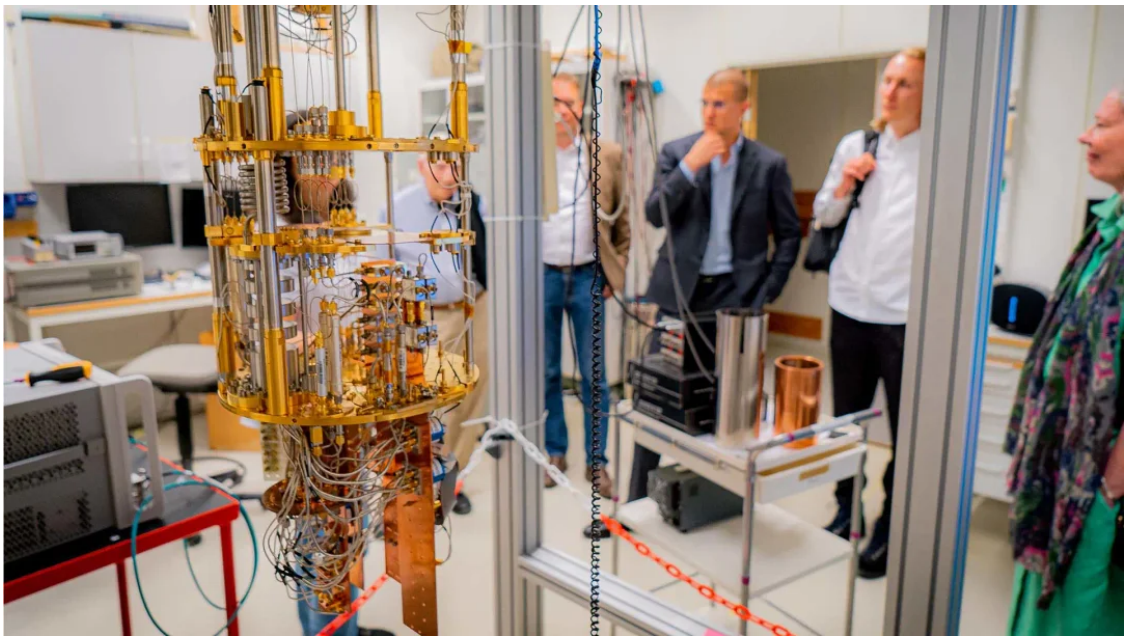
"We aim for six resonators with high connectivity between all of them. The challenge is to reliably produce large non-classical states and to create a highly entangled system via the coupler," says Axel Eriksson, one of the co-investigators for the project at Chalmers.

On the theory side, the Chalmers team will provide a rigorous proof of computational advantage for such an architecture based on the superconducting resonators and investigate suitable bosonic states to use as input states in the computational task.

"We will try to find a sweet spot of parameters, where the computational task can be run robustly even in the presence of noise. With this project we also hope to be able to conclusively discard the Turing thesis which says that every computer based on physical laws is simulatable with a Turing machine," says Giulia Ferrini, principal investigator for the theory work at Chalmers.

Ferrini adds that the project ties very well and have good synergies with the WACQT activities on continuous-variable quantum computing.

Read more about VeriQuB



Great interest in Chalmers' quantum computer

In step with the progress of quantum technology, the outside world's interest in Chalmers' quantum computer is boosting – as is the number of study visits at WACQT. This spring the center has welcomed curious students, companies, and decision-makers from Sweden and abroad.

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Young physicist receives international attention

Prize for best paper on quantum foundations from the Institute for Quantum Optics and Quantum Information in Vienna and a special recognition from the Institute of Physics in the UK. Already at the age of 29, Armin Tavakoli is a promising star in theoretical quantum physics. He is funded by WACQT and works as an assistant professor at Lund University.

Read more at the Lund University website (in Swedish)
The prized paper "Quantum theory based on real numbers can be experimentally falsified"
IOP Publishing's International Quantum Award winners

Daryoush Shiri is elevated to Senior Member of IEEE

Daryoush Shiri, WACQT researcher specialized in microwave simulations in the quantum computer project at Chalmers, was in September elevated to Senior Member of IEEE – a technical professional organization with over 400 000 members all over the world. Senior Member is the highest professional level for which an IEEE member may apply. It requires extensive experience and reflects professional accomplishment and maturity.

[tom länk]

Lena Gustafsson has received the Chalmers Medal

Lena Gustafsson, chair of the WACQT board, has been awarded the 2023 Chalmers Medal. She was Chalmers' first vice president 2003–2006, and since 2017 she contributes to Chalmers' activities again as chair of the WACQT board. According to the motivation, Lena Gustafsson has been important in many contexts and has contributed greatly to strengthening and developing the conditions for strong Swedish education, research, utilisation and innovation.

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Göran Johansson has been appointed co-director of WACQT

Per Delsing is now accompanied as WACQT director by Göran Johansson who was appointed co-director in June. Göran Johansson is professor and head of the Applied Quantum Physics Laboratory at Chalmers. He has been a principal investigator of WACQT since the start, leading the theory efforts in quantum computing and simulation. As co-director, Göran Johansson will be responsible of the excellence programme, graduate school, industrial collaboration, and EDU-WACQT.

"As co-director, I get a broader responsibility than before for the excellence program, but I intend to keep my focus on modelling and use-cases and be even more engaged in working with our industrial partners. I leave the leadership of the Graduate School committee in the safe hands of Peter Samuelsson at Lund University but will still feel responsible for that the school gets the resources it needs," says Göran Johansson.

Per Delsing is this year's William Chalmers lecturer

In his William Chalmers Lecture, titled "Why is everyone talking about quantum computers?", Per Delsing talked about how quantum computers will affect our everyday lives, how Sweden can be made a front runner in quantum technology and when we can expect the

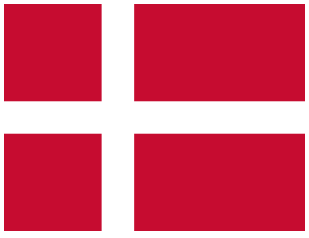
great quantum revolution to begin. The lecture, which took place at Chalmers 7 November, was given in Swedish and open to the general public.
Read more

Selected world-wide news

IBM's claim for quantum utility questioned by the scientific community. In a publication in Nature early this summer, IBM demonstrated a quantum computation of the magnetization of a model quantum system by using a 127-qubit quantum processor, which no classical computer has the memory to simulate. This use of a quantum processor to compute the properties of a real system was advertised as "utility quantum computing" – that is, usefulness even before anyone can demonstrate fault-tolerant, error-corrected quantum computation. WACQT's Göran Wendin and Jonas Bylander discussed this work in a Nature News & Views commentary, and it was also featured in Dagens Nyheter, The New York Times, and other outlets.
However, just days after publication, three papers (1, 2, 3) were uploaded to the Arxiv preprint server with claims of classical simulations outperforming IBM's results by using better computational methods. Google Quantum AI suggested that IBM's calculation really didn't involve more than 31 entangled qubits. The ensuing discussion all over the internet prompted a response by IBM which posted a follow-up preprint, claiming that all simulations – including that performed on a quantum computer – come within 20 % of each other, and that the data points from experiments on similar systems lie within this range.
"Perhaps one cannot quite know which one is more correct. At least this would become reality soon, and we need ultimately to compare the results of quantum computation to experimental reality as the final judge," says Jonas Bylander, principal investigator in WACQT.

The UK invests another 2.5 billion pounds in quantum technology. In addition to its 1-billion-pound National Quantum Technologies Programme from 2014, the United Kingdom has launched a ten-year national quantum strategy backed by 2.5 billion pounds of public funding. The plan is to fund new frontiers of quantum research, support and develop the growing quantum sector, prepare the wider economy for the quantum revolution, and ensure that the UK leads internationally in the regulation and ethical use of quantum technologies.

"It is clear that the UK wants to build on what they started already in 2014 and now substantially increase its national efforts on



The Danish government announces 1 billion DKK investment. In June, the Danish government published the first part of Denmark's national quantum strategy and committed to invest one billion DKK into quantum research and innovation from 2023 to 2027. The first part of the Danish strategy focuses on how Denmark can retain its position as a global leader in quantum research. The second part is going to be published in the fall of 2023 and will spotlight the potentials for development, commercialization, and application of quantum technologies in Denmark.

"It is very positive to see the Danish government following up on the earlier

quantum technology in the coming decade," says Göran Johansson, co-director of WACQT.

The UK National Quantum Strategy
News article in Tech Monitor

announced 1.5 billion DKK quantum computing effort by the Novo Nordisk Foundation," says Göran Johansson, co-director of WACQT.

Press release from the Danish government
Explainer at the Danish Quantum Community website

Pioneering experiments push the boundary of "quantumness". Quantum physics rules the microscopic world, while classical physics reigns over the macroscopic realm. Power changes hands somewhere in between but exactly how and at what scale is still unknown. A new experiment with an acoustic resonator demonstrates quantum superposition in a collection of 10^16 atoms, weighing around 1 microgram, as reported in Physical Review Letters. In a paper in Science, the same group also reports having prepared, observed, and controlled a type of quantum states known as 'cat states' of a 16-microgram mechanical resonator.

"These beautiful experiments demonstrate that we nowadays have quantum control over objects that we thought years ago to behave only classically. The next major step after these pioneering experiments will now be to create non-classical states in such massive objects over larger spatial separations," says Witlef Wieczorek, researcher in macroscopic quantum behaviour and quantum sensing at Chalmers.

Feature article in Physics
Scientific paper in Physical Review Letters
Scientific paper in Science

NIST standardizes encryption algorithms that can resist attack by quantum computers. Our digital society is highly dependent on secure information, but with the progress of quantum computers that potentially can break today's encryptions, the security risks are rapidly increasing. Last year, the National Institute of Standards and Technology (NIST) in the US selected four classical encryption algorithms designed to withstand hacking attacks by quantum computers, so called post-quantum cryptography. Now, the agency is in the process of standardizing these algorithms. Draft standards have been released for three of them, and the worldwide cryptographic community has been invited to provide feedback until November 2023.

"This is another step in the preparations for the day when quantum computers become really powerful. Some services already use these new encryption algorithms, since there may be data that you encrypt now that you want to remain safe for decades," says Anton Frisk Kockum, senior researcher at WACQT.

As reported in WACQT Newsletter #9, OpenSSH – a widely used tool for remote login on computers – already has implemented one of these new algorithms.

Read more at the NIST website

Founder of quantum information theory has passed away. Göran Lindblad, professor emeritus in theoretical physics at KTH, was one of Sweden's most well-cited scientists. He was one of the founders of quantum information theory and derived a fundamental equation describing the time evolution of open quantum systems now known as the Lindblad equation, which is widely used today.

Obituary in Physics Today
Lindblad's personal page at the KTH web

Northern Prospects of Quantum. The Estonian, Finnish, Latvian, Lithuanian, Norwegian, and Swedish EU Research and Innovation Liaison Offices in Brussels organised a day dedicated to quantum trends and best practices in the Nordic-Baltic region by the end of March. Amongst other, national funders, researchers, European Commission staff, and companies discussed societal impacts of quantum technology, recent evolutions in national quantum agendas, directions for quantum business, ingredients for thriving quantum ecosystems, and policy implications both at national, regional, and European level. WACQT researchers Per Delsing, Göran Johansson, Mohamed Bourenanne (as founder of QuCertify AB), and Johannes Swartling from Deep Light Vision AB presented emerging messages on national agendas, education as a solid foundation, and on creating quantum companies.

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