Quantum physics: Putting a spin on photon entanglement

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Abstract

Entanglement is an interesting property that unique to quantum mechanics. Two entangled particles have a none-separable wave function and are intrinsically linked. They occupy a superposition of states which are based on the probabilistic nature of quantum mechanics. Measurement of the state of one particle will instantaneously collapse the wave function and create a definite state of the other particle regardless of their location or separation distance. This was first investigated in the famous EPR paradox which shows that entanglement violates locality.

Quantum information is based on entanglement and can lead to quantum computers, which can be many orders of magnitude more powerful and faster than classical computers, quantum communication, which is protected from hacking by the laws of physics, and quantum teleportation. Two independent experiments, performed by De Greve *et al*. and Gao *et al*. demonstrate entanglement by optically pumping a quantum dot, which can trap an electron in discrete states, and allowing it to spontaneously decay thus entangling the electron's spin to the emitted photon's polarization and frequency. Practical applications require entanglement of only two states. Greve's group entangles the electron's spin with the photon's polarization by down-converting the frequency and broadening its range which eliminates the sharp frequency peaks. This has the advantage of using wavelengths that are used in telecommunication. Gao's group entangles the spin with the photon's frequency by filtering the photons to give them a counterclockwise polarization. This has the advantage of separating entangled photons from the large number of emitted clockwise laser photons.

References

1) Economou, S. E. Nature 491, 343-344 (2012)
2) De Greve, K. et al. Nature 491, 421-425 (2012)
3) Gao, W. B. et al. Nature 491, 426-430 (2012)