Quantum leaps: This time it's the EU!

The European Commission has launched an ambitious €1 billion research initiative on quantum technology, which will contribute, among other things, to the development of quantum supercomputers; expected to surpass traditional supercomputers, these could dramatically improve the technology used in areas such as communication, computing and sensing.

The quantum computing revolution: A global race

'Quantum technologies', a growing branch of physics and engineering, is an umbrella term for all technologies using quantum phenomena to achieve new goals. Developed in Europe in the first decades of the 20th century, quantum physics brought about a revolution, which resulted in ground-breaking technologies and products throughout the 20th century, such as the transistor and the laser.

According to many experts, a second revolution is under way with regard to the application of quantum technology, including quantum computing. The industrial and societal impacts of this revolution are likely to be radically transformative, as new innovations – ranging from ultra-sensitive sensors for biomedical imaging, to secure communication networks, to new paradigms for computation and computers – gradually come to fruition. It is expected that the engineering of quantum phenomena could lead to new classes of devices and computing capabilities, permitting novel approaches to solving problems that cannot be addressed with existing technology.

While traditional computers encode information in binary bits (with two values: 0 or 1), quantum computers are based on quantum bits or 'qubits' (units of quantum information). Qubits operate according to two key principles of quantum physics: superposition and entanglement. Superposition means that the state of each qubit is not limited to 0 or 1, as binary bits are – it can be any combination of the two states. Entanglement means that qubits separated by hundreds of kilometres can be linked together to create a system where the state of each qubit depends on the state of the others. These specific properties allow quantum computers to operate in a different way to current computers, so that they have the potential to be millions of times more powerful than today's most powerful supercomputers.

Leading companies, such as Google, Microsoft and IBM, and research labs in Europe, Asia and the US, are investing heavily in quantum technologies. Moreover, they are racing each other to reach 'quantum supremacy', the point at which quantum computers become more powerful than traditional supercomputers.

Some of the largest quantum simulations have been done in the US, Switzerland and China, which also lead the global race in traditional supercomputers.

Chinese scientists reached an impressive quantum achievement in June 2017, after they succeeded in building the first quantum satellite network, which showcased the longest distance entanglement ever attained (1 200 km), and the first between the Earth and space.

Quantum computing for specific tasks will be more widely available over the next three to five years, as companies are increasingly investing in such projects. However, it will be more than ten years before we see computers that are fully based on quantum technology. This is partly due to their current limited potential to scale up, create qubits and reduce error rates, compared to traditional computers, which have been improved in this respect over recent decades.

Author: Mar Negreiro, Members' Research Service
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What is the EU doing?

In the EU we want to speed up investments to lead this race in the years to come. Currently, Europe is in the lead when it comes to research publications on quantum technologies, but not when it comes to investment in intellectual property resulting in new inventions. In the 2013-2015 period, 2 455 EU authors published quantum physics papers, compared to 1 913 Chinese and 1 564 North American ones. However, China and the US have the lead when it comes to patenting new quantum-based technology.

To improve this situation, some EU Member States are funding programmes that facilitate the transfer of academic research results to industrial products or applications by way of common projects carried out jointly by academia and industry. Examples of such programmes are the UK's national quantum technologies programme, QT Hubs, the Netherlands' advanced quantum research centre, QuTech, Germany's quantum technologies initiative, QUTEGA, and Denmark's quantum innovation centre, QuBiz.

More developments are expected in the EU as a result of the new €1 billion flagship initiative on quantum technologies. This significant budget builds upon funding worth more than €300 million that has already been invested in quantum research in the framework of European research programmes over the past 20 years.

A quantum manifesto signed in 2016 by more than 3 000 representatives from academia, industry and government and funding institutions, called for the Member States and the Commission to launch an ambitious, long-term, flagship-scale initiative combining education, science, engineering and entrepreneurship across Europe. This has resulted in the EU initiative on quantum technologies.

A first call for proposals for the flagship's preparatory phase was launched last year, and the Commission plans to launch an operational phase within the EU research programme, Horizon 2020, later this year.

Brexit could potentially create some problems for the initiative, as the UK has been playing a leading role in EU quantum research and patenting to date. However, the timing of the project should mean that any uncertainties surrounding the extent of the UK's involvement in the longer term will have been clarified well before the start of the next phase.

European Parliament position

On 16 February 2017, the Parliament adopted a resolution which welcomed the Commission's €1 billion flagship-scale initiative in quantum technology, stressing the need to accelerate its development and bring commercial products to public and private users, and asking for a transparent and open stakeholder consultation.

This note has been prepared for the European Youth Event, taking place in Strasbourg in June 2018.