Using 'slow light' to modulate single photon wavepackets

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(PhysOrg.com) -- Single photons have been studied for a long time, Steve Harris tells PhysOrg.com. “But this is the first time that their wavepackets have been modulated.” Just as electrons may be described as either particles or waves, photons may also be described as particles or waves, and “in a similar manner to classical pulses of light their wavepackets may be modulated to encode additional information.” Harris immediately notes that over the last several years that several groups of scientists have used other techniques to generate shaped photonic wavepackets.

Harris, who heads a research group at Stanford University in California, points out that the use of an electro-optical modulator offers a higher degree of control, and is much faster than is shaping during the generation process.

For example, a single photonic wave packet may be modulated with a set of pulses, each with arbitrary phase. Along with Pavel Kolchin, Chinmay Belthangady, Shengwang Du and Guang-Yu Yin, Harris has demonstrated how single photons can be modulated using standard telecommunication technology. The work done by the group can be seen in *Physical Review Letters*: “Electro-Optic Modulation of Single Photons.”

Harris explains, “The key idea of the present work is the generation of a pair of photons that are born together. One of them moves to the left, and serves as a timer. It gives the time origin and tells you where the one that went to the right is." The timer photon is destroyed as it is measured, but the other photon remains viable, and it modulated.

In order to make this work, though, the modulation has to be faster than the width of the wavepacket of the photon that you want to modulate. Paired photons generated in nonlinear crystals are generally too short to be modulated with present technology.

So, how did Harris and his group get around this difficulty? "We lengthened the pulse, rather than make the modulation faster." Harris and his group used techniques called "slow light" (which Harris helped pioneer) and "electromagnetically induced transparency." The techniques used to make "slow light" quite literally slow down the speed of light by ten thousand to a million times. Using these techniques, it is possible to make biphotons (pairs of photons) with a pulse length of several hundred nanoseconds, as opposed to the more typical length of about 40 picoseconds.

Though there is the possibility that the process that the Stanford group has demonstrated could be used as a method of loading a single photons into an optical cavity, Harris cautions, "There are no immediate applications that I'm ready to tell you are going to fly. But there are some potential uses for this in the area of quantum information processing."

Asked what he expects to do next, Harris replies, "We plan on looking into the interaction of shaped photons with atoms, and seeing how the atoms respond."

"Sometimes, in science, when you do something new, unexpected things come of it."