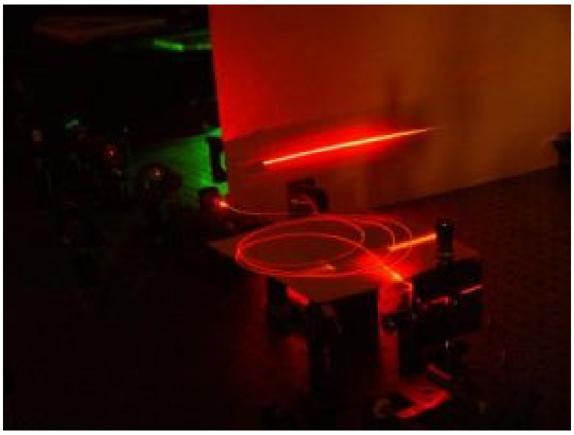
Mass weddings -- NIST's new efficient 2-photon source



A microstructured optical fiber in NIST's new paired-photon source delivers high numbers of photon pairs over a broad bandwidth with low noise, all in a compact device for quantum communication devices. Credit: Migdall/NIST

For a variety of applications in physics and technology, ranging from quantum information theory to telecommunications, it's handy to have access to pairs of photons created simultaneously, with a chosen energy. In a significant improvement on previous designs, physicists at the National Institute of Standards and Technology have devised a system that delivers such pairs with great efficiency over a wide range of energy, and with very little noise from extraneous photons.

Paired photons can be generated—albeit very inefficiently—in standard optical media such as glass optical fibers. Photons normally travel through glass independently, without interacting, but if monochromatic laser light is sent down even an ordinary optical fiber, very occasionally two of the input photons will interact, producing an output photon pair with one higher in energy than the original photons and the other lower by the same amount.

Because the vast majority of photons go through the fiber unchanged, the relative intensity of these pairs is very small. Worse, the fiber generates the pairs randomly with a range of possible energies, so picking out those with some specific energy reduces the number of useful photon pairs still further. Worse yet, there is noise in the system due to the phenomenon called "Raman scattering," in which individual photons bounce off the fiber's molecular structure and change their energies. Scattering produces photons that look as if they might be one half of a pair, but aren't.

To beat these odds, the new NIST two-photon source relies on a microstructured optical fiber. The fiber has a slender glass core at the center of an array of hollow channels, giving it a honeycomb appearance in cross-section. The geometrical structure of the fiber tightly restricts the way light can travel down it, increasing the intensity of light in the thin central core. Higher intensity means that photons are crowded more densely together, making events such as pair production more likely.

That greater efficiency allows the NIST researchers to get significant production of photon pairs by sending laser light through a mere 1.8 meters of the microstructured fiber, in contrast to the hundreds of meters of ordinary fiber that might be used in other systems. In addition, modifying the size of the channels in the microstructured fiber allows its properties to be optimized to reduce the amount of Raman scattering relative to the two-photon light of interest. The result is a source that produces significantly more pairs of photons over a wide frequency range, and with greatly reduced contamination by spurious Raman photons.

Photon pairs from the new source could be useful, for example, in exploring quantum "entanglement," in which measurements on one of a pair of quantum particles with a common origin exert a subtle influence on the properties of the other, or in quantum cryptography.

Citations: J. Fan and A. Migdall. A broadband high spectral brightness fiber-based two-photon source. *Optics Express* 15, 2915 (2007).
J. Fan, A. Migdall and L. Wang. A twin photon source based on optical fiber. *Optics and Photonics News*. March, 2007.

Source: National Institute of Standards and Technology