How to certify a quantum computer

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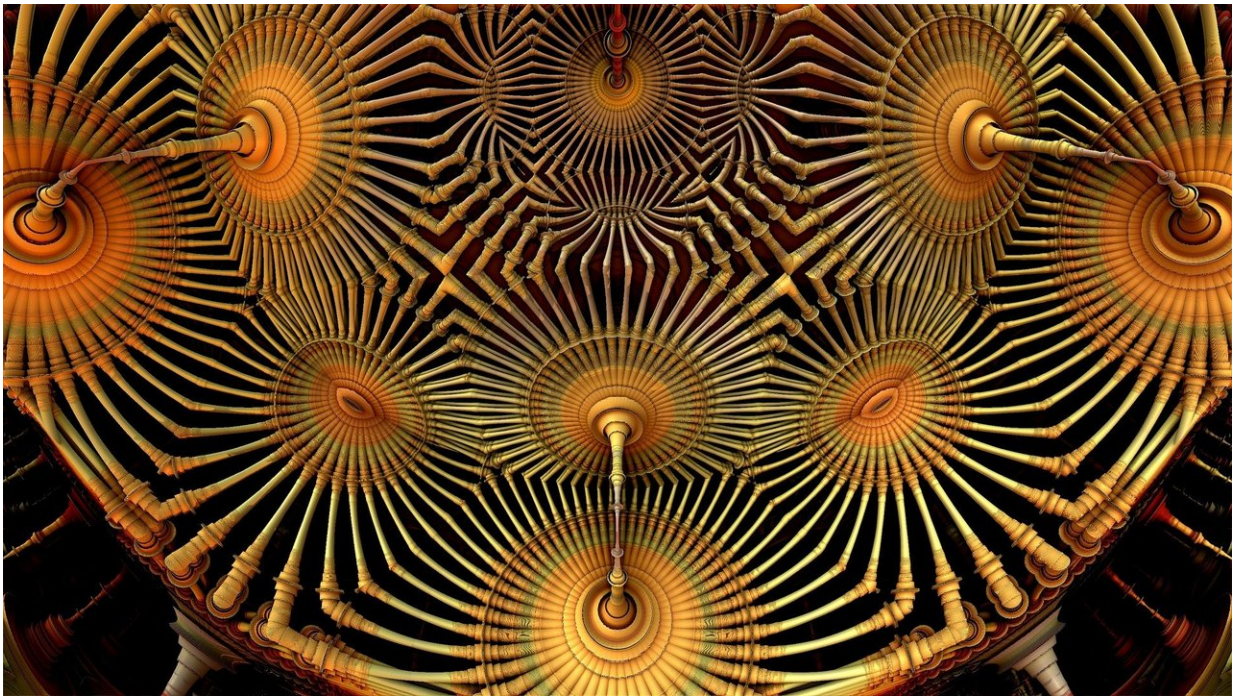

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Quantum computers are being developed by teams working not only at universities but also at Google, IBM, Microsoft and D-Wave, a start-up company. And things are evolving quickly, says Nicolas Sangouard, SNSF Professor at the University of Basel. "In a few years at most, I expect the computing power of quantum computers to significantly outstrip the computing power of ordinary computers. We call that 'quantum supremacy'".

Sangouard and his co-workers recently showed how to check that these computers are fit for purpose. For they are not just powerful but also very delicate: some operate at temperature extremes as low as 270 degrees below zero. The researchers' approach enables them to certify all the components of a quantum computer – from short- and long-term memory, to information processors, to the converters required to connect the computer to a secure quantum communications network. The protocol offers an additional advantage: it only uses the components already in the computer, thus obviating the need for additional devices. In principle, the protocol will work with any type of quantum computer, whatever the technology behind it.

A machine that tests itself

"The power of quantum computers is what makes them difficult to certify," says Sangouard. "Even the fastest ordinary computers are too slow to check the calculations made by such devices." Moreover, quantum computers will eventually be able to communicate with each other securely through a dedicated quantum communications network. So it's important to make sure that they aren't a weak link, says Sangouard.

That's why the research team has developed a completely quantum certification method that uses the computer's own building blocks. "We were inspired by Bell tests, which were devised by a physicist working at CERN in the 1960s," says Sangouard. "Normally, these tests are used to check whether particles are behaving according to quantum rules. We modified the tests to enable them to check the operation of the various components of a quantum computer. Because such a device is basically capable of doing the tests, our procedure is very simple to set up and doesn't require any special skills."

"What prompted the project was a seminar talk by a scientist invited to

the University of Basel," says Sangouard. "The talk dealt with a complicated aspect of quantum physics, but we were motivated to translate it into a useful method for quantum computers. For me, that's a perfect example of how a conference is not just a means of learning in a passive way but also offers significant opportunities to innovate."

More information: Pavel Sekatski et al. Certifying the Building Blocks of Quantum Computers from Bell's Theorem, *Physical Review Letters* (2018). DOI: 10.1103/PhysRevLett.121.180505

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