# 'All-optical' switch could advance light-based telecommunications

April 28 2005

Duke University physicists have developed a switching technique that uses a very weak beam of light to control a much stronger beam. The achievement could make optical telecommunications devices perform far more efficiently, and perhaps also aid in the development of futuristic quantum communications devices, the scientists said.

"What's important here is that this is an 'all-optical' switch, using only light, with a weak beam affecting a strong one," said physics professor Daniel Gauthier, the Duke team leader.

Such a switching technique could improve today's telecommunications switching arrays that must repeatedly and inefficiently convert light to electricity and then back to light -- a method especially impractical for very high speed telecommunications networks, Gauthier said in an interview.

Until now, Gauthier said, scientists have primarily demonstrated switching techniques that use stronger light beams to control weaker ones. "And that's not very useful in a telecommunications networking device because you would need a lot of energy to switch a tiny amount," he said.

Gauthier and other team members will describe their findings in the Friday, April 29, 2005, issue of the research journal Science, in a report whose first author is Gauthier's graduate student Andrew Dawes. Additional co-authors are Gauthier's post-doctoral research associate

Lucas Illing and former Duke physics undergraduate Susan Clark, who is now in graduate study at Stanford University.

Their research is funded by the Defense Advance Research Projects Agency, the National Science Foundation and the U.S. Army Research Office.

The Duke team's switching system makes use of an instability that Gauthier initially studied in graduate school.

The scientists point two identical beams of laser light at each other while both opposing beams also pass through a warmed rubidium vapor trapped in a glass vacuum tube.

Normally, such counter pointed laser light beams would just unresponsively pass through each other, Gauthier said. But this laser light is of just the right infrared wavelength to be affected by the natural excitations of the rubidium atoms.

This interaction between the light and the rubidium atoms triggers an instability that creates two additional beams. When these secondary beams are projected on a screen, they form an optical pattern. That pattern, consisting of a pair of spots, can be rotated to a new alignment when a third "switching" beam is passed through the rubidium vapor.

Crucially, the strength of the switching beam is also much weaker than the original beams. According to their Science report, the Duke physicists have been able to operate their switch with beams up to 6,500 times weaker than the light in the optical pattern.

"So the idea is, we've got beams that are pointing in one direction and might be going down to a particular place in a network," Gauthier said. "Then, by putting in a very weak beam, we can rotate those original beams to a new orientation. So the spots could then go to different channels in a network system, for example."

The idea of such a weak signal controlling a stronger one "makes the switch 'cascadable,'" Gauthier said. "That's what you need to be able to have the output of one switch affect the input of another switch downstream. No other group we know of has demonstrated this in an all-optical switch."

So far, the Duke group has used weak switching beams consisting of as few as 2,700 individual particles of light, known as photons.

Their report in Science also suggests possible techniques for using switching beams as weak as single photons, perhaps by reducing the size of the laser beams or modifying the atomic vapor.

"There are some applications in quantum information where you would like to have a switch that could be actuated with a single photon," Gauthier said. Quantum computing and telecommunications refers to systems that make use of the quirky features of quantum mechanics to solve otherwise intractable computational problems and provide secure communications channels.

Those quantum effects only manifest themselves in systems where individual photons, electrons or atoms can be manipulated.

Source: Duke University