Physicists establish 'spooky' quantum communication

September 5 2007

Physicists at the University of Michigan have coaxed two separate atoms to communicate with a sort of quantum intuition that Albert Einstein called "spooky."

In doing so, the researchers have made an advance toward super-fast quantum computing. The research could also be a building block for a quantum internet.

Scientists used light to establish what's called "entanglement" between two atoms, which were trapped a meter apart in separate enclosures (think of entangling like controlling the outcome of one coin flip with the outcome of a separate coin flip).

A paper on the findings appears in the Sept. 6 edition of the journal *Nature*.

"This linkage between remote atoms could be the fundamental piece of a radically new quantum computer architecture," said Professor Christopher Monroe, the principal investigator who did this research while at U-M, but is now at the University of Maryland. "Now that the technique has been demonstrated, it should be possible to scale it up to networks of many interconnected components that will eventually be necessary for quantum information processing."

David Moehring, the lead author of the paper who did this research as a U-M graduate student, says the most important feature of this experiment is the distance between the two atoms. Moehring graduated and now has a position at the Max-Planck-Institute for Quantum Optics in Germany.

"The separation of the qubits in our entangled state is the most important feature," Moehring said. "Localized entanglement has been performed in ion trap qubits in the past, but if one desires to build a scalable quantum computer network (or a quantum internet), the creation of entanglement schemes between remotely entangled qubit memories is necessary."

In this experiment, the researchers used two atoms to function as qubits, or quantum bits, storing a piece of information in their electron configuration. They then excited each atom, inducing electrons to fall into a lower energy state and emit one photon, or one particle of light, in the process.

The atoms, which were actually ions of the rare-earth element ytterbium, are capable of emitting two different types of photon of different wavelengths. The type of photon released by each atom indicates the particular state of the atom. Because of this, each photon was entangled with its atom.

By manipulating the photons emitted from each of the two atoms and guiding them to interact along a fiber optic thread, the researchers were able to detect the resulting photon clicks and entangle the atoms. Monroe says the fiber optic thread was necessary to establish entanglement of the atoms, but then the fiber could be severed and the two atoms would remain entangled, even if one were "(carefully) taken to Jupiter."

Each qubit's information is like a single bit of information in a conventional computer, which is represented as a 0 or a 1. Things get weird on the quantum scale, though, and a qubit can be either a 0, a 1, or both at the same time, Monroe says. Scientists call this phenomenon "superposition." Even weirder, scientists can't directly observe superposition, because the act of measuring the qubit affects it and forces it to become either a 0 or a 1.

Entangled particles can default to the same position once measured, for example always ending in 0,0 or 1,1.

"When entangled objects are measured, they always result in some sort of correlation, like always getting two coins to come up the same, even though they may be very far apart," Monroe said. "Einstein called this 'spooky action-at-a-distance,' and it was the basis for his nonbelief in quantum mechanics. But entanglement exists, and although very difficult to control, it is actually the basis for quantum computers."

Scientists could set the position of one qubit and know that its entangled mate will follow suit.

Entanglement provides extra wiring between quantum circuits, Monroe says. And it allows quantum computers to perform tasks impossible with conventional computers. Quantum computers could transmit provably secure encrypted data, for example. And they could factor numbers incredibly faster than today's machines, making most current encryption technology obsolete (most encryption today is based on the inability for man or machine to factor large numbers efficiently).

Source: University of Michigan

Citation: Physicists establish 'spooky' quantum communication (2007, September 5) retrieved 25 April 2024 from https://phys.org/news/2007-09-physicists-spooky-quantum.html