Quantum computing advances with control of entanglement

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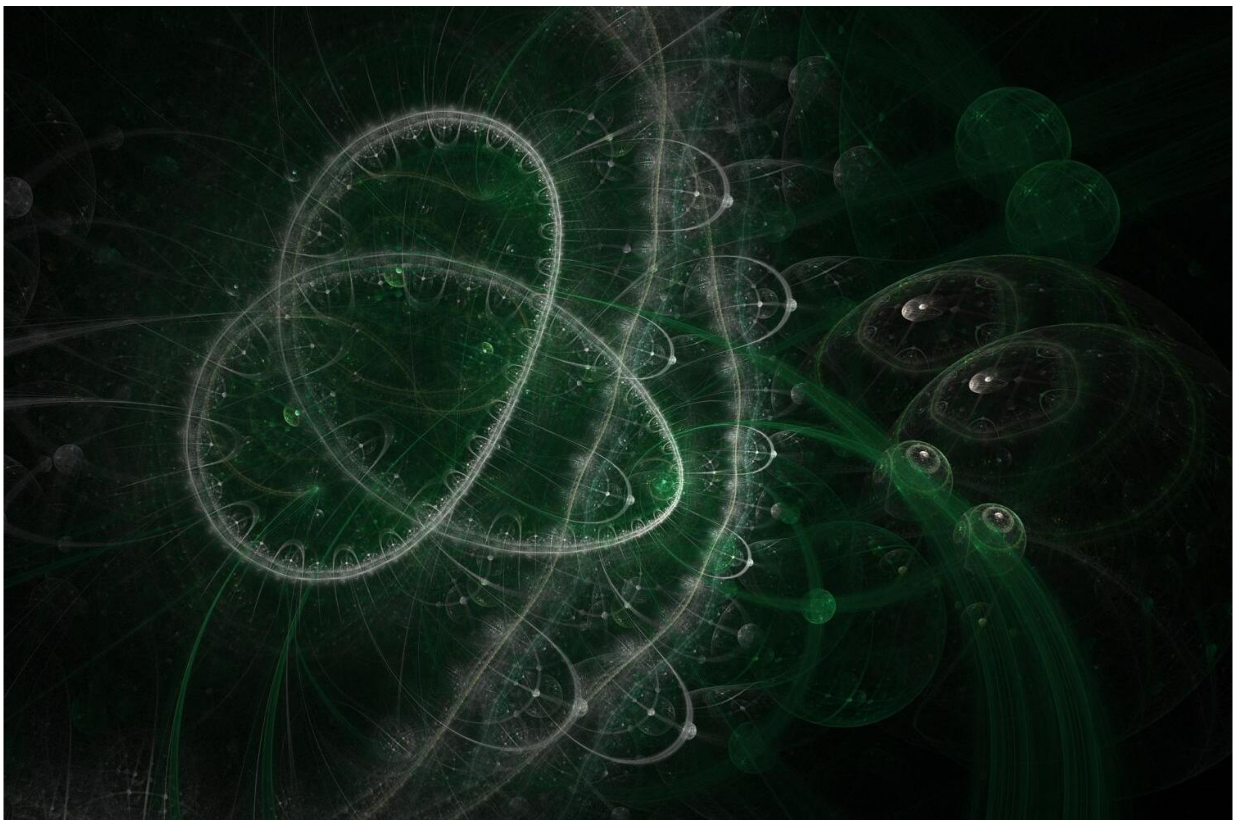

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When the quantum computer was imagined 30 years ago, it was revered for its potential to quickly and accurately complete practical tasks often considered impossible for mere humans and for conventional computers.

But, there was one big catch: Tiny-scale quantum effects fall apart too easily to be practical for reliably powering computers.

Now, a team of scientists in Japan may have overcome this obstacle. Using laser light, they have developed a precise, continuous control technology giving 60 times more success than previous efforts in sustaining the lifetime of "qubits," the unit that quantum computers encode. In particular, the researchers have shown that they can continue to create a quantum behavior known as the entangled state—entangling more than one million different physical systems, a world record that was only limited in their investigation by data storage space.

This feat is important because entangled quantum particles, such as atoms, electrons and photons, are a resource of quantum information processing created by the behaviors that emerge at the tiny quantum scale. Harnessing them ushers in a new era of information technology. From such behaviors as superposition and entanglement, quantum particles can perform enormous calculations simultaneously. The report of their investigation appears this week in the journal *APL Photonics*.

"There is a problem of the lifetime of qubits for quantum information processing. We have solved the problem, and we can continue to do quantum information processing for any time period we want," explained Akira Furusawa, of the Department of Applied Physics, School of Engineering at the University of Tokyo and lead researcher on the study. "The most difficult aspect of this achievement was continuous phase locking between squeezed light beams, but we have solved the problem."

Quantum computers are considered a next generation of computing after the integrated circuit, silicon-chip based computers that now dominate information processing technology. Current computers use long strings of zeros and ones—called bits—to process information. By contrast, quantum computers process information by harnessing the remarkable power of quantum mechanics that encodes 0s and 1s in quantum states called qubits. Qubits configure in two unusual ways: "superposition" and "entanglement."

Brace yourself—quantum behaviors are unusual. Einstein himself characterized entanglement as "spooky action at a distance."

Start with the fact that quantum systems can be in several states simultaneously—the up and down of superposition, for example. Particles also exhibit the quantum behavior of entanglement. It is a deeply intimate property between quantum particles that unites them perfectly in a shared existence, even at immense distance. In other words, spooky.

And it is this spooky action—entanglement—that the University of Tokyo team discovered how to manage so it can be applied to run quantum computers.

For the next steps on this promising path toward making quantum computing practical, Furusawa envisions creating 2-D and 3-D lattices of the entangled state. "This will enable us to make topological quantum computing, which is very robust quantum computing," he said.

More information: "Generation of one-million-mode continuous-variable cluster state by unlimited time-domain multiplexing," by Jun-ici Yoshikawa, Shota Yokoyama, Tishiyuki Kaji, Chanond Sornphiphatphong, Yu Shiozawa, Kenzo Makino and Akira Furusawa, *APL Photonics*, September 27, 2016, scitation.aip.org/content/aip/ … /6/10.1063/1.4962732.

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