Quantum computing gets down to business

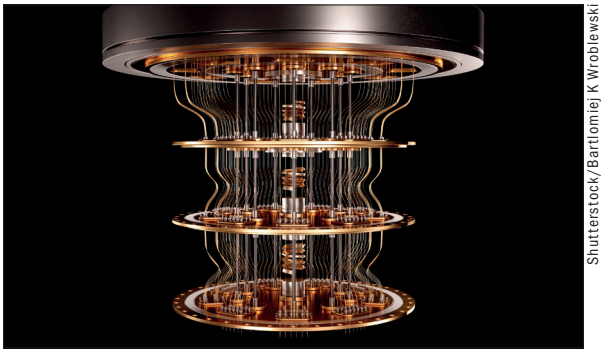
Martijn Boerkamp reports how investments into quantum computing have ballooned in the past year, bringing huge expectations for the sector

Quantum research today means big business. What was once seen as a scientific curiosity, quantum computing now promises to transform many aspects of everyday life from cybersecurity to drug development and weather forecasting. In recent years work in quantum computing has begun to move out of universities and into corporate research labs, with large multinationals as well as start-ups and venture capitalists entering the race to commercialize quantum technologies. But for all the record funding announcements and hype, some warn that this is fostering a "quantum bubble" that may soon pop.

The heart and soul of a quantum computer are quantum bits, or qubits. These are different from standard computer bits, which can be either 0 or 1. Qubits, on the other hand, can be both. Using this feature for complex computational problems means it could be possible to calculate solutions much faster than today's fastest computers by scaling computing to calculate with many qubits, resulting in exponential increase in computing power. Qubits can be made from different hardware platforms, such as superconducting qubits or trapped ions. Other upcoming methods are photonic quantum processors that use light instead.

Experts say that a real "quantum advantage" can only be expected when quantum computers operate with a million qubits. And with the current record still below 100 qubits there is still some way to go. But what is mostly hindering progress is the decoherence of the qubits themselves. To avoid this, they usually have to be operated at near 0 K and shielded from each other and the environment. Scientifically, however, there is nothing stopping the creation of large-scale quantum computers, but there are some tough engineering problems to solve.

Some of those challenges are being met by huge government programmes. In the US, the government is putting $1.2bn into its National Quantum Initiative programme that is aimed at both academia and the private sector, while the UK government is nearing the end of its 10-year £1bn National Quantum Technology Programme, which began in 2013. Meanwhile, the Netherlands funnelled €615m last year into the umbrella organization Quantum Delta NL to foster the development of quantum technologies. This all stands in the shadow, however, of China's $10bn estimated funding for its national programme.



Shutterstock/Bartlomiej K Wroblewski

Money spinner Companies and governments are investing billions in the race to commercialize quantum technologies.

Given that there is a solid scientific foundation underpinning the potential of quantum technology, the question is not if it will happen but when

From big tech to small tech

Quantum computing is currently dominated by tech giants such as IBM, Amazon, Hewlett Packard, Honeywell, Google and Microsoft (see pp39–42), with some of these investing heavily in quantum initiatives. Google has a 53-qubit quantum processor named Sycamore while IBM unveiled its plans to produce a 433-qubit chip later this year and a 1121-qubit chip in 2023. IBM quantum devices have already been made available for use by more than 200 000 clients via a cloud-based service.

Indeed, many large corporations are exploring quantum applications. Goldman Sachs is developing quantum optimization algorithms to price assets based on the inherent risk associated with, for example, different options or stocks. It says that financial operations could already benefit from quantum computers in the next five years. Car manufacturer Daimler, meanwhile, is investigating how quantum computers can simulate new materials for the development of higher-performing and lower-cost car batteries. HSBC bank announced last April a partnership with IBM to study the potential of quantum computing in banking.

And it is not just the big players that are in the game. The number of quantum-based start-ups has been on the rise for several years, with 265 according to the latest estimate from *Quantum Computing Report*. And some are making big steps forward. US-based start-up ColdQuanta launched a 100-qubit processor based on cold atoms this year and hopes to upgrade to 1000 qubits in the next three years. Another US company – IonQ – was the first quantum start-up that began trading publicly on the New York Stock Exchange last year, which allowed it to raise well over $600m in investment funding. Another significant deal features PsiQuantum, which secured a $450m round this year, based on its promise to build a full-scale photonic-based quantum computer by 2025.

Quantum-based start-ups are also attracting the interest of venture capitalists. This is slightly counterintuitive as venture capitalists typically bet on "safe horses", which is not the case with commercial products that are expected to hit the market a decade or so from now. Nonetheless, according to the consultancy firm McKinsey, venture capital and other private capital now make up more than 70% of quantum technology investments. And where only $93.5m was invested in 2015, in 2021 that figure had risen to a staggering $3.2bn.

The danger of all this investment is that it leads to a bubble, but that it not worrying some, at least for now. "I don't believe there will be a general crash of investment, because in the next few years we will see successes being announced, and organizations using quantum computing for real-world commercial or scientific applications," says Doug Finke who runs *Quantum Computing Report*.

Freeke Heijman, director of ecosystem development at Quantum Delta NL adds that a little bit of hype is not necessarily bad as it will help to excite people to go into quantum technologies. "Given that there is a solid scientific foundation underpinning the potential of quantum technology, the question is not if it will happen but when," she adds.

- For more on quantum developments, read the 2022 *Physics World Quantum Science and Technologies Briefing* bit.ly/3zT96ps