BREAKING NEWS

Chicago Quantum Exchange takes first steps toward a future that could revolutionize computing, medicine and cybersecurity

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Flashes of what may become a transformative new technology are coursing through a network of optic fibers under Chicago.

Researchers have created one of the world's largest networks for sharing quantum information — a field of science that depends on paradoxes so strange that Albert Einstein didn't believe them.

The network, which connects the University of Chicago with Argonne National Laboratory in Lemont, is a rudimentary version of what scientists hope someday to become the internet of the future. For now, it's opened up to businesses and researchers to test fundamentals of quantum information sharing.

The network was announced this week by the Chicago Quantum Exchange — which also involves Fermi National Accelerator Laboratory, Northwestern University, the University of Illinois and the University of Wisconsin.

People work in the Pritzker Nanofabrication Facility, June 15, 2022, inside the William Eckhardt Research Center at the University of Chicago. The Chicago Quantum Exchange is expanding its quantum network to make it available to more researchers and companies. Quantum computing is a pioneering, secure format said to be hacker-proof and of possible use by banks, the health care industry, and others for secure communications. (Erin Hooley / Chicago Tribune)

With a $500 million federal investment in recent years and $200 million from the state, Chicago, Urbana-Champaign, and Madison form a leading region for quantum information research.

Why does this matter to the average person? Because quantum information has the potential to help crack currently unsolvable problems, both threaten and protect private information, and lead to breakthroughs in agriculture, medicine and climate change.

While classical computing uses bits of information containing either a 1 or zero, quantum bits, or qubits, are like a coin flipped in the air — they contain both a 1 and zero, to be determined once it's observed.

That quality of being in two or more states at once, called superposition, is one of the many paradoxes of quantum mechanics — how particles behave at the atomic and subatomic level. It’s also a potentially crucial advantage, because it can handle exponentially more complex problems.

Another key aspect is the property of entanglement, in which qubits separated by great distances can still be correlated, so a measurement in one place reveals a measurement far away.

The newly expanded Chicago network, created in collaboration with Toshiba, distributes particles of light, called photons. Trying to intercept the photons destroys them and the information they contain — making it far more difficult to hack.

The new network allows researchers to “push the boundaries of what is currently possible,” said University of Chicago professor David Awschalom, director of the Chicago Quantum Exchange.

Fourth-year graduate student Cyrus Zeledon, left, and postdoctoral student Leah Weiss, right, show senior undergraduate Tiarna Wise around one of the quantum science laboratories, June 15, 2022, inside the William Eckhardt Research Center at the University of Chicago. (Erin Hooley / Chicago Tribune)

However, researchers must solve many practical problems before large-scale quantum computing and networking are possible.

For instance, researchers at Argonne are working on creating a "foundry" where dependable qubits could be forged. One example is a diamond membrane with tiny pockets to hold and process qubits of information. Researchers at Argonne also have created a qubit by freezing neon to hold a single electron.

Because quantum phenomena are extremely sensitive to any disturbance, they might also be used as tiny sensors for medical or other applications — but they'd also have to be made more durable.

The quantum network was launched at Argonne in 2020, but has now expanded to Hyde Park and opened for use by businesses and researchers to test new communication devices, security protocols and algorithms. Any venture that depends on secure information, such as banks' financial records of hospital medical records, would potentially use such a system.

Quantum computers, while in development now, may someday be able to perform far more complex calculations than current computers, such as folding proteins, which could be useful in developing drugs to treat diseases such as Alzheimer's.

In addition to driving research, the quantum field is stimulating economic development in the region. A hardware company, EeroQ, announced in January that it's moving its headquarters to Chicago. Another local software company, Super.tech, was recently acquired, and several others are starting up in the region.

Because quantum computing could be used to hack into traditional encryption, it has also attracted the bipartisan attention of federal lawmakers. The National Quantum Initiative Act was signed into law by President Donald Trump in 2018 to accelerate quantum development for national security purposes.

In May, President Joe Biden directed federal agency to migrate to quantum-resistant cryptography on its most critical defense and intelligence systems.

Ironically, basic mathematical problems, such as 5+5=10, are somewhat difficult through quantum computing. Quantum information is likely to be used for high-end applications, while classical computing will likely continue to be practical for many daily uses.

Renowned physicist Einstein famously scoffed at the paradoxes and uncertainties of quantum mechanics, saying that God does not "play dice" with the universe. But quantum theories have been proven correct in applications from nuclear energy to MRIs.

Stephen Gray, senior scientist at Argonne, who works on algorithms to run on quantum computers, said quantum work is very difficult, and that no one understands it fully.

But there have been significant developments in the field over the past 30 years, leading to what some scientists jokingly called Quantum 2.0, with practical advances expected over the next decade.

“We’re betting in the next five to 10 years there’ll be a true quantum advantage (over classical computing),” Gray said. “We’re not there yet. Some naysayers shake their canes and say it’s never going to happen. But we’re positive.”

Just as early work on conventional computers eventually led to cellphones, it’s hard to predict where quantum research will lead, said Brian DeMarco, professor of physics at the University of Illinois at Urbana-Champaign, who works with the Chicago Quantum Exchange.

“That’s why it’s an exciting time,” he said. “The most important applications are yet to be discovered.”

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