Cornell Scientists Time-Compress Optical Signals

(Cornell University [1]) - Cornell researchers have developed an ingenious method to time-compress optical signals. The process could enable optical communication systems to carry many more bits per second or could also be used to generate short bursts of light with complex waveforms needed to control chemistry and physics experiments where changes are induced by light.

In tests, the researchers compressed a series of optical pulses carrying information at 10 gigabits per second (Gps) into a much shorter burst carrying the same information at 270 Gps.

The research is reported in the online edition of the journal Nature Photonics and in a forthcoming print edition.

Alexander Gaeta, professor of applied and engineering physics, calls the compression device a "temporal telescope." The "lenses" are two tiny optical waveguides on a silicon chip designed by Michal Lipson, associate professor of electrical and computer engineering, in which signals can be manipulated by a process called "four-wave mixing." A signal and a "pump" are combined inside a waveguide only 300x550 nanometers in cross section, smaller than the wavelength of the infrared light traveling through it. (A nanometer is a billionth of a meter, about the length of three atoms in a row.) In the confined space, the two light beams mix together to create a new, combined signal.

In the first waveguide a signal that varies in intensity over time -- in the demonstration case, a series of on and off pulses representing ones and zeros -- is combined with a pump pulse containing a broad range of wavelengths of light. The output is a spectrum of wavelengths in which the intensity, or brightness, at each wavelength corresponds to the amplitude of the original signal at a particular moment in time.

The second waveguide combines this spectrum with another pump pulse that is much shorter than the original signal and reverses the process, creating a signal that varies in amplitude corresponding to variations in intensity across the spectrum. The resulting output signal mirrors the original input, but is compressed to the length of the second pump pulse.

As Gaeta puts it, the "focal length" of the temporal lens is determined by the length of the pump pulse. As with conventional glass lenses, putting two temporal lenses together creates a telescope. In this case the system looks through the wrong end of the telescope, making things look smaller.

The demonstration was also done with more complex waveforms, including amplitude- and frequency-modulated signals.

Modulating light into complex waveforms over very short time scales is difficult and expensive, Gaeta said. This process, he said, makes it possible to generate a signal on a long time scale using off-the-shelf methods, and then compress the result to the desired time scale. The process also offers a new way to connect the relatively slow outputs of silicon electronics to photonic systems, he added.

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Links:
[1] http://www.news.cornell.edu/