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Physicists entangle photons, pave way to atomic-scale measurements

Toronto, Canada | 14 May 2004 - University of Toronto physicists have developed a way to combine three photons into an entangled state, which could ultimately lead to an extremely precise new measurement system.

Their study appears in the 13 May issue of the journal *Nature*. The findings could ultimately prove useful in developing ways to measure gravitational waves or the energy structure of atoms, and could also help in the development of quantum computers.

Previous studies have theorized that quantum computers using entangled photons could perform calculations far more quickly than current computers. "We know that today's computers are approaching limits of size and speed," says lead author and post-doctoral fellow Morgan Mitchell. "Quantum computing offers a possible way to move beyond that. Our research borrows some tricks from quantum computing and applies them to precision measurement."

Mitchell, working with Professor Aephraim Steinberg and graduate student Jeff Lundeen, first prepared three photons each with a different state of polarization. The researchers directed one photon along a main pathway or beam, then added a second photon. If researchers determined that both photons continued down the main beam, they concluded the two had become entangled. A third photon, with yet another polarization, was then added.

The team was able to create a three-photon state in 58% of their attempts. "Nobody has taken three distinct photons and made a three-photon entangled state before," he says. The entire process occurred within nanoseconds over a physical span of less than a meter.

The researchers then demonstrated the use of the three-photon entangled state to make extremely precise measurements. To do so, they used an experiment based on a paradox associated with quantum mechanics, which suggests that a particle can be in two places at once. By observing the movement of the photons past a series of mirrors and filters, the team was able to determine how far the photons had traveled.

Because the team used photons in a three-photon state, the system could provide measurements that were three times as precise as those made by a single photon. Since the new system, in theory, could incorporate an even larger number of photons, it could someday lead to a measurement system with significantly greater accuracy than anything that currently exists. The next step could be a practical test involving a measurement, says Mitchell.

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
14 May 2004

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