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Fast quantum computer building block created

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(PhysOrg.com) -- The fastest quantum computer bit that exploits the main advantage of the qubit over the conventional bit has been demonstrated by researchers at University of Michigan, U.S. Naval Research Laboratory and the University of California at San Diego.

The scientists used lasers to create an initialized quantum state of this solid-state qubit at rates of about a gigahertz, or a billion times per second. They can also use lasers to achieve fundamental steps toward programming it.

A conventional bit can be a 0 or a 1. A quantum bit, or qubit, can be both at the same time. Until now, scientists couldn't stabilize that duality.

Physics professor Duncan Steel, doctoral student Xiaodong Xu and their colleagues used lasers to coherently, or stably, trap the spin of one electron confined in a single semiconductor quantum dot. A quantum dot is like a transistor in a conventional computer.

The scientists trapped the spin in a dark state in which they can arbitrarily adjust the amount of 0 and 1 the qubit represents. They call this state "dark" because it does not absorb light. Therefore, light does not cause loss of coherence between the two states. In other words, the light does not destabilize the qubit. A paper on these findings will be published in *Nature Physics* and is available early in the online edition.

"We are the first to show that you can do this to a single electron in a self-assembled quantum dot," Steel said. "If you're going to do quantum computing, you have to be able to work with one electron at a time."

Spin is an intrinsic property of the electron that isn't a real rotation. Steel compares it to the magnetic poles. Electrons are said to have spin up or down. In quantum computing, the up and down directions represent the 0s and 1s of conventional computing.

Steel's approach to developing a quantum computer is to use ultrafast lasers to manipulate arrays of semiconductor quantum dots, each containing one electron. Quantum logic gates are formed by quantum mechanical interactions between the dots.

Previously in Steel's lab, researchers have used a laser to produce an electron in a state representative of a 1 or a 0 and a small amount of the other state. Now, using two laser frequencies, they have trapped it as a 0 and a 1 at the same time, and they can adjust the amount of each.

Because the electron is trapped in a dark state, applied light can't destroy the coherence. Energy from light can flip the spin of electrons, or quantum bits, which would jumble any information being stored in the bit.

"This dark state is a place where information can be stored without any error," Steel said.

Because of their ability to represent multiple states simultaneously, quantum computers could theoretically factor numbers dramatically faster and with smaller computers than conventional computers. For this reason, they could vastly improve computer security.

"The National Security Agency has said that based on our present technology, we have about a 20-year window of security," Steel said.

"That means if we sent up a satellite today, it would take somebody about 20 years to crack the code. Quantum computers will let you develop a code that would be impossible to crack with a conventional computer."

Physicists achieved this by using two continuous wave lasers.

The paper is called "Coherent Population Trapping of an Electron Spin in a Single Negatively Charged Quantum Dot." It is available online at www.nature.com/nphys/journal/v … /full/nphys1054.html .

Provided by University of Michigan

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