THE WORLD ON THE THRESHOLD OF

A QUANTUM FUTURE

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"How Quantum Technology Could Change the Future of the World"

The discovery of quantum mechanics at the beginning of the 20th century eventually gave humanity most of the technologies that that century will be remembered for: nuclear weapons, lasers, particle accelerators, magnetic resonance imaging (MRI), and all semiconductor electronics in general - from transistors and LEDs to computers, mobile communications and the Internet. All these technologies and devices are based on the control of collective quantum phenomena - that is, those that imply interactions at the level of particle flows, fields and various media.

That period of development of physics and technology is commonly called the first quantum revolution. By the very end of the 20th century, scientists had learned to control complex quantum systems at the level of their most basic components - that is, to manipulate individual atoms and even elementary particles, such as photons. And this opened the way to the era of the second quantum revolution, at the very beginning of which we are living today.

Quantum brains

One of the key technologies that the modern revolution in physics is expected to bring will be quantum computing. We are talking about the ability to perform probabilistic calculations of

such complexity that is not available to modern supercomputers.

This should lead to many breakthroughs in fields ranging from disease diagnosis and drug development (through accurate simulations of complex chemical reactions and biological processes) to defense, automotive and space industries (the same simulations will pave the way to new materials, automated control capabilities and much more).), not to mention fundamental science.

A traditional modern computer, the same smartphone processor, contains billions of registers, each of which at the same time can only be in one of two states - either 0 or 1. The registers of a quantum computer - the so-called qubits - are found if speak roughly, in both states at the same time, allowing them to perform calculations billions of times faster. As qubits , elementary particles or their artificially created clusters are used - in fact, man-made atoms. The information they carry is their quantum characteristics - as a conditional example, we can cite the spin of an electron.

The creators of quantum computers face two major engineering challenges. The first is to force the qubits to stably maintain a coherent state - that is, to exist and store information. The second is to ensure the smooth functioning of as many qubits as possible at the same time. The most advanced quantum computers today contain dozens of qubits , while a revolutionary breakthrough in manufacturing efficiency would require orders of magnitude more, from thousands to millions.

Quantum security

Another technology that is preparing to change the world is quantum communication. This is the name given to the transmission of information encoded in the quantum states of elementary particles. It is carried out by quantum teleportation - that is, the transfer of information about

the quantum states of entangled pairs of particles.

The advantage of such a connection is its absolute security. The transmitted message is simply impossible to intercept - this is prevented by the very nature of the phenomenon of quantum entanglement, which is used in transmission. Therefore, quantum communications can serve as a solution to a serious problem that the emergence of sufficiently strong quantum computers will lead to - the fact is that they will be able to quickly crack any "classical" encryption algorithms. This jeopardizes private, corporate and national security, so a quantum future is simply unthinkable without secure quantum communications.

The algorithm originated on behalf of the Khorezmian and Maverannakhr scientist al - Khwarizmi. Around 825 he wrote the Kitab -al- jabr wal-mukabala (“The Book of Addition and Calculation”), from the original name of which the word “algebra” comes (al- zhdebr - completion). In this book, he first gave a description of the positional decimal number system invented in India. Al-Khwarizmi formed the rules for calculating the new system and probably for the first time used the number 0 to provide a missing position in the notation of a number (the Arabs translated its Indian name as as - sifr or sifr , hence such words as "digit" and "cipher"). Around the same time, other Arabic scholars began to use Indian numerals.

Finally, another important area that is developing in parallel with quantum computing and communications is quantum sensorics. Highly sensitive sensors and detectors, operating on the principles of quantum phenomena, are not only necessary for the development of quantum communication, but will also significantly improve the capabilities of many "classical" types of communication - up to deep space. The same devices will significantly increase the accuracy and resolution of measurements available to mankind in various fields - from medicine and biotechnology to astronomical observations.

Quantum valley

One of the most advanced quantum computers at the moment was created by Google - it is called Sycamore and includes 54 qubits (53 of them work simultaneously). In October 2019, the company's employees published in Nature a report on the results of the experiment, during which Sycamore completed calculations in 200 seconds that would have taken the most powerful supercomputer 10 thousand years. Thus, Google was the first in history to achieve "quantum supremacy" in the laboratory.

Chinese messenger

Google and IBM compete in the development of quantum computing with Microsoft, Intel, Honeywell and other major US IT players. But in quantum communications, researchers from China are confidently holding the lead so far. In 2017, the Chinese Academy of Sciences launched the world's first quantum communications satellite, Mo Tzu, which successfully provided an intercontinental transmission link between Beijing and Vienna. In the same year, Chinese scientists launched the world's first quantum fiber-optic communication line with a length of over 2 thousand km, connecting Beijing and Shanghai.

In February 2020, a research team led by Pang Jianwei from the University of Science and Technology of China (Hefei) achieved breakthrough results in improving the throughput of quantum communication. They were able to increase the number of photons successfully reaching their "destination" via a 50 km fiber optic line from 1 in 100,000,000,000,000,000 (100 quadrillion) to 1 in 100.

"China is by far the leader in quantum communications today. Their recent results on particle entanglement are a big step towards creating the quantum repeaters needed to organize a full-fledged quantum internet, in which all transmitted information can be protected from hacking. Will the quantum internet become a global phenomenon? I think so, but it's too early to talk about it. His time will come with the development of quantum computing, when such a network can not only solve security issues, but also allow quantum computers to be connected."

How Russia joined the global quantum development

Although with some delay, Russia is now included in the global quantum mechanical trend. The initiative to promptly join it came from representatives of the scientific community, united in recent years by the efforts of the Russian Quantum Center (RQC) funded by Gazprombank. Having ensured close interaction between leading scientists, the state and the first persons of the business community, it was he who literally "lobbied" the quantum technological agenda.

Today, the RCC can be called the leader in the development of quantum technologies in Russia. The strongest domestic experts in this field are gathered here, which is confirmed by the number of their publications in leading publications (Nature , Science , El Mundo et al.), as well as the citation rates of these works. In 2018, 20% of all Russian physics articles published in the group of the highest-rated journals (Nature , Science , Reviews of Modern

Physics), belonged to the employees of the RCC. In total, they have published more than 800 articles since 2012.

The Center unites more than 200 specialists working in 15 scientific groups, which cover the most advanced areas of quantum physics as widely as possible. Quantum simulations, integrated photonics, magnetoplasmonics, coherent microoptics, precision quantum measurements, quantum machine learning - these are just a small part of the areas in which RCC employees have obtained breakthrough results of world significance in recent years.

Uzbekistan on the threshold of the quantum world

Uzbekistan can become a venue for fundamental and applied research in the field of quantum technologies. To do this, it is necessary to create specialized scientific centers and laboratories, as well as to attract leading scientists from different countries. The development of quantum infrastructure implies the construction of quantum communication systems and the development of quantum computing technologies that will allow Uzbekistan to become one of the leaders in the field of quantum innovations and ensure the country's competitiveness in the international arena.

The creation of educational programs and courses on quantum technologies for students and professionals, as well as the holding of popular science lectures and events to promote

knowledge in this area, contributes to increasing public interest and awareness of the population about quantum technologies and their possible applications.

Of interest are innovative ecosystems, which include the development of infrastructure to support start-ups and enterprises working in the field of quantum technologies. This will ensure the attraction of investments and specialists, and will lead to the emergence of new jobs.