

Master of Science

Quantum Engineering



Welcome

The Master of Science in Quantum Engineering at ETH Zurich was created to meet the rising demand for scientifically trained engineers who can employ the fundamental laws of quantum mechanics to create technological applications that go beyond the capabilities of classical methods. In this programme, the Department of Information Technology and Electrical Engineering and the Department of Physics at ETH join forces to provide an interdisciplinary curriculum at the interface of fundamental science and cutting-edge engineering.

"Quantum technology offers the opportunity to perform measurements with unprecedented precision, limited only by the very fundamental laws of nature."

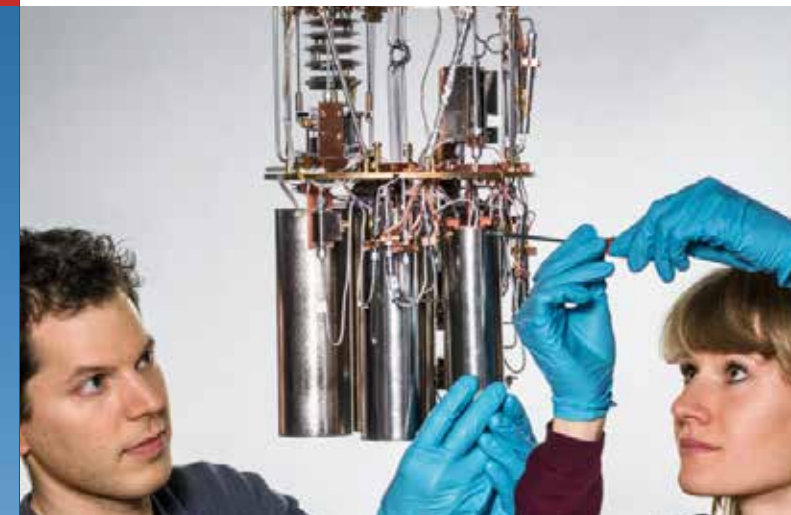
Prof. Lukas Novotny, *Photonics Laboratory at ETH Zurich*

The second quantum revolution

Since its inception more than a century ago, quantum mechanics has transformed our understanding of the physical laws at a microscopic scale. This understanding has led to the development of devices that form the toolbox of today's state-of-the-art engineering. Currently, a second quantum revolution is underway. Equipped with a fully developed theory of quantum mechanics, a new breed of engineers is exploiting quantum systems as a technological resource. The Master of Science in Quantum Engineering at ETH Zurich provides you with the knowledge and skills in engineering and physics required to understand and develop quantum technologies.



The development of quantum mechanics in the first half of the 20th century greatly extended the reach of physical theory, enabling explanation of a wide variety of experimental observations that previous "classical" descriptions could not account for. Most notably, quantum mechanics unveiled the internal structure of atoms, molecules, and solid materials. This understanding has led to groundbreaking inventions such as the laser and solid-state transistors. Currently, a second wave of quantum technologies is under development.

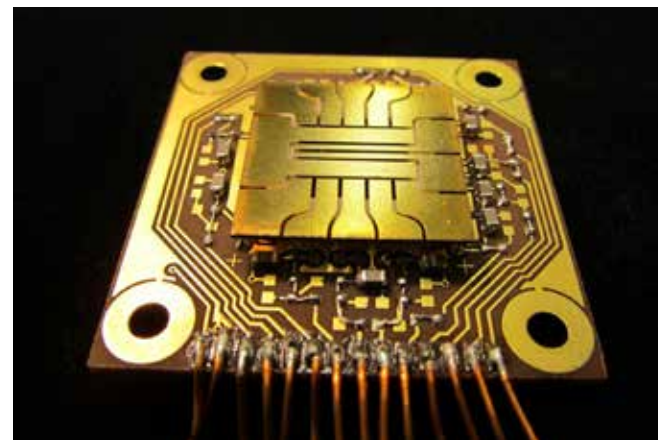


The rise of quantum technology



Refinement of quantum theory throughout the 20th century made clear that the laws of quantum mechanics allow for effects that go far beyond those we commonly observe in nature. These effects include entanglement, superposition, teleportation, and squeezing. Soon after these discoveries, scientists identified their potential for applications, which could significantly surpass any currently available technology. Computing, simulation, measurement technology, and cryptography are amongst the different fields of engineering that are currently transformed by the development of quantum technologies. In the last few years, companies around the world have started to invest heavily in those technologies, increasing demand for specialised engineers to drive quantum technology forward.

A quantum engineer harnesses the laws of quantum mechanics to provide technological solutions to problems currently unsolvable using classical resources. To tackle this formidable task, on the one hand, a quantum engineer needs to be well versed in quantum theory, in order to understand the fundamental laws of nature governing the working principles of all quantum machines. On the other hand, the quantum engineer needs to understand the current state of the art of electrical engineering. This understanding is indispensable for two reasons. First, the quantum engineer needs to identify where a quantum solution provides supremacy over its classical counterpart. Second, the quantum engineer needs to integrate novel quantum technologies with established classical methods to provide complete solutions able to solve pressing real-world problems.



Curriculum structure

ETH Zurich offers the Master's degree programme in Quantum Engineering (MSc QE) to equip students with a unique knowledge base at the interface of electrical engineering and quantum physics. This training will allow students to take a leading role in the coming age of quantum technology. Tasks for quantum engineers include development of new technologies in companies, applied and fundamental research in the public and the private sectors, consulting work, as well as advising governments and policy makers.

The MSc QE is a full-time study programme for four semesters. The programme consists of core courses, elective courses, a semester project, an industry internship or quantum engineering laboratory, and a final Master's thesis. All the courses, the laboratory courses, and the semester project are completed in three semesters. The Master's thesis takes an additional six months. To collect on-the-job experience, students carry out a full-time internship in industry for one semester or they participate in advanced QuanTech workshops to gain hands-on experience with quantum technology (both worth 12 credit points). The full programme comprises a workload of 120 credit points ECTS.

Most of the examinations take place in January / February and in August (between semesters).

The entire programme is in English. Knowledge of German is not required.

Each student can design their individual curriculum by choosing from a wide variety of courses offered at ETH Zurich. These choices are made under the supervision of a selected tutor (an ETH professor or scientist in the field of quantum science and technology) who must approve the course selection.

"Quantum computers have a much broader range of software commands at their disposal than do classical computers. That's why we need computer scientists who really can exploit these advantages."

Prof. Renato Renner, *Institute for Theoretical Physics at ETH Zurich*

Courses (64 + 2 credit points)

As a foundation, students acquire at least 24 credit points from a list of core courses. All courses are listed in the course catalogue (www.vvz.ethz.ch). Furthermore, students acquire at least 40 credit points from elective courses spanning the whole range from engineering to physics. To provide a well-rounded education, 2 credit points must be obtained from the Science in Perspective courses offered by the Department of Humanities, Social and Political Sciences (D-GESS).

Semester Project (12 credit points)

The semester project offers students hands-on research experience and the opportunity to improve their practical skills. The semester project should take up about half of a student's time during one semester. The projects are offered by individual laboratories at ETH.

Internship in industry, QuanTech workshops (12 credit points)

To collect on-the-job experience, students carry out a full-time internship in industry for one semester. Alternatively, students participate in advanced QuanTech workshops to gain hands-on experience with quantum technology.

Master's Thesis (30 credit points)

The capstone of the MSc in QE programme is the Master's thesis (six months full-time). The course work, the semester project, and the internship in industry (or alternatively the QuanTech workshops) must be completed before beginning the Master's thesis. Thesis topics are offered by the individual laboratories of the departments involved in the MSc QE programme.

Prospective Students

How to apply

The Master's programme in Quantum Engineering at ETH welcomes applications from students holding a Bachelor's degree in either electrical engineering or physics from an internationally recognised university. Details on qualifying Bachelor's degrees and additional requirements are published on the ETH Admissions Office website: www.ethz.ch/en/studies/registration-application/master/application/admission-prerequisites

Application deadlines and details on admission are given at: www.admission.ethz.ch

Tuition and Cost of Living

The tuition fee is only 580 Swiss francs per semester. However, students need to budget about 22,000 Swiss francs (20,000 euros) per year for living in Zurich (accommodation, living expenses, health insurance, etc.). A very limited number of scholarships are available for applicants with outstanding academic records. For more details see: www.ethz.ch/en/studies/financial

Continuing with Doctoral Studies?

Good Master's students may consider continuing their studies towards a doctorate. Applications should be made directly to a professor.

ETH Zurich

ETH Zurich is one of the leading international universities for technology and the natural sciences. It is well-known for its excellent education, groundbreaking fundamental research, and for implementing its results directly into practice. To researchers, it offers an inspiring working environment, to students, a comprehensive education.

Founded in 1855, ETH Zurich today has more than 18,000 students from over 110 countries, including 3,900 doctoral students. About 500 professors currently teach and conduct research in engineering, architecture, mathematics, natural sciences, system-oriented sciences, and management and social sciences. ETH Zurich regularly appears at the top of international rankings as one of the best universities in the world. 21 Nobel Laureates have studied, taught or conducted research at ETH Zurich, underlining the excellent reputation of the university.

Student Life

Zurich is consistently rated as one of the best places in the world to live. The city is situated on the beautiful lake of Zurich with the mountains less than an hour away. Zurich is clean and safe and has an excellent public transportation system and a high standard of living. The city has an international flair and offers many cultural activities as well as a vibrant nightlife. Most Swiss are multilingual and English is often the language of choice. Although German is not required for the Master's programme, some knowledge will make navigating the city and the university much easier. Language courses for students are available at: www.sprachenzentrum.uzh.ch. ETH Zurich itself offers a wide variety of sports, music, recreational and continuing education opportunities.

An overview can be found at: www.ethz.ch/en/campus

Brochures on every topic of life in Zurich are available in English at: www.welcome.zh.ch



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