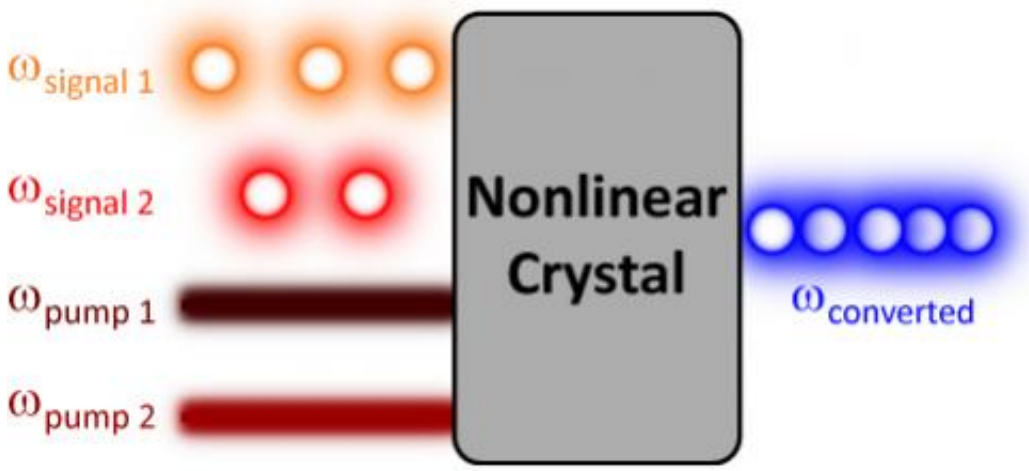
Photons emitted by quantum dots can be made indistinguishable through quantum frequency conversion

December 20 2012



The quantum frequency conversion system uses two pump lasers whose frequency difference is matched to the difference between the two input photon streams, causing the new photons from a nonlinear crystal to be emitted at exactly the same frequency.

(Phys.org)—An international collaboration led by researchers from the NIST Center for Nanoscale Science and Technology has demonstrated the ability to make photons emitted by quantum dots at different frequencies identical to each other by shifting their frequencies to match. This "quantum frequency conversion" is an important step for

making solid-state, single photon sources, including quantum dots, more useful light sources for photonic quantum information science.

Quantum dot sources are desirable due to their high brightness, stability, and amenability to scalable fabrication technology, but frequency variations arising from nonuniform device fabrication have limited their usefulness. Previous research has focused on tuning the sources themselves, for example by inducing strain or by varying the electrical and optical fields surrounding the structures. In their new approach, the CNST-led team uses a fundamentally different approach – manipulating the photons after they are generated, rather than altering the sources.

As reported in the October 5, 2012 issue of *Physical Review Letters* and featured in the November issue of *Physics Today*, the experiment uses photons emitted from a semiconductor quantum dot at two different frequencies which are determined by two of the dot's different energy states. The team demonstrated that the photons can be converted to the same frequency, or color, using quantum frequency conversion, a process in which each a single photon stream is combined with light from a much stronger pump laser in a nonlinear crystal which outputs photons at a frequency that is the sum of the two inputs. Two pump lasers are used, with the frequency difference between them set to match the difference between the two input photon streams, causing the new photons to be at exactly the same frequency. An interference measurement is used to confirm that the frequency-converted photons have become identical. Since the current work uses relatively large nonlinear crystals for frequency conversion, future work will focus on implementing the conversion method in smaller and more scalable device architectures.

More information: Ates, S. et al. Two-photon interference using background-free quantum frequency conversion of single photons emitted by an InAs quantum dot. *Physical Review Letters* 109, 147405

(2012).

Provided by National Institute of Standards and Technology