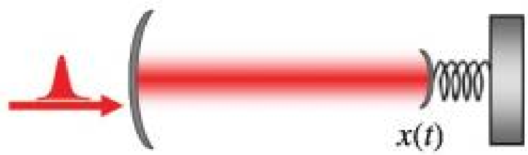
New way to store light could prove useful for optical communication

October 3 2011, by Lisa Zyga



Schematic of an optomechanical resonator, which can store light and perform wavelength conversion. Image credit: Victor Fiore, et al. ©2011 American Physical Society

(PhysOrg.com) -- Due to its high data carrying capacity and low loss, light can serve as an ideal information carrier. However, due to the high speed at which it travels, light is difficult to store. Because the ability to store light is important for optical networks as well as long-distance quantum communication networks, researchers have been investigating various light storage techniques. While previous studies have demonstrated that light can be stored as acoustic excitations, spin excitations, and atomic excitations, scientists have now added storing light as mechanical excitations to this list.

The team of physicists, who are from the University of Oregon and the University of California-Merced, have published their study on storing optical information as mechanical excitations in a recent issue of Physical Review Letters.

The physicists have performed a proof-of-principle experiment in which they stored optical information as mechanical excitations inside silica microspheres. The microspheres serve as optomechanical resonators, which have resonating cavities that allow the scientists to generate mechanical excitations.

"The mechanical excitation is a breathing mode of the spherical resonator," Professor Hailin Wang of the University of Oregon told *PhysOrg.com*.

The researchers used a tunable laser to write and read the information. To write, a writing pulse couples a signal pulse at the cavity resonance to a mechanical mode, which generates a mechanical excitation. The optical information can be stored as a mechanical excitation for a length of time that depends on the mechanical excitation's decay time, which is relatively long. To retrieve the information, a reverse process is performed, in which a readout pulse maps the mechanical excitation back to an optical pulse.

"The storage lifetime is 3.5 microseconds," Wang said. "It can in principle be much longer by reducing the mechanical loss or damping."

Due to the nature of this storage technique, it can also convert wavelengths of one size to another, which gives it a unique advantage over other light storage techniques. This wavelength conversion capability stems from the mechanical mode's ability to couple to any optical resonance by radiation pressure. Since the storage and retrieval process are strongly dependent on the radiation pressure, the signal pulse's wavelength can be modified by changing the intensity of the writing and readout pulses.

The capability of wavelength conversion could play an important role in communication networks by converting information from an original wavelength (such as microwaves) to a wavelength that is suitable for long-distance communication. For quantum networks, the ability could be used to map photons emitted from one quantum system to photons that can couple to another type of quantum system.

Overall, the capability of wavelength conversion combined with the potential for a long storage lifetime could have a variety of applications for optical information networks. Although the mechanical oscillator's thermal excitations currently prevent the technique from being used for optomechanical light storage in the quantum regime, recent experiments in cooling mechanical oscillators may overcome this problem. With these advances, the new way to store light could have applications in quantum memory and other quantum systems.

"My group is interested in using this type of optomechanical interactions to demonstrate optical wavelength conversion, mapping an optical pulse from one wavelength (or color) to another," Wang said. "We will also want to do this in the quantum regime, preserving the quantum mechanical state of light."

More information: Victor Fiore, et al. "Storing Optical Information as a Mechanical Excitation in a Silica Optomechanical Resonator." Physical Review Letters 107, 133601 (2011)
DOI:10.1103/PhysRevLett.107.133601