FEBRUARY 2024

the new now QUANTUM

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FEBRUARY 2024

The era of QUANTUM

THE REVOLUTION IS UNDERWAY

WHAT LIES AHEAD

TECHNOLOGIST (SUPPLEMENT)

Editorial

QUANTUM PHYSICS IS EMERGING FROM THE LABORATORIES

SWITZERLAND MUST POSITION

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FONDATION INARTIS
SWISS ACADEMY OF ENGINEERING SCIENCES (SATW)

Each year brings its share of new concepts (buzzwords), which are more or less relevant, that will have an impact on the news, and that, without us realising it, gradually invade our daily lives. These words are not banal. They reflect hopes, our foremost concerns, the world in the making, and forge the one in which we will soon live. One that we cannot ignore is that of the

QUANTUM TECHNOLOGIES

FROM CRYPTOGRAPHY TO COMPUTING

VIA THE SENSORY.

This new world is not really new. It was born at the beginning of the 20th century, when quantum physics brought us many innovations, such as transistors, computers, mobile phones, MRIs, lasers and LEDs. Since then, we have entered the second quantum revolution. Its promises have caused a sharp acceleration in recent years, leading to a global race for quantum advantage*. Among the most discussed applications, there is a new generation of computers that promises to solve much more complex calculations than with current super-systems. This would make it possible to optimise the entire supply chain in real time, target a protein for a drug specific to each patient or simulate the entire functioning of the brain.

Today, these technologies are emerging from the laboratories, and they are demonstrating their first industrial successes. In Geneva, the work of Professor Nicolas Gisin's group in the field of quantum cryptography gave birth to a pioneer, which has become one of the world leaders in its field. ID Quantique has been marketing recognised tamper-proof encryption systems for twenty years, and now also random number generators and quantum sensors that are capable of measuring light to the pixel or photon.

This example illustrates the fact that, through its cutting-edge research and successful technology transfers, Switzerland has an excellent card to play in these emerging technologies that, according to BCG in 2020 and 2021, attracted more than two billion in private funds, double all that had been invested in it in the previous decade. To these amounts, government support must be added, which is particularly significant in the case of China, Japan, India, Canada and the US (Fig. 1). As for the future markets that are opening up to these products, BCG estimates them at between 450 and 850 billion in the next 15 to 30 years (Fig.2).

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B

MAIN AREAS OF APPLICATION

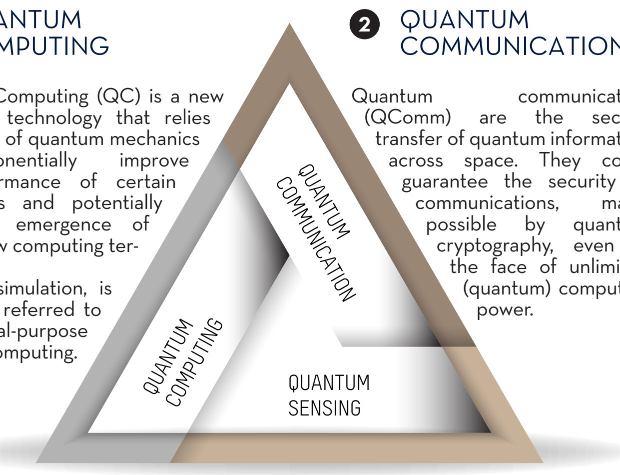
COMPUTERS, COMMUNICATIONS AND SENSORY TOPICS

1 QUANTUM COMPUTING

Quantum Computing (QC) is a new computing technology that relies on the laws of quantum mechanics to exponentially improve the performance of certain applications and potentially allow the emergence of entirely new computing territories.
Quantum simulation, is sometimes referred to as special-purpose quantum computing.

2 QUANTUM COMMUNICATION

Quantum communication (QComm) are the secure transfer of quantum information across space. They could guarantee the security of communications, made possible by quantum cryptography, even in the face of unlimited (quantum) computing power.



3 QUANTUM SENSING

Quantum sensing (QS) is the new generation of sensors built from quantum systems. It could provide measurements of various quantities (for example, gravity, time, electromagnetism) that are orders of magnitude more sensitive than conventional sensors.

C

TRAINING TO APPROACH THE QUANTUM FIELD

5 SKILLS THAT ARE NECESSARY TO START A CAREER IN QUANTUM COMPUTING

1. Curiosity - It may sound cheesy, but it's the first and most important quality you must possess. It's not technically something you can obtain. It is nevertheless crucial!

2. Basics of Electronics - Quantum is, after all, a computing domain, and it has three main layers: algorithmic, software, and hardware. You will likely end up specialising in one of these areas.

3. Linear Algebra and Probability Theory - Mathematics is also an essential element, especially linear algebra and probability theory.

4. Understanding of physics - In the case of conventional computing, it is no longer necessary to know exactly how the hardware works in order to create with it. Most of the time, you just need to know how to use it. This is not the case for quantum computing! To be a quantum software programmer, you need to know how a quantum computer works, and then use that knowledge to create your applications, which will require you to understand some physics and the mechanics of how quantum algorithms work.

5. Basic programming - In order to facilitate the transition to quantum computing, programming languages are often conventional, Python being one of the most widely used.

WHILE THE SCIENTIFIC COMMUNITY IS NOT UNANIMOUS ON THE EXTENT OF THE MATURITY OF QUANTUM COMPUTING AND OTHER TECHNOLOGIES ASSOCIATED WITH IT, EVERYONE CAN AGREE ON THE FACT THAT A TECHNOLOGICAL REVOLUTION IS UNDERWAY...

IN PRACTICE

D

BETWEEN COMPETITION AND COOPERATION, EUROPEAN COUNTRIES ARE ADVANCING WHEN IT COMES TO QUANTUM TECHNOLOGIES

MANY COUNTRIES AROUND THE WORLD RECOGNISE THE IMPORTANCE OF QUANTUM COMPUTING AND QUANTUM TECHNOLOGIES, AND ARE INVESTING HEAVILY IN THE RESEARCH, DEVELOPMENT AND IMPLEMENTATION OF THIS EMERGING TECHNOLOGY.

United States: The United States is at the forefront of quantum research, with substantial investments from the federal government, individual states, and the private sector. Initiatives such as the National Quantum Initiative Act aim to accelerate the development of quantum computing in the United States.

China: China has stepped up its investments in quantum, recognising its transformational potential. It is conducting extensive research, investing in quantum technology companies and aiming to become a world leader in quantum computing.

European Union: The EU has launched the Quantum Flagship programme, a €1 billion initiative to boost quantum research and innovation. Several EU member states, such as Germany, France and the Netherlands, are also making significant investments.

Canada: Canada is committed to quantum research with investments from both government and the private sector. Research centres and startups are working on various aspects of quantum computing.

Japan: Japan has also stepped up its efforts in quantum research. Japanese research institutions and companies are investing in the development of quantum technologies.

Australia: Australia has positioned itself as a major player in quantum research. Initiatives such as the Centre for Quantum Computation and Communication Technology have received significant financial support.

Switzerland: The "Swiss Quantum Initiative" aims to consolidate Switzerland's excellent position in the field of quantum technologies and strengthen its international competitiveness. It includes the targeted strengthening of research through competitive calls for projects, the development of attractive curricula in the field of education, knowledge and technology transfer in collaboration with industry and international cooperation. The Swiss Confederation is making CHF 10 million available for 2023 and 2024 for national projects. Additional federal funding is planned for 2025–2028. These funds will be supplemented by higher education institutions.

UK: The UK has launched the Quantum Technologies Programme, aimed at accelerating the development of quantum technology. Investments have been made in research, education and the development of the quantum industry.

Singapore: Singapore is investing in quantum research and development to strengthen its position as a leading technology hub in Asia. International collaborations are also encouraged.

40 billion for quantum
(2023 estimate)

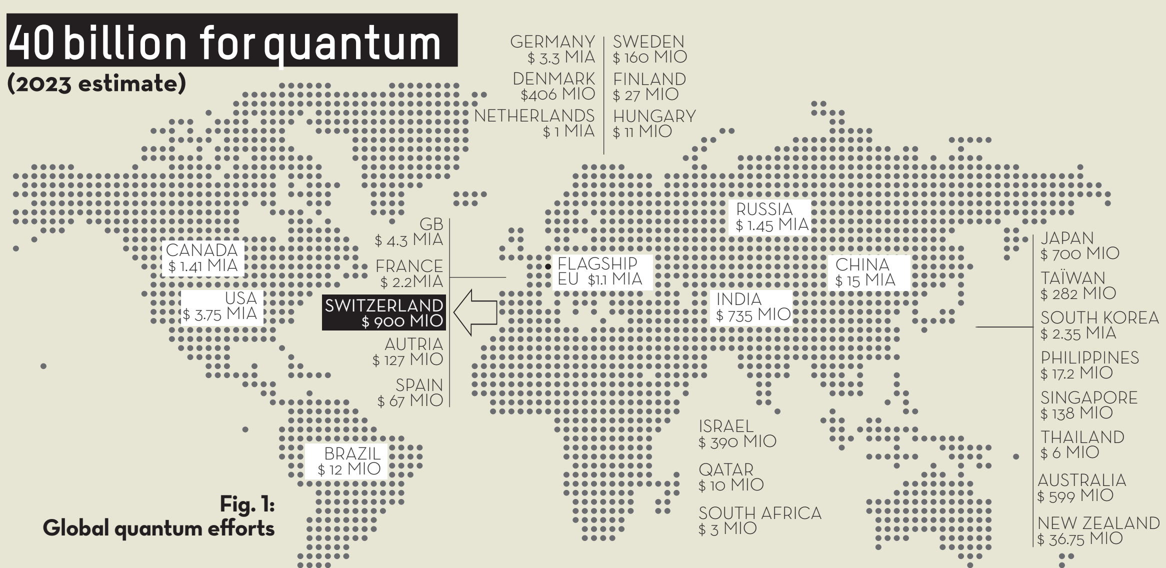


Fig. 1: Global quantum efforts

APPLICATIONS

SLOWLY BUT SURELY, QUANTUM COMPUTING IS PREPARING A REVOLUTION IN MANY AREAS:

- A | ARTIFICIAL INTELLIGENCE
- B | BETTER BATTERIES
- C | CLEANER FERTILISATION
- D | CYBERSECURITY
- E | DEVELOPMENT OF MEDICINE
- F | DISCOVERY OF ELECTRONIC MATERIALS
- G | FINANCIAL MODELING
- H | SOLAR CAPTURE
- I | TRAFFIC OPTIMISATION
- J | WEATHER FORECASTING AND CLIMATE CHANGE

* QUANTUM ADVANTAGE

"QUANTUM ADVANTAGE" IS WHEN A QUANTUM COMPUTER IS ABLE TO PERFORM A TASK THAT A CONVENTIONAL COMPUTER CANNOT.

F

QUANTUM AND ME

WHAT DOES QUANTUM HAVE TO DO WITH ME?

The quantum world, though often perceived as complex and remote from our daily reality, has significant implications that can directly affect our lives.
Here are some aspects that show how quantum can affect us:

- Information Technologies: Quantum technologies can revolutionise the field of computing. Quantum computers promise much more computing power than conventional computers, which could impact the areas of cybersecurity, complex modeling and optimisation.
- Secure Communication: Quantum communications offer high levels of security. Quantum principles enable the creation of tamper-proof communication systems, which could have direct implications for the confidentiality of information exchanges.
- Medicine and Imaging: Quantum technologies can be used in the medical field to improve imaging, early disease detection and drug development. This could lead to significant advances in health care.
- Energy and Storage: Quantum computers could revolutionise material modeling for more efficient energy applications. Moreover, quantum technologies can influence the development of new materials for energy storage.
- Quantum Internet: The idea of a quantum internet could transform the way we transmit and receive information online. This could potentially increase the security of online transactions and the exchange of sensitive information.
- Molecule Simulation: Quantum computers can more accurately simulate the behaviour of molecules, which is essential for the design of new materials, drugs and chemical catalysts.
- Technological Innovation: Advances in quantum can stimulate technological innovation in general. By understanding and exploiting quantum principles, new technologies are emerging, paving the way for revolutionary applications.
- Understanding the world: Although the direct implications may not be obvious in everyday life, understanding the quantum world offers a different perspective on the nature of reality. This can enrich our fundamental understanding of how the universe works.

In short, although quantum may seem distant, advances in this field have ramifications that affect various aspects of our daily lives, from technology to medicine to communications security. Research and developments in the quantum field can therefore have a concrete and tangible impact on our future.

G

ENABLING TECHNOLOGIES

WHAT TECHNOLOGIES DOES QUANTUM COMPUTING NEED ?

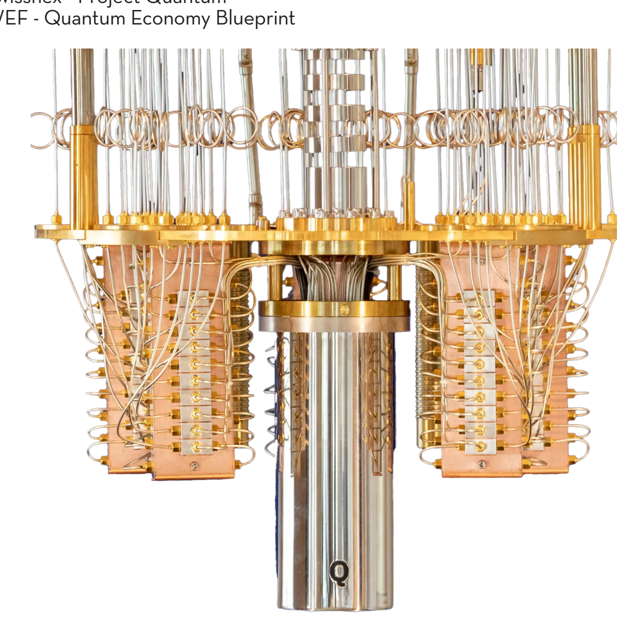
Quantum computing requires several specific technologies to operate efficiently. Some of the key technologies required for the successful development and implementation of quantum computing include:

- Qubits (Quantum Bits): Qubits are the fundamental unit of quantum computing, equivalent to bits in classical computing. They exploit quantum properties such as superposition and entanglement to store and manipulate information.
- Quantum controls: Quantum systems require sophisticated control mechanisms to manipulate qubits. This involves devices to apply quantum gates, adjust quantum states, and manage interference.
- Cooling systems: Qubits are often subject to environmental interference. Cooling systems, such as dilution refrigerators or cryogenic systems, are used to maintain very low temperatures, close to absolute zero, to reduce quantum noise.
- Quantum Detector Techniques: To measure the state of a qubit without disturbing it, sensitive quantum detectors are used. This may involve techniques such as photon detection or other quantum signals emitted by the quantum system.
- Error Quantum Correction: Due to the fragility of qubits, quantum error correction techniques are needed. This includes algorithms and devices designed to detect and correct errors that may occur due to interference or hardware imperfections.
- Quantum Architecture: Designing the architecture of a quantum processor is essential. This includes the layout of qubits, the connections between them, and how quantum operations are performed. Different architectures, such as lattice architectures or topological architectures, are explored.
- Quantum Human-Machine Interfaces: To allow users to interact with quantum systems, human-machine interfaces adapted to quantum principles must be developed. This may include ways to express quantum algorithms and interpret the results.
- Quantum Communication: To establish quantum communication networks or to connect remote quantum processors, quantum communication technologies are needed. This involves securely transmitting quantum information.
- Quantum Algorithms: The development of specific algorithms exploiting the power of quantum computing is crucial. This includes factorisation, quantum research, and optimisation algorithms that take advantage of quantum benefits.
- Quantum Security: With the capabilities of quantum computing to break some classic cryptography algorithms, quantum security methods are needed to ensure secure communications in a world where quantum computers are widely available.

These technologies represent some of the challenges and critical components of the successful development of quantum computing. Researchers and engineers are actively working on these aspects to overcome obstacles and realise the revolutionary potential of quantum computing.

FIND OUT MORE & SOURCES

EY - The race to enterprise-scale quantum computers is on
Lake star - State of Quantum 2024
McKinsey & Company - The Rise of Quantum Computing 2023
McKinsey & Company - Quantum Technology Monitor 2023
Swissnex - Project Quantum
WEF - Quantum Economy Blueprint



BUSINESS

E

THE BUSINESS OF QUANTUM

A POTENTIAL MARKET OF $106 BILLION

1 | A POTENTIAL MARKET OF $106 B

QUANTUM COMPUTING
$9B–$93B
estimated market by 2040
$5.4B invested end 2022
223 start-ups end 2022

POTENTIAL ECONOMIC VALUE
$620B–$1'270B
across four industries by 2035: chemicals, life sciences, finance, and automotive

QUANTUM SENSING
$1B–$6B
estimated market by 2040
$0.4B invested end 2022
23 start-ups end 2022

QUANTUM COMMUNICATION
$1B–$7B
estimated market by 2040
$1.0B invested end 2022
72 start-ups end 2022

$106B POTENTIAL QUANTUM TECHNOLOGY MARKET SIZE BY (2040)

350 start-ups in the ecosystem (2040)

$34B TOTAL GOVERNMENT INVESTMENT ANNOUNCED

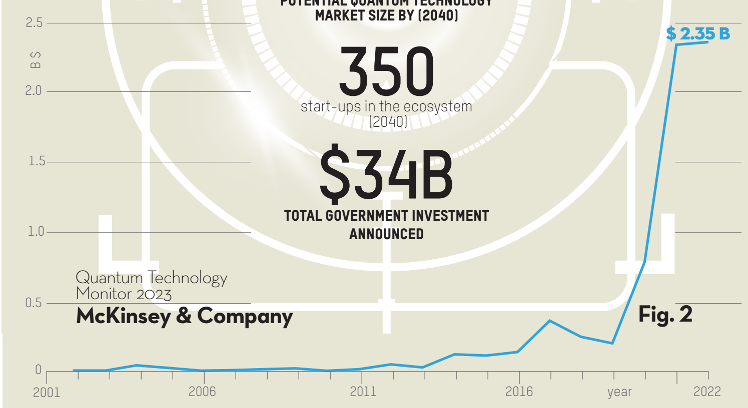


Fig. 2

2 | START-UP INVESTMENTS

The total annual start-up investment in quantum technologies has reached the highest level ever, although it has increased by 1% year on year.

A

WHAT IS QUANTUM, OR THE SECOND QUANTUM REVOLUTION?

THE MEETING OF

MATTER AND LIGHT

A BRIEF HISTORY OF QUANTUM

The advent of quantum came about in two stages. We usually talk about the two quantum revolutions, referring to two periods of major transformations in the field of quantum physics.

First Quantum Revolution

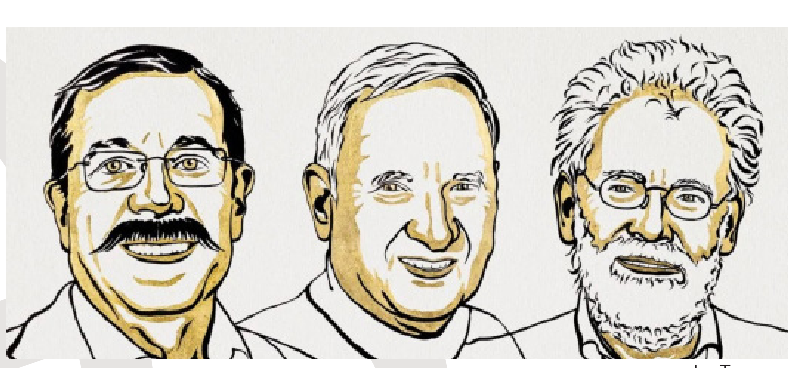
The First Quantum Revolution took place in the early 20th century with the pioneering work of Max Planck (recognised as the father of quantum physics), Albert Einstein, Niels Bohr, Werner Heisenberg, Erwin Schrödinger, and others. It shook our vision of the world, introduced surprising concepts such as wave-particle duality, and gave birth to quantum mechanics, a new theory that revolutionised our understanding of nature at the microscopic scale. This period led to major inventions such as the transistor, the laser, and integrated circuits of computers.

Second quantum revolution

Less known is the development of a second quantum revolution, initiated in 1935 by the debate between Albert Einstein and Niels Bohr about the radical implications of quantum mechanics, notably the idea that reality was intrinsically probabilistic and that the measurement of one quantum property could instantly influence another, even at a great distance (the phenomenon of quantum entanglement). To decide, it would be necessary to wait until the early 1980s, when Alain Aspect carried out in Orsay the experiment that would offer proof of the existence of entanglement. Bohr was therefore right, but by revealing a fundamental aspect of quantum physics, Einstein was not wrong!

It is this revolution, which is still unfolding before our eyes, that has brought us new concrete applications, particularly in the field of cryptography. It is at the heart of new technologies, such as quantum computing.

SCIENCE



3 Nobels for real hopes © Le Temps

On 4 October 2022, the Nobel Prize for Physics rewarded three pioneers of this second quantum revolution: the Austrian Anton Zeilinger, the American John Clauser and the Frenchman Alain Aspect, for their "experiments with intricate photons paving the way for quantum information science".

QUANTUM COMPUTING IN 10 LINES

Quantum computing relies on the principles of quantum mechanics to perform calculations. Unlike conventional computing, which uses bits to represent 0 or 1, quantum computing uses qubits that can exist in several states simultaneously through superposition. These qubits can also be entangled, meaning that the state of one may depend on the state of the other, even if they are separated.

Quantum computing offers considerable potential for solving complex problems, such as large-number factorisation, molecular simulation and optimisation. However, it also poses challenges in terms of qubit stability and quantum error handling. Companies and countries around the world are investing in quantum research to harness the full potential of this emerging technology ... but right now the quantum processor is still at the exploratory stage: it takes up a lot of space, must be cooled to cryogenic temperatures, and requires a very high vacuum and sophisticated optics to control the qubits.

Welcome

TO THE WORLD OF QUANTUM

THE NEW NOW QUANTUM

We are only at the beginning of quantum history, but we must follow it. All sectors of the economy are concerned, and in a few years, industrialists who will not have a quantum strategy may miss the turn. We must ensure a concerted effort, both in terms of understanding the issues, raising awareness of the political and economic world, and societal impacts... and ensure that we do not suffer from a shortage of talent to implement the new tools that will be made possible. As many issues as those addressed by this document on quantum in Switzerland.

quantum.inartis.ch

Executive SUMMARY

THE STAKES OF QUANTUM

- WHILE THE SCIENTIFIC COMMUNITY IS NOT UNANIMOUS ON THE DEGREE OF MATURITY OF QUANTUM COMPUTING AND OTHER RELATED TECHNOLOGIES, EVERYONE AGREES THAT A TECHNOLOGICAL REVOLUTION IS UNDERWAY.
- THE SECOND QUANTUM REVOLUTION IS UNDERWAY, AND WILL LEAVE ON THE SIDELINES COMPANIES AND COUNTRIES THAT HAVE NOT INVESTED HEAVILY IN THESE TECHNOLOGIES.
- THE INDUSTRIAL COMMUNITY THAT HAS THE INDUSTRIAL KNOW-HOW TO DEVELOP THE ENABLING TECHNOLOGIES WILL BE ABLE TO POSITION SWITZERLAND AND ITS SMES AS INDUSTRIAL ACTORS IN THE SUPPLY CHAIN AND SUBCONTRACTING. THE CHALLENGE FOR THESE COMPANIES LIES IN THEIR ABILITY TO DEVELOP CONCRETE SOLUTIONS IN THIS VAST BREEDING GROUND OF OPPORTUNITY THAT IS QUANTUM.

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the **new now** QUANTUM

H

WELCOME TO THE QUANTUM AGE

CONNECT PEOPLE IN THE QUANTUM FIELD AND BEYOND, PROVIDING OPPORTUNITIES TO LEARN, COLLABORATE, AND ACHIEVE MORE TOGETHER.
PROMOTE THE ADOPTION AND BENEFITS OF QUANTUM TECHNOLOGIES ACROSS THE SWISS ECONOMY
CULTIVATE A VIBRANT DOMESTIC QUANTUM ECOSYSTEM TO PROPEL INNOVATION AND MAINTAIN A COMPETITIVE EDGE

QUANTUM IN SWITZERLAND

ENTER THE WORLD OF QUANTUM TODAY. HOW?

While the scientific community is not unanimous on the degree of maturity of quantum computing and other related technologies, everyone agrees that a technological revolution is underway... and the technological opportunities to get a foothold in the new world of quantum computing exist! They fall into two broad categories.

1/ The first is that of machines exploiting quantum technologies per se, such as cold atoms, ion traps, superconducting loops, photon polarisation, etc. Although computers based on these quantum phenomena are currently only capable of mobilising a small number of qubits, they are nonetheless capable of running quantum algorithms, and so we can already start developing proofs of concept for real-life use cases. Some applications could therefore see the light of day on this type of machine before 2030.

2/ The other category of machine that can be used today to familiarise oneself with the implementation of quantum algorithms are emulators, which "simulate" the operation of a quantum computer on a conventional machine. The problem is that emulating a qubit in this way requires considerable computing power. And the need for computing power will grow exponentially with the emulation of additional qubits... In short, even if these two categories of machines are only a foretaste of what future quantum computers will really be able to do, they already allow us to prefigure their operation, to imagine uses that will evolve over time, and to get our hands on a technology that will soon occupy a predominant place. It's a bit like skiers training on artificial slopes, waiting for the racing season to open! Each field of use has its own players.

When it comes to quantum computing, there are:

- Players who aim to become quantum computer manufacturers, often very large international players such as IBM, Google etc.
- Developers of software solutions, designing quantum algorithms, enabling the implementation of such applications.
- Vertical users and application developers using the new possibilities offered by quantum computing.
- The industrial community, which has the industrial know-how to develop enabling technologies, and which could position Switzerland and its SMEs as industrial players in the supply chain of these future machines. The challenge for these companies lies in their ability to develop concrete solutions in the vast field opened up by quantum computing... a real opportunity that SATW, Swissengineering and Swissmem and their partners aim to highlight.

satw — www.satw.ch
SWISS ENGINEERING STV UTS ATS — www.swissengineering.ch
SWISSMEM — www.swissmem.ch

1

QUANTUM-BASEL | PRIVATE

QUANTUMBASEL

QuantumBasel is Switzerland's first commercial quantum center, embedded in the uptownBasel innovation campus and specializing in quantum computing and artificial intelligence. The center of competence provides seamless access to world-leading quantum systems and high-performance computing via a purpose-built platform for enterprises, research institutes, startups, and universities. QuantumBasel's team includes quantum algorithm researchers and data scientists who collaborate with organizations to run Quantum/AI proof-of-concept projects as well as education programs.

QuantumBasel

Contact :
Damir Bogdan, CEO
info@quantumbasel.com

https://quantumbasel.com

REGIO BASEL

Mission: Cluster of Excellence connecting scientists and entrepreneurs for shaping and strengthening quantum science and technology.

Contacts:
frederik.floether@quantumbasel.com
clement. javerzac@fhnw.ch

THE ENTREPRENEURS

They grasped the potential of quantum computing and formed an outstanding cluster involving industry, research and entrepreneurs, with the aim of democratising the power of quantum. By setting up the first commercially available quantum computer in Switzerland, combined with the deployment of two generations of IonQ quantum systems, QuantumBasel have ushered in a new era in quantum computing.

The network:
UNIBS; FHNW; Unispital Basel; Basel Quantum Center, QuantumBasel, NCCR SpinMAP, Basel Precision Instruments, Qnami, IonQ, QAI Ventures...

2

ION-Q

IonQ, a leader in trapped ion quantum computing, established in Basel its European quantum data centre. They are developing a general-purpose trapped ion quantum computer and software to generate, optimise, and execute quantum circuits.

https://www.ionq.com

3

QNAMI

is a leading Quantum Sensing Company. They are a driving force for the next era of quantum sensing, by serving as a bridge between scientific ideas and industrial solutions.

https://qnami.ch

4

ETHZ-PSI OCH

QUANTUM COMPUTING HUB

The quantum Computing Hub of the ETH – PSI (Paul Scherrer Institute), targets the technical and scientific challenges on the way to realising largescale quantum computers based on both superconducting circuits and trapped ions.

WE NEED TO INSTILL A SENSE OF URGENCY IN SWITZERLAND'S QUANTUM INDUSTRY. SWITZERLAND CANNOT AFFORD TO BE SLOW, AND WE CAN ONLY ACHIEVE SOMETHING WHEN WE WORK COLLECTIVELY.

ZURICH

Mission: Zurich has a long tradition of research excellence: no fewer than 22 Nobel Prizes have been awarded to researchers who have or had a connection with the ETH Zurich.

Contact:
Prof. Peter Seitz, SATW
peter.seitz@satw.ch

THE NOBEL RETREAT

In Zurich, quantum research thrives within academic institutions like ETH Zurich and the University of Zurich, exploring quantum computing, communication, and materials science. Collaborations between researchers, industry partners, and government agencies drive innovation and advancements in quantum technologies. Zurich's vibrant quantum ecosystem fosters interdisciplinary initiatives and positions the city as a global hub for quantum science and innovation.

Contact:
ETH Zurich, UNIZH, EMPA, Zurich Instruments, QZabre, IBM Research, Verve Venture, Google...

5

ETH ZURICH RESEARCH

QUANTUM CENTER

The Quantum Center is the central hub for coordinating the various scientific and structural activities in quantum science and technology across departments at ETH Zurich, and for developing a sustainable basis for research and teaching in this emerging discipline.

ETH zürich

Goal:
Experiencing State-Of-The-Art Quantum Technologies

Contact:
Prof. Dr. Andreas Wallraff
Founding Director
qc@ethz.ch

https://qc.ethz.ch

6

IBM RESEARCH

IBM RESEARCH LAB

IBM is a pioneer in quantum computing, developing advanced hardware and software solutions. Its IBM Quantum Platform offers cloud-based access to quantum processors, allowing researchers, developers and clients worldwide to explore quantum algorithms and applications. IBM is actively engaged in quantum research, focusing on qubit technology, error correction, and quantum algorithm development.

Goal: IBM's contributions to quantum computing highlight its commitment to pushing the boundaries of computing and solving complex problems in various domains.

IBM Research | Zurich

https://www.zurich.ibm.com
thinklab@zurich.ibm.com

7

EMPA RESEARCH

QUANTUM DEVICES

EMPA, the Swiss Federal Laboratories for Materials Science and Technology, actively engages in quantum research, focusing on materials, nanotechnology, and photonics. Its work spans quantum materials, quantum sensing, and quantum computing, aiming to drive innovation and practical applications.

Empa — Materials Science and Technology

Goal: EMPA's quantum endeavors underscore Switzerland's commitment to advancing cutting-edge science and technology on the global stage.

Contact:
Prof. Dr. Mickael Lucien Perrin

https://www.empa.ch

8

ZURICH INSTRUMENTS

is a leading global manufacturer of quantum computing control systems. They provide state-of-the-art laboratory equipment, including lock-in amplifiers, waveform generators, and impedance analysers.

https://www.zhinst.com

9

TERRA QUANTUM

Terra Quantum offers Quantum as a Service in the areas of quantum algorithms, quantum computing and quantum security.

https://terraquantum.swiss

QUANTUM COMMUNITY CONTRIBUTORS (not exhaustive)

Alpes Laser	PRI	St-Blaise	1998	/alpeslasers.ch/
Basel Precision Instruments	PRI	Basel	2018	/baspi.ch/
Basel Quantum Center	HUB	Basel	2017	/quantum.unibas.ch/
CERN Quantum Technology Initiative	RES	Geneva	2018	/quantum.cern/
Constructor	PPP	Schaffhausen	2019	/constructor.org/
CSEM	PRI	Neuchâtel	1984	/csem.ch/
Enlightra	PRI	Renens	2018	/enlightra.com/
EPFL	RES	Lausanne	1969	/epfl.ch/
EMPA	RES	Zürich		/empa.ch/
ETHZ-PSI Quantum Computing Hub	HUB	Aargau	2021	/bit.ly/3YNkYnz
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Fachhochschule Nordwestschweiz	RES	Aargau	2006	/fhnw.ch/
Federal Institute of Metrology	RES	Bern	1862	/metas.ch/
Geneva Quantum Centre (GQC)	HUB	Geneva	2022	/gqc.unige.ch/
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HITACHI Energy	PRI	Zürich	1910	/hitachienergy.com/
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Innosuisse	GOV	Bern	2001	/innosuisse.ch/
International Telecom Union (ITU)	GOV	Geneva	1865	/itu.int/
IonQ	PRI	Basel	2023	/ionq.com/
IRsweep (part of Sensirion)	PRI	Zurich	2014	/irsweep.com/
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Lakestar Advisors GmbH	PRI	Zurich	2009	/lakestar.com/
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NCCR SPIN «Spin Qubits in Silicon»	NCCR	Basel	2020	/nccr-spin.ch/
NCCR SwissMAP	NCCR	Basel	2014	/nccr-swissmap.ch/
Novartis AG	PRI	Basel	1996	/novartis.com/
Open Quantum Initiative	RES	Geneva	2023	/oqi.gesda.global/
Paul Scherrer Institute (PSI)	RES	Aargau	1988	/psi.ch/
Polariton Technologies AG	PRI	Zürich	2019	/polariton.ch/
QAI-ventures	PRI	Basel	2023	/qai-ventures.com/
Quantum Analytics	PRI	Zurich		/quantumanalytics.ch/
q-edu-lab.com	NET	Zurich	2018	/q-edu-lab.com/
QNAMI AG	PRI	Basel	2017	/qnami.ch/
QSE (Center for Quantum Sci. & Eng.)	RES	Lausanne	2019	/epfl.ch/
QuantumBasel	PRI	Basel	Date	/quantumbasel.com/
Quantum FutureX	PRI	Geneva	2019	www.quantumfuturex.ch
Quantum Center (QC)	RES	Zürich	2021	/qc.ethz.ch/
Quantum Engineering Commission	NET	Zürich	2020	/qec.amiv.ethz.ch/
Quantum Science and Engineering	RES	Vaud	2021	/siq@epfl.ch/
QZabre	PRI	Zurich	2018	/qzabre.com/
Roche (Hoffaman-la-Roche)	PRI	BASEL		/roche.ch/
SATW (Swiss Acad. of Eng. Sciences)	NET	BERN	1982	/satw.ch/
SCNAT (Swiss Academy of Sciences)	NET	BERN	1815	/scnat.ch/
SUPSI	RES	Manno	1997	/supsi.ch/
ETHZ	RES	Zurich	1855	/ethz.ch/
Swiss Innovation Forum (SIF)	NET	Zurich	2006	/swiss-innovation.com/
Swiss Innovation Park (SIP)	HUB	Zürich	2015	/switzerland-innovation.com/
Swiss Quantum Commission (SQC)	GOV	Bern	2023	/quantum.scnat.ch/
Swiss Startup Association	NET	Zurich	2015	/swissstartupassociation.ch/
Swiss Tech Transfer Asso (SwiTT)	NET	Bern	2003	/switt.ch/home
Swiss Venture Club	NET	Zurich	2001	/svc.swiss/fr
Swissmem	NET	Zurich	1895	/swissmem.ch/
SwissPhotonics	NET	Wollerau		/swissphotonics.net/
Swissnex	GOV	Zurich	2000	/swissnex.org/
Synergy Quantum	PRI	Geneva	2018	/synergyquantum.swiss/
Terra Quantum	PRI	St. Gallen	2019	/terraquantum.swiss/
The Swiss Nanoscience Institute (SNI)	RES	Basel	2006	/nanoscience.unibas.ch/
Università della Svizzera Italiana (USI)	RES	Lugano	1996	/usi.ch/
University of Basel, UNIBAS	RES	Basel	1460	/unibas.ch/en/
University of Geneva, UNIGE	RES	Geneva	1559	/unige.ch/
UptownBasel Infinity AG	PRI	Basel	2022	/quantumbasel.com/
Verve Ventures	PRI	Zürich	2007	/verve.vc/
Werner Siemens Foundation	NPO	Zug	1923	/ wernersiemens-stiftung.ch/
WEF (World Economic Forum)	NET	Geneva	1971	/weforum.org/
Zurich University of Applied Sciences	RES	Zurich	2007	/zhaw.ch/
Zurich Instruments	PRI	Zurich	2008	/zhinst.com/

List of abbreviations :
HUB: Hub - Gov: Governmental agency - INNO: Innovation catalyst - NET: Network - NCCR: National Centres of Competence in Research - NPO: non profit organisation - PPP:Public Private Partnership - PRI: Private - RES: Research.

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ID QUANTIQUE PRIVATE

SINCE: 2001

ID Quantique harnesses light to develop and industrialise advanced quantum products and technologies for organisations to ensure long-term protection of data and public safety.

IDQ

Contacts:
Prof. Nicolas Gisin, Chairman
Dr. Grégoire Ribordy, CEO
info@idquantique.com

www.idquantique.com

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CERN

QUANTUM PHYSICS @ QTI

While primarily focused on particle physics, CERN contributes to quantum technology research by exploring the fundamental nature of matter and forces. Its Quantum Technology Initiative (QTI) explores quantum's transformative potential.

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GESDA

OPEN QUANTUM INSTITUTE

The Open quantum Institute seeks to inclusively unleash the powers of quantum computing to ensure that the whole world contributes to and benefits from quantum computing.

https://oqi.gesda.global

GENEVA

Mission: Over 20 years of pioneering single-photon detection, quantum pioneer ID Quantique has helped academic research teams develop new ideas and concepts to solve complex scientific problems.

Contact:
secretariat-gap@unige.ch

THE PIONEERS

The birthplace of UNIGE, CERN and GESDA, Geneva saw the birth of the first start-up company from its laboratories, ID Quantique, which has since entered its industrial phase.

In Geneva, the work of Professor Nicolas Gisin's group in the field of quantum cryptography has given rise to a pioneer that has become one of the world leaders in its field. For the past 20 years, ID Quantique has been providing quantum-safe security solutions for the protection of data in transit (using Quantum Key Distribution technology), as well as quantum random numbers generators delivering true randomness and high performance single-photon detection solutions capable of measuring light to the nearest photon or pixel.

The network:
UNIGE (Quantum Center), ID Quantique, GESDA, CERN, NCCR SPIN, WEF, ITU...

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EPFL RESEARCH

QSE CENTER

The Center for Quantum Science and Engineering functions as a hub to establish and promote interdisciplinary research, education and innovation programs in the fields of quantum science and engineering at EPFL.

EPFL

Goal: Conducting fundamental and applied research, fostering collaboration between academia and industry.

Contact:
Philippe Caroff
Executive Director
qse@epfl.ch

https://www.epfl.ch/research/domains/quantum-center/

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SWISS QUANTUM INITIATIVE

The Swiss Quantum Initiative (SQI) is a federal initiative aiming to consolidate Switzerland's position in the field of quantum technology and to strengthen its competitiveness. Hosted by the Swiss Academy of Sciences (SCNAT) and led by the Swiss Quantum Commission (SQC), the SQI supports research through competitive calls for proposals, develop educational curricula and promote knowledge and technology transfer.

scnat — académie des sciences naturelles

Contact :
Dr. Andreas Masuhr
Head of the Quantum Initiative
andreas.masuhr@scnat.ch

https://quantum.scnat.ch

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NCCR SPIN

The National Center for Competence in Research (NCCR) SPIN develops reliable, fast, compact, scalable spin qubits in silicon. The NCCR SPIN team consists of researchers from the University of Basel, IBM Research – Zurich, ETH Zurich, and EPFL. The team members come from several disciplines, including quantum physics, materials science, engineering, and computer science. NCCR SPIN is designed to promote close collaboration between theory and experimentation, and between academia and industry.

Contact:
Prof. Dominik Zumbühl,
Director

Leading house:
Basel university

www.nccr-spin.ch

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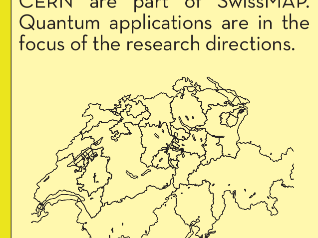
NCCR SWISSMAP

The National Centre of Competence in Research SwissMAP encourages the mutual exchange of ideas and methods at the cutting edge of research in mathematics and theoretical physics.

Currently, seven universities and CERN are part of SwissMAP. Quantum applications are in the focus of the research directions.



Contact:
Prof. Stanislav Smirnov
Director

Leading house:
Geneva university

www.nccr-swissmap.ch

TICINO

EMERGING HUB

Ticino is increasingly embracing quantum technologies from different research perspectives. The region's commitment to quantum technologies underscores its ambition to drive technological advancements and economic growth also in this challenging area.

The network:
USI, Supsi ...

THE SWISS ARGUMENT

KEY FACTS

- In 2007, Switzerland deployed the world's first commercial quantum cryptography system, developed by Geneva-based ID Quantique.
- Swiss research publications in quantum have the highest relative impact factor of any country in the world for the 2016–2020 period.
- Switzerland is home of the IBM Research Centre, working on the cutting edge of quantum research.
- Creation in 2022 of the Swiss Quantum Initiative, with a planned initial investment of CHF 80M.
- QuantumBasel is investing $500M to create a major European quantum computing hub, and has signed deals with IBM, D-Wave, and IonQ.

https://swissnex.org/quantum

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SWISS ACADEMY OF ENGINEERING SCIENCES

SATW

The Swiss Academy of Engineering Sciences is actively involved in exploring the potential of quantum technologies for Switzerland's future. It fosters collaborations between academia, industry, and policymakers to advance quantum research, development, and implementation.

satw technology for society

Goal: Conducting and promoting the early identification of topics relevant to society in education, research and innovation.

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Quantum leader
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www.satw.ch

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