Reversible data transfers from light to sound

December 13 2007

As a step towards designing tomorrow's super-fast optical communications networks, a Duke University-led research team has demonstrated a way to transfer encoded information from a laser beam to sound waves and then back to light waves again.

Swapping data between media like this would allow information to be captured and retained for very brief intervals. Data could be stored within pockets of acoustic vibration created when laser beams interact along a short strand of optical fiber, the team reported in the Dec. 14, 2007 issue of the journal *Science*.

The Duke experiments address a barrier to efforts at developing computer networks that can run on light instead of electrons. "The real gist of the work is how to create a memory for optical pulses," said Duke physics professor Daniel Gauthier, the report's corresponding author.

Computers in use now manipulate the flow of electrons to shunt the data they carry into memory. But light has proved to be stubbornly resistant to similar traffic controls. "We don't have random access memories for light the way electronic computers do," Gauthier said.

The new method, suggested by Gauthier's postdoctoral research associate Zhaoming Zhu, uses a phenomenon called "stimulated Brillouin scattering." Opposing laser beams passing though each other along an optical fiber create acoustic vibrations known as phonons within the glass.

"To efficiently create such acoustic waves, you have to have two laser beams of slightly different frequencies interacting with each other," Gauthier said.

In a series of experiments at Duke, Zhu found that if he encoded information onto one of those laser beams, the data could be imprinted on newly-created phonons. Such phonon sounds are much too high-pitched for humans to hear, Gauthier said.

Zhu, the Science report's first author, documented that phonons could retain the data for as long as 12 billionths of a second. The information could then be successfully re-transferred from sound to light again by shining a third laser beam through the fiber.

"While short by human standards, 12 billionths of a second is long in comparison to the time scales used in optical data transmission," said coauthor Robert Boyd, a professor of optics and physics at the University of Rochester's Institute of Optics.

While Zhu conducted the experiments, Gauthier and Boyd examined the findings' theoretical underpinnings. The work was funded by the Defense Advanced Research Projects Agency's Defense Sciences Office Slow-Light Program.

The new method works at room temperatures and at wavelengths of light compatible with optical fibers already used in telecommunications, giving it several advantages over competing techniques for manipulating light.

More work will be needed before this approach becomes workable in optical computation, Gauthier acknowledged. First, the power used for the write and read pulses is about 100 watts, "rather high for any type of telecommunications application," he said.

"The other issue is that we're only storing the data for about 10 nanoseconds," Gauthier added. "There may be a few applications where such short storage times would be okay. But, for many applications, you would like to store it for seconds."

In their report, the authors suggest other kinds of fiber optic materials that might yield better results.

"I'm hoping that other scientists around the world will come up with new ideas based on our work," Gauthier said. "The Duke team will also be pushing the state of the art in this field with our own ideas."

Source: Duke University