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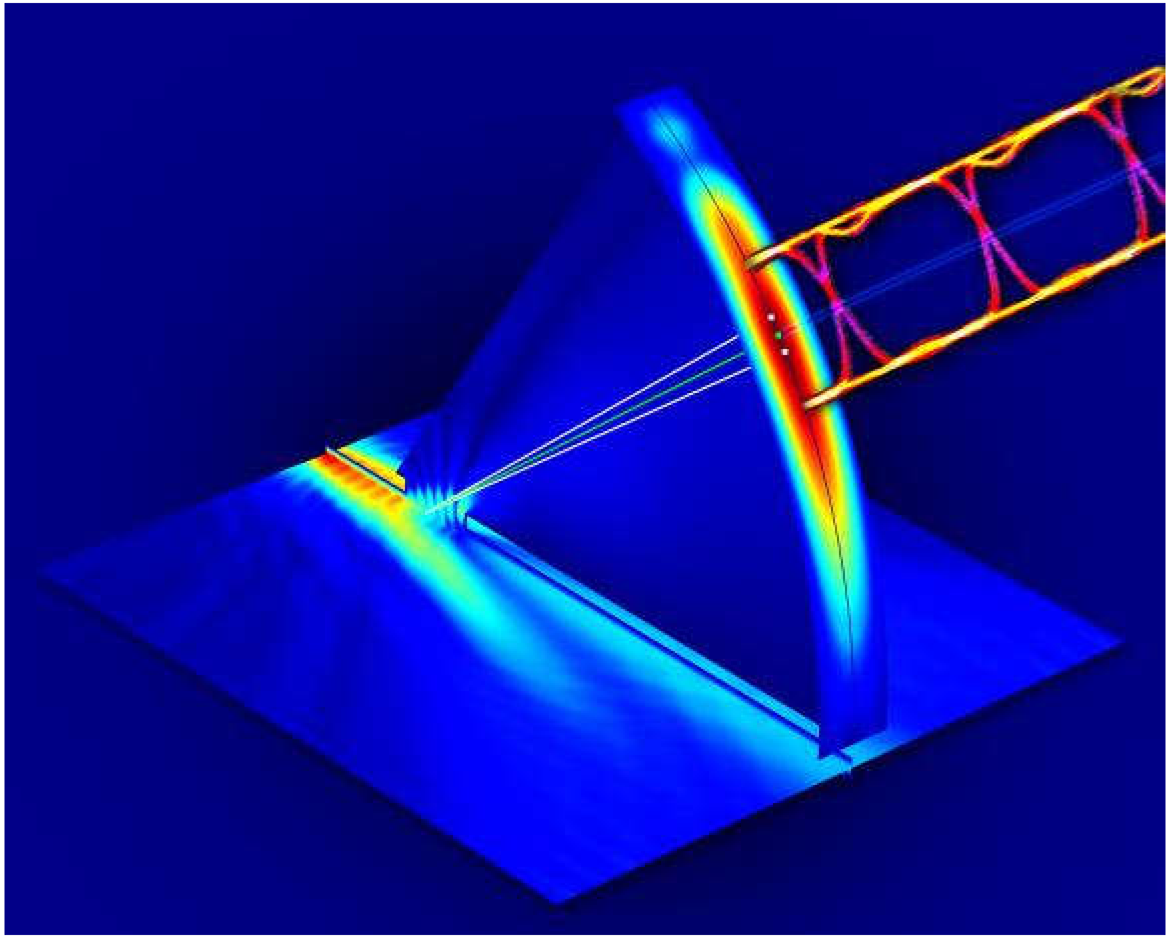

Terahertz multiplexer A research team led by a Brown University engineer have demonstrated the first data transmission through a terahertz multiplexer. *Mittleman lab/Brown University/Ducournau Lab/CNRS/University of Lille*

Scientists report first data transmission through terahertz multiplexer

August 10, 2017 Media contact: Kevin Stacey 401-863-3766

Researchers have demonstrated the transmission of two separate video signals through a terahertz multiplexer at a data rate more than 100 times faster than today's fastest cellular data networks.

PROVIDENCE, R.I. [Brown University] — Multiplexing, the ability to send multiple signals through a single channel, is a fundamental feature of any voice or data communication system. An international research team has demonstrated for the first time a method for multiplexing data carried on terahertz waves, high-frequency radiation that may enable the next generation of ultra-high bandwidth wireless networks.

In the journal Nature Communications, the researchers report the transmission of two real-time video signals through a terahertz multiplexer at an aggregate data rate of 50 gigabits per second, approximately 100 times the optimal data rate of today's fastest cellular network.

"We showed that we can transmit separate data streams on terahertz waves at very high speeds and with very low error rates," said Daniel Mittleman, a professor in Brown's School of Engineering and the paper's corresponding author. "This is the first time anybody has characterized a terahertz multiplexing system using actual data, and our results show that our approach could be viable in future terahertz wireless networks."

Current voice and data networks use microwaves to carry signals wirelessly. But the demand for data transmission is quickly becoming more than microwave networks can handle. Terahertz waves have higher frequencies than microwaves and therefore a much larger capacity to carry data. However, scientists have only just begun experimenting with terahertz frequencies, and many of the basic components necessary for terahertz communication don't exist yet.

A system for multiplexing and demultiplexing (also known as mux/demux) is one of those basic components. It's the technology that allows one cable to carry multiple TV channels or hundreds of users to access a wireless Wi-Fi network.

The mux/demux approach Mittleman and his colleagues developed uses two metal plates placed parallel to each other to form a waveguide. One of the plates has a slit cut into it. When terahertz waves travel through the waveguide, some of the radiation leaks out of the slit. The angle at which radiation beams escape is dependent upon the frequency of the wave.

"We can put several waves at several different frequencies — each of them carrying a data stream — into the waveguide, and they won't interfere with each other because they're different frequencies; that's multiplexing," Mittleman said. "Each of those frequencies leaks out of the slit at a different angle, separating the data streams; that's demultiplexing."

Because of the nature of terahertz waves, signals in terahertz communications networks will propagate as directional beams, not omnidirectional broadcasts like in existing wireless systems. This directional relationship between propagation angle and frequency is the key to enabling mux/demux in terahertz systems. A user at a particular location (and therefore at a particular angle from the multiplexing system) will communicate on a particular frequency.

In 2015, Mittleman's lab first published a paper describing their waveguide concept. For that initial work, the team used a broadband terahertz light source to confirm that different frequencies did indeed emerge from the device at different angles.

While that was an effective proof of concept, Mittleman said, this latest work took the critical step of testing the device with real data.

Working with Guillaume Ducournau at Institut d'Electronique de Microélectronique et de Nanotechnologie, CNRS/University of Lille, in France, the researchers encoded two high-definition television broadcasts onto terahertz waves of two different frequencies: 264.7 GHz and 322.5 GHz. They then beamed both frequencies together into the multiplexer system, with a television receiver set to detect the signals as they emerged from the device. When the researchers aligned their receiver to the angle from which 264.7 GHz waves were emitted, they saw the first channel. When they aligned with 322.5 GHz, they saw the second.

Sidebar

Daniel Mittleman: Mittleman's lab gets license for outdoor terahertz testing

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Further experiments showed that transmissions were error-free up to 10 gigabits per second, which is much faster than today’s standard Wi-Fi speeds. Error rates increased somewhat when the speed was boosted to 50 gigabits per second (25 gigabits per channel), but were still well within the range that can be fixed using forward error correction, which is commonly used in today's communications networks.

In addition to demonstrating that the device worked, Mittleman says the research revealed some surprising details about transmitting data on terahertz waves. When a terahertz wave is modulated to encode data — meaning turned on and off to make zeros and ones — the main wave is accompanied by sideband frequencies that also must be detected by a receiver in order to transmit all the data. The research showed that the angle of the detector with respect to the sidebands is important to keeping the error rate down.

"If the angle is a little off, we might be detecting the full power of the signal, but we're receiving one sideband a little better than the other, which increases the error rate." Mittleman explained. "So it's important to have the angle right."

Fundamental details like that will be critical, Mittleman said, when it comes time to start designing the architecture for complete terahertz data systems. "It's something we didn't expect, and it shows how important it is to characterize these systems using data rather than just an unmodulated radiation source."

The researchers plan to continue developing this and other terahertz components. Mittleman recently received a license from the FCC to perform outdoor tests at terahertz frequencies on the Brown University campus (see sidebar).

"We think that we have the highest-frequency license currently issued by the FCC, and we hope it's a sign that the agency is starting to think seriously about terahertz communication," Mittleman said. "Companies are going to be reluctant to develop terahertz technologies until there's a serious effort by regulators to allocate frequency bands for specific uses, so this is a step in the right direction."

This work was supported by the U.S. National Science Foundation, the U.S. Army Research Office, the W.M. Keck Foundation and France's Agence Nationale de la Recherche under the COM'TONIQ and TERALINKS research grants and in the framework of the CPER "Photonics for Society" developed within the Hauts-de-France region.

Note to Editors: