Controlling light with light

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"Interband transitions controlling intersubband transitions" is the technical description for what has been achieved in an optics lab in Stevens Institute of Technology's Physics Department. Robert K. Murawski, a post-doctoral research assistant working under the direction of Professor Rainer Martini , has a simpler way to describe it: "Controlling light with light."

Regardless of styling, the concept is not a new one, but its first demonstration in a laboratory opens new horizons in telecommunications, with implications for the secure, all-optical transmission of voice and data. Martini credits Murawski for having made the initial measurements proving that the principle is physically possible in a controlled environment.

“Basically,” explains Murawski, “we use a conventional kind of laser beam to ‘switch’ another, more advanced kind of laser beam – and it all happens in mid air.

“One laser beam is mid-infrared,” he says. “We illuminate it directly with a fiber-optic laser diode, which is near-infrared – and if that light has a message on it, then the mid-infrared will have a message on it once it passes through. You can use the fact, then, that the mid-infrared can transmit to the atmosphere to do things like free-space communications without fiber optics.”

“All current wavelength for optical communication is near-infrared, which is highly unreliable in a free-space environment,” explains

Martini, a veteran of Lucent Technologies and the director of the Ultrafast Laser Spectroscopy & Communication Laboratory at Stevens. “The mid-infrared, which is generated by what is called a ‘quantum cascade laser’ or QCL, overcomes many of those limitations in traveling through free space. Plus, because it is ultra-focused, the QCL beam is a much more secure means by which to communicate than by broadcasting or other kinds of telephony.”

Another beauty of the near-infrared/QCL assembly, says Martini, is that “your switches act on two different wavelengths, and they are clearly separate and distinct. The two wavelengths can be handled and processed in independence. There’s no overlap, because we have the whole system clearly detangled.”

Martini and Murawski are quite confident that their achievement is unique.

“In the quantum cascade physics knowledge-base,” says Murawski, “there’s little if any work that’s been done like this. Interband transitions are really not talked about.”

Murawski believes that in the field of advanced quantum cascade lasers, in the physics area, Martini’s lab has developed a more complete picture of those particular dynamics “than anyone else currently working around the world.”

“Robert’s thesis,” says Martini, “is really the first complete theoretical discussion about the immense potential of modulating QCL at high speeds. His thesis sets the limits for how fast that laser can be.”

Murawski, who defended his dissertation in early May, says that the Martini lab has also figured out “how to preserve the integrity of the hardware package. You don’t want the QCL damaged or melting down while it's in action."

Martini is also proud that his lab houses a unique quantum cascade laser.

"It managed the fastest-recorded QCL modulation in the world. Everybody talked about it," he says, "but we achieved it."

Martini says that the controlling of light with light opens up a world of futuristic applications which – because they are imaginable – may at some point be possible.

"The question is," he says, "What is happening in the laser beam when the interband transition takes place? The QCL is unique. One of the big issues is, you send current through it, and that current drops down making the laser transition. So when the first electron drops down, it tells the other electrons to go with it. So there's a kind of 'intelligence among the electrons.' If we can reach in and manipulate that action, who knows what we can engineer using the properties of the laser beam?"

The original news release can be found here.