Q&A: Why is there so much hype about the quantum computer?

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Ulrich Busk Hoff is a researcher at DTU. Credit: Mikal Schlosser

How far along are the quantum technologies? And what do we really mean when we use the word quantum? Senior Adviser Ulrich Busk Hoff has been conducting research into and communicating about quantum physics for several years. Here he provides an overview of a rapidly developing field.

What is quantum technology?

It is the field of technologies in which quantum physics is actively utilized. That is technologies that are only possible using quantum physical phenomena. These are typically phenomena such as superposition, where an object, such as an atom, can assume more than one value or be in more than one place at the same time, and entanglement, where an object, such as an atom, is physically separated from another atom, but where they are nevertheless connected so that an impact of one atom will also affect the other.

Quantum physics is more than 100 years old, so what's new?

The ideas are indeed old—from the time of Niels Bohr and Einstein—but we have now reached a stage where the theories have been demonstrated and we can begin to exploit them in practice. We can do this because today we can control quantum physical systems such as atoms, electrons, or photons in such a way that they can be used for technological solutions like encryption, sensors, and computers—although most of it is still only possible in laboratories.

Which quantum technology is most mature?

We are quite advanced in encryption and sensors. In the past year, DTU has participated in several demonstration experiments with quantum-encrypted data being sent between two geographical locations.

In quantum sensors, there are already many different types that can measure physical quantities with extreme precision. Some can measure tiny variations in the gravitational field. This can, for example, be utilized in construction works for subsoil mapping before construction,

or to predict earthquakes. Other sensors measure magnetic fields from, for example, muscle activity and nerve paths and have great potential in fields such as medical diagnosis. Magnetic field sensors can also be used for military purposes like navigation.

The quantum computer is probably the most immature technology.

Why is there so much hype about the quantum computer?

There are several reasons. What started the hype, and is in some way still driving it, is an algorithm for quantum computers that Peter Shor, an American mathematician and professor at MIT, developed in 1994. Shor's algorithm makes it possible for a powerful quantum computer to break RSA encryption. This is the encryption that is widely used when we send data on the Internet.

But there is also a clear assumption that quantum computers will eventually be able to handle many other calculations that are impossible using an ordinary computer. Therefore, a huge market potential is predicted for quantum computers. In other words, there is a lot of money to be made for those who can realize the quantum computer.

And the hype is also partly due to the quantum computer being so difficult to develop and to its exploitation of quantum phenomena that are incomprehensible to many. The fascination with the technology itself contributes to the hype.

When will we have quantum computers?

We are still very far from having a fully developed quantum computer. It is still unclear which physical system will constitute the quantum bits

that can be utilized quantum-mechanically inside the quantum computer. Some are testing photons, other atoms, or ions—and yet others electrons in superconducting material. In some places, mechanical oscillations are used. Research and development is being conducted within all these platforms worldwide.

Calculations show that it takes a quantum computer of 10–20 million quantum bits to break an RSA encryption. Right now, the largest quantum computer is in the region of 430 quantum bits. So there is still some way to go. So, at the risk of becoming a laughing stock for posterity, I would guess that it will take another 20 years before we have a quantum computer that meets these expectations.

Will I get a quantum computer at home?

I will answer this based on where the technology is today and what we think a quantum computer will be good at—and with this in mind—my guess would be that quantum computers will not be something we will have at home. It will be meant for very specific and large-scale calculations. It will not be a computer we can use to go on Facebook or watch YouTube videos.

I would think that the quantum computer will have a role like HPC (high performance computing), which you can buy access to today if you need to perform large-scale calculations. But I could be completely wrong. Technology often develops completely differently than we predict, so we may all be walking around with a quantum computer in our pockets in 30 years.

Do you need to be interested in quantum physics as a non-physicist?

Quantum phenomena such as superposition and entanglement are a highly fascinating part of nature that can cause wonder and inspire completely new thoughts in us as humans. Instead of racing through the world with blinkers on, it makes us stop up and recognize that there is much more to nature than what immediately meets the eye. It is like the firmament. We could basically be indifferent to black holes and "dark matter," but I think that it is about fascination, general education, and being aware of what nature actually contains.

Right now, we do not encounter the applications of quantum technology in our everyday lives. This means that when we talk about them, we have to talk about quantum phenomena. They challenge us, because we have no experience with, for example, superposition in our visible world, which is governed by conventional physics, where objects such as a chair can only be in one place in the room.

But I think that when we start using quantum technology, we will stop focusing on the underlying quantum phenomena. This is, in fact, the case with other technologies such as PCs and mobile phones. Most of us do not think about how they work. But we do know how to use them.

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