Turning 'funky' quantum mysteries into computing reality

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The strange world of quantum mechanics can provide a way to surpass limits in speed, efficiency and accuracy of computing, communications and measurement, according to research by MIT scientist Seth Lloyd.

Quantum mechanics is the set of physical theories that explain the behavior of matter and energy at the scale of atoms and subatomic particles. It includes a number of strange properties that differ significantly from the way things work at sizes that people can observe directly, which are governed by classical physics.

“There are limits, if you think classically,” said Lloyd, a professor in MIT’s Research Laboratory of Electronics and Department of Mechanical Engineering. But while classical physics imposes limits that are already beginning to constrain things like computer chip development and precision measuring systems, “once you think quantum mechanically you can start to surpass those limits,” he said.

Lloyd will be speaking about this research at the American Association for the Advancement of Science annual meeting in Boston, on Saturday, Feb. 16, in a session on Quantum Information Theory.

“Over the last decade, a bunch of my colleagues and postdocs and I have been looking at how quantum mechanics can make things better.” What Lloyd refers to as the “funky effects” of quantum theory, such as squeezing and entanglement, could ultimately be harnessed to make measurements of time and distance more precise and computers more efficient. “Once you open your eyes to the quantum world, you see a whole lot of things you simply cannot do classically,” he said.

Among the ways that these quantum effects are beginning to be harnessed in the lab, he said, is in prototypes of new imaging systems that can precisely track the time of arrival of individual photons, the basic particles of light. “There’s significantly greater accuracy in the time-of-arrival measurement than what one would expect,” he said. And this could ultimately lead to systems that can detect finer detail, for example in a microscope’s view of a minuscule object, than what were thought to be the ultimate physical limitations of optical systems set by the dimensions of wavelengths of light.

In addition, quantum effects could be used to make much-more-efficient memory chips for computers, by drastically reducing the number of transistors that need to be used each time data is stored or retrieved in a random-access memory location. Lloyd and his collaborators devised an entirely new way of addressing memory locations, using quantum principles, which they call a “bucket brigade” system. A similar, enhanced scheme could also be used in future quantum computers, which are expected to be feasible at some point and could be especially adept at complex operations such as pattern recognition.

Another example of the potential power of quantum effects is in making more accurate clocks, using the property of entanglement, in which two separate particles can instantaneously affect each other’s characteristics.

While some of these potential applications have been theorized for many years, Lloyd said, experiments are “slowly catching up” to the theory. “We can do a lot already,” he said, “and we’re hoping to demonstrate a lot more” in coming years.

Source: Massachusetts Institute of Technology