Research and Education Group Applied Quantum Computing

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Research and Education Group Applied Quantum Computing

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Quantum Technology

Quantum mechanics was being constructed at the start of the last century and started a whole range of discoveries such as nuclear energy, transistors, particle accelerators for medical treatments and much more. The second quantum revolution, which started in the eighties of the last century, is characterized by the active involvement of humans into quantum mechanics. Quantum mechanics became quantum technology manipulating entities at a quantum level to create specific effects. Quantum technology consists of:

- Quantum Computing, using superposition, interference and entanglement makes new and better solutions for classical hard problems possible;
- Quantum Communication, entanglement and the no-cloning principle creates an inherent secure communication;
- Quantum Sensing, the fragility of quantum entities is being used for ultra precise sensing.

The focus of this poster is Quantum Computing and the activities initiated by the Amsterdam University of Applied Sciences in the domain of this emerging technology.

Quantum Computing

The enormous potential of quantum computing became clear to everybody when Peter Shore theoretically proved an exponentially speed up of computing by Quantum Computers. In 1994 he showed that the widely used factorisation method used in RSA encryption could be solved exponentially faster than on a classical computer. This will make the RSA encryption useless when quantum computers with sufficient capacity are engineered. It is expected that such computers will be created in 10 to 15 years.

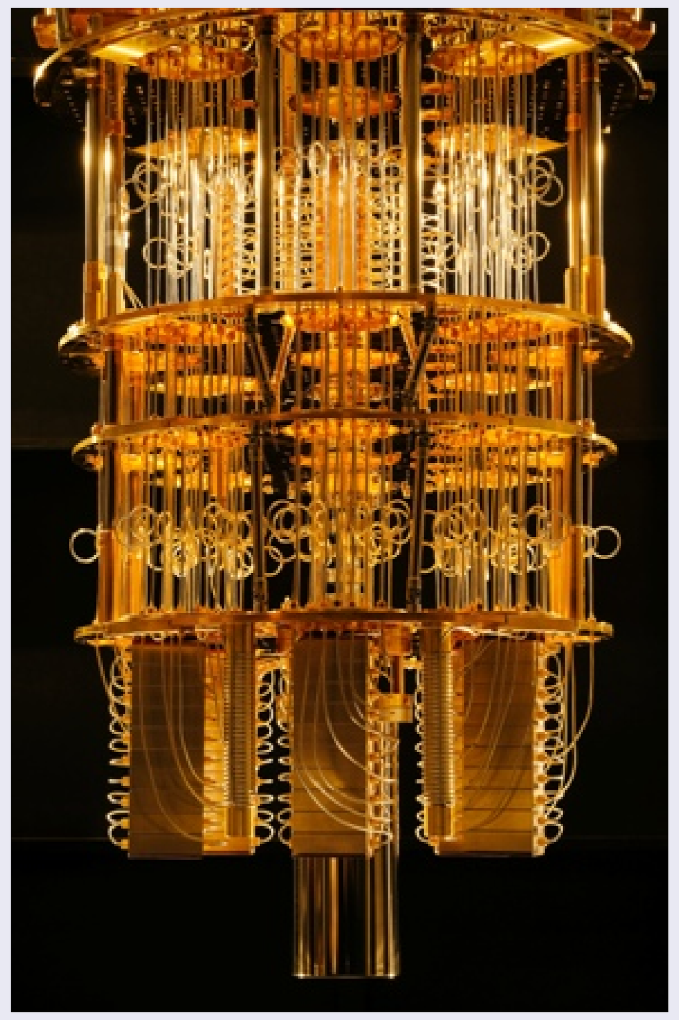

Figure: IBM Quantum Computer. Source: www.ibm.com

Figure 1 shows the kernel of a Quantum Computer. It is one of the coolest places on earth, just above 0 Kelvin, i.e. 273 $^{\circ}C$. This temperature is needed to mitigate the thermal influence otherwise would destruct the states of the fundamental unit of Quantum Computing, i.e. the qubit. While the Quantum Processing unit (QPU) is being kept at that very low temperature it is for the engineers to figure out how to manipulate these qubits and extract data from them. The decoherence problem, i.e. the difficulty keeping qubits in a specific state, error correction and how to get at the heart of the computer with the necessary cables are the big challenges momentarily. It is unclear when these problems are solved. When they are solved and Quantum Computing really takes of some of the problems which can not be solved now come within reach of a solution.

Quantum Computing is expected to solve problems in the economic sectors of:

- Chemicals and Petroleum, by simulating behaviour of atoms and molecules
- Distribution and Logistics, by using specific optimization algorithms
- Financial Services, by using quantum computers as accelerators for intensive computing
- Health Care and Life Sciences,
- Manufacturing,

Quantum Technology at the Amsterdam University of Applied Sciences

The Amsterdam University of Applied Sciences started a research and education group on Applied Quantum Computing at September 1st 2020. This group has a focus on Quantum Computing and Quantum Sensing. Quantum Computing is done together with the Computer Science program and Quantum Sensing with the new Technical Physics program which will start September 1st 2021.

Quantum Computing research group | Amsterdam University of Applied Sciences

Minor Applied Quantum Computing

Starting February 1st 2021 a minor Quantum Computing is organised. During this minor bachelor students are introduced into Quantum Computing and work on real world problems. The minor can be attended by students having some familiarity with Computer Science, Physics or Mathematics and comprises 30 ECTS.

Courses

Students are introduced into the subject at the course Quantum Computing Introduction and Mathematics. During an intensive two week period the students get familiar with the most basic concepts and tools. In the advanced course several subjects such as search, factorization, VQE, machine learning and optimization are discussed. In the second period students elaborate on the quantum stack and various topics such as the quantum eco system, societal impact, quantum communication and sensing, and more.

Projects

As part of the minor students work on a project. These projects are formulated together with external parties such as national computing centre SURFsara and the chemistry oriented company Qu & Co in Amsterdam. An example of a project is looking for the best circuits for particular algorithms on a range of hardware. Or optimizing the hybrid setting for QPU-accelerators. These projects are part of a research program conducted by the research group Applied Quantum Computing. Students participate in small teams for a period of about four months. The projects self extend over a longer time. Lecturers/researcher are supervising the work of the students.

International Summerschool

The summerschool starts in July and is open for students from all over the world. In two weeks students are introduced into the world of Quantum Computing. Attending hands on workshops students learn to program simple algorithms and their mathematical basic. Students will work in international teams on a number of selected projects. A day trip to QuTech is also scheduled.

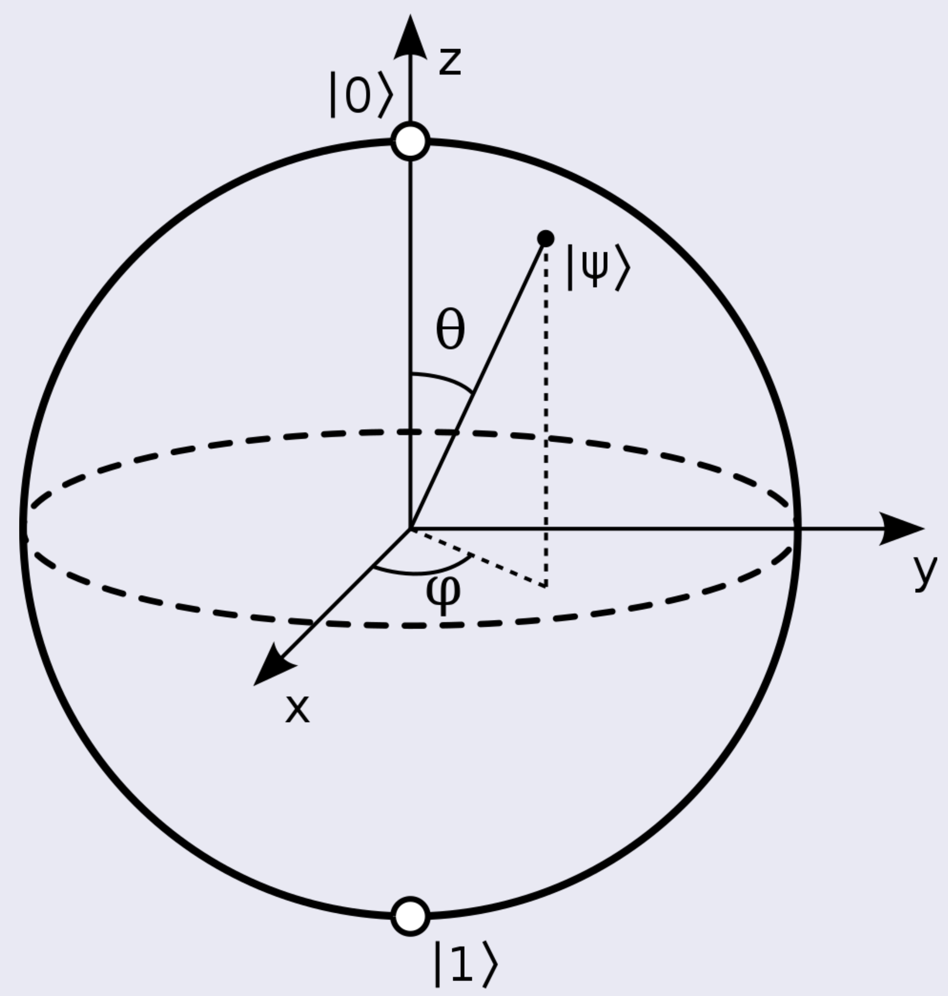

Figure: Bloch sphere. Source: www.wikipedia.org

Quantum.Amsterdam

Quantum.Amsterdam is an innovation hub for software and application in the Dutch quantum ecosystem which started in 2020. It aims to be the gateway to the quantum world for companies to explore and develop quantum software and new applications. Knowledge partners of Quantum.Amsterdam are: QuSoft, CWI, University of Amsterdam, VU University of Amsterdam, Amsterdam University of Applied Sciences and SURFsara. It offers joint research with knowledge partners, training and education, support for start-ups.

Quantum.Amsterdam

National Agenda Quantum Technology or QΔNL

The National Agenda Quantum Technology was presented by Robert Dijkgraaf in September 2019. Less than a year later €23.5 M came available from the Ministry of Economic Affairs and the program was launched.

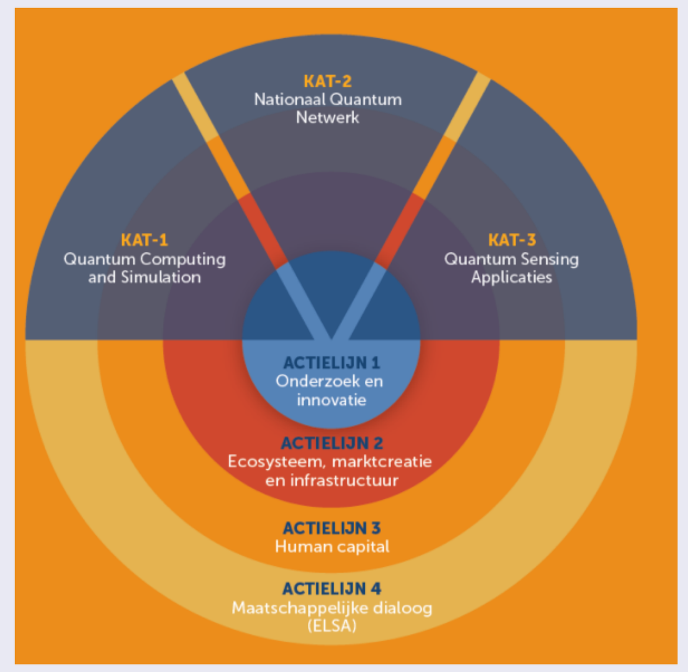

Figure: Four action lines and three ambitious unifying CAT programmes. Source: NAQT

Figure 3 shows the three catalyst programs (CAT programs):

1. Quantum Computing and Simulation: at QuTech research is being done to develop a quantum computer, at QuSoft algorithms are created to make use of such a computer
2. National Quantum Network: an open national infrastructure will facilitate development of a software and security industry
3. Quantum Sensing Applications: a testing and user facility will be realized to assist enterprises with innovation

The actionlines as presented are defined as follows:

1. Research and Innovation: the goal is to create breakthroughs in the fields of quantum computing, simulation, communication, sensing and post-quantum cryptography
2. Ecosystem, Market Creation and Infrastructure: international relations, creation of fieldlabs, extension of clean rooms, support for start-ups
3. Human Capital: education, collaboration and knowledge exchange, attracting talent, initiating conferences, summer schools and student exchange
4. Social Dialogue: initiation of a dialogue, formation of professorship, development of ethical and legal frameworks for quantum technology

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