

In Quantum Computing, Light May Lead the Way

Yale University



New Haven, CT— Light might be able to play a bigger, more versatile role in the future of quantum computing, according to new research by Yale University scientists.

A team of Yale physicists has coaxed an unprecedented number of light particles, or photons, to behave quantum mechanically, or to assume more than one state simultaneously, such as “alive” and “dead.” In this case, the light is in the form of trapped microwave photons. Control over a greater number of photons — more than 100 in this case — raises the possibility that such states of light could play the part of several quantum bits (qubits), the building blocks typically found in a quantum computer. This could potentially minimize the physical scale and cost of building a quantum computer.

The quantum computer, a still embryonic technology, would be a hyper-fast tool with exponentially faster information processing than today’s most sophisticated computers.

“Scientists are constantly trying to overcome the great engineering challenges of creating, controlling, and measuring large quantum mechanical systems,” said Brian Vlastakis, a Yale graduate student and lead author of a paper published Sept. 27 in the journal *Science*. “Mastering these challenges is necessary for developing a quantum computer. This experiment shows that we can create and control a large quantum mechanical system built on photons. It also suggests we might be able to expand the role of photons in quantum information systems.”

The photon states generated in the Yale experiment mimic the metaphorical “Schrödinger’s cat,” which describes the counterintuitive idea that objects we

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Published on Scientific Computing (<http://www.scientificcomputing.com>)

encounter every day should also exhibit the strange behaviors of quantum mechanics — a housecat that could be alive and dead at the same time, for example.

In current quantum computing models, scientists typically describe systems built of many artificial quantum components known as qubits. Photons are a good tool for transferring information between qubits, but their ability to serve as qubits is limited, due to difficulty controlling them. The new research, led by Sterling Professor of Applied Physics and Physics Robert Schoelkopf, shows that large numbers of photons can be controlled with the help of a lone qubit. This suggests the possibility that a collection of photons may soon play the role of many qubits, potentially minimizing the cost and scale of quantum computing devices.

Because it still remains difficult to realize systems of many qubits, any savings in the number of parts required may be significant, researchers said.

“Just a few years ago, achieving this level of control over such a large system wouldn’t have seemed feasible,” said Schoelkopf. “With these results, we are starting to think about new ways to realize the functions required for a future quantum computer.”

Schoelkopf, Vlastakis and their team used superconducting materials to store microwave photons inside resonant cavities operated at cryogenic temperatures, which they then controlled using a single fabricated quantum bit and computer-controlled electronic pulses. They generated quantum states with more than 100 photons, a dramatic increase from the 10 or 20 generated in other experiments.

The paper is titled “[Deterministically encoding quantum information using 100-photon Schroedinger cat states](#) [1].”

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The National Science Foundation, Intelligence Advanced Research Projects Activity, and the Army Research Office provided support for the research.

Source URL (retrieved on 12/10/2013 - 6:46am):

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