

Entanglement Swapping: A New Quantum Trick

October 11 2007, by Laura Mgrdichian

In an important step for the infant field of quantum communications, researchers from the University of Geneva in Switzerland have, for the first time, realized an “entanglement swapping” experiment with photon pairs emitted continuously by two different sources. This experiment is a key facet of quantum entanglement, the strange phenomenon in which two photons or other quantum bodies behave as one unit, even if spatially separate. Entanglement is at the heart of many proposed quantum information and communications schemes, including quantum computing and encryption.

University of Geneva physicist Matthäus Halder, the experiment's corresponding scientist, explained to *PhysOrg.com*, “Normally, entanglement between two photons is obtained by emitting them simultaneously by the same source. We've shown that entanglement can be transferred, or swapped, onto two particles that originated from different sources and were formerly completely independent. This is the first time that two autonomous photons from continuous sources have been entangled.”

In their scheme, two independent pairs of entangled photons, A1-A2 and B1-B2, are emitted by autonomous sources. By taking a joint measurement on one photon in each pair (A1 and B1), these photons fall into an entangled state (later verified using detectors), one of the four so-called “Bell states,” named for physicist John Bell, a key contributor to quantum physics. The joint measurement is thus known as a Bell-state measurement (BSM), and it is the foundation of the experiment.

As a result of the BSM, the two remaining photons (A2 and B2) are projected on an entangled state despite being unaware of the other's presence and never having previously interacted. Hence the entanglement of the initial pairs has been “swapped.”

The key element of a successful BSM is the precise timing of the two photon pairs. This has been obtained, up until now, by using pulsed sources, which send out photons in discrete bunches. But pulsed sources must be synchronized to emit the photon bunches at an exact time, a very difficult task.

Alternatively, Halder and his colleagues show that continuous photon sources can be used. These sources do not require any synchronization, and are therefore likely to be much easier to incorporate into future real-world quantum communications systems.

In this case, photons with the proper timing is obtained not when they are emitted, but when they are later detected by separate detectors. The detectors' temporal resolution (the precision of its measurements with respect to time) allowed Halder and his group to “post-select” only those photons that were emitted at the right time.

This research is described in the August 19, 2007, online edition of *Nature Physics*.

Citation: Matthäus Halder, Alexios Beveratos, Nicolas Gisin, Valerio Scarani, Christoph Simon, and Hugo Zbinden, “Entangling independent photons by time measurement” *Nature Phys*, 3, 692-659 (2007)

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