Physicists develop key component for terahertz wireless

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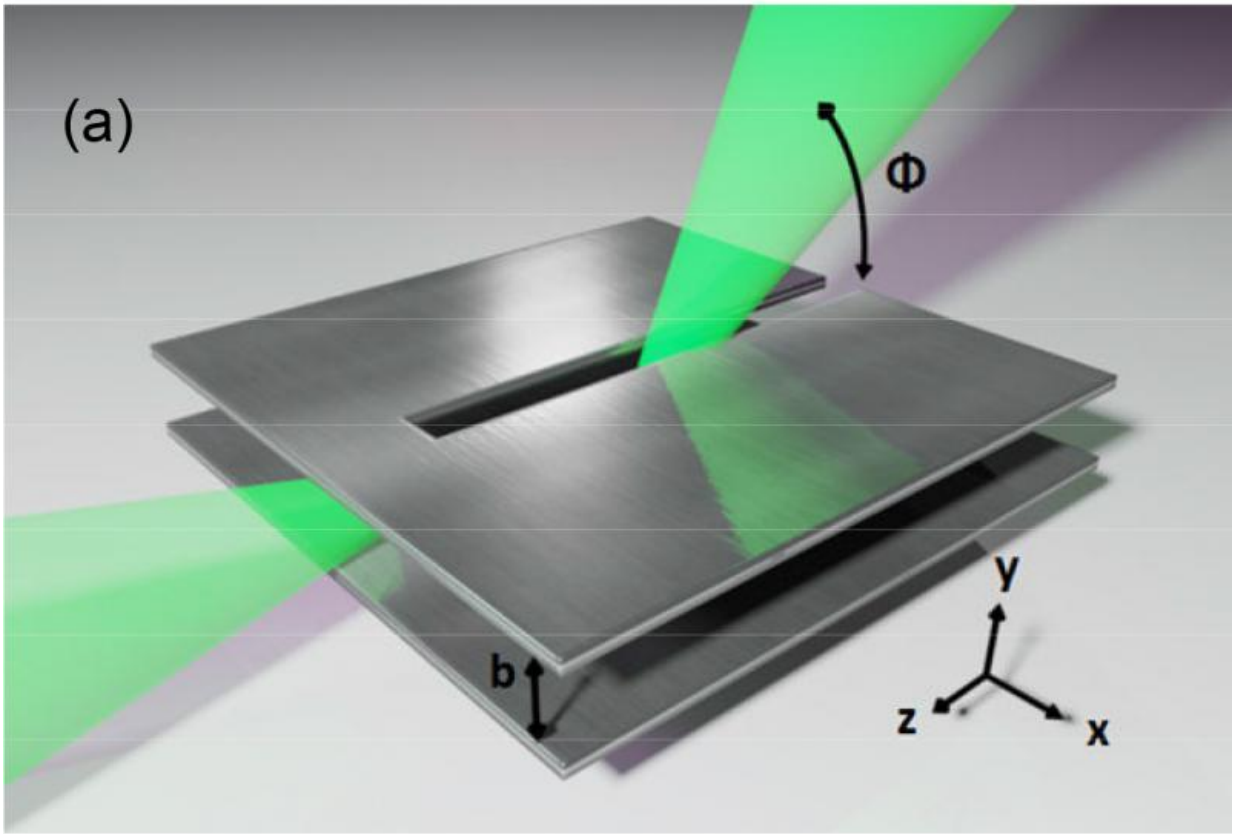

All communications networks need some form of multiplexing -- the ability to send multiple data streams through a single medium. Researchers from Brown have used a leaky wave antenna to separate terahertz waves by frequency. The work provides a viable multiplexing and demultiplexing strategy for future terahertz data networks, which have the potential to deliver data many times faster than today's cellular or Wi-Fi networks. Credit: Mittleman Lab / Brown University

Terahertz radiation could one day provide the backbone for wireless systems that can deliver data up to one hundred times faster than today's cellular or Wi-Fi networks. But there remain many technical challenges to be solved before terahertz wireless is ready for prime time.

Researchers from Brown University have taken a major step toward addressing one of those challenges. They've developed what they believe to be the first system for multiplexing terahertz waves. Multiplexers are devices that enable separate streams of data to travel through a single medium. It's the technology that makes it possible for a single cable to carry multiple TV channels or for a fiber optic line to carry thousands of phone calls at the same time.

"Any terahertz communications application is going to need some form of multiplexing and demultiplexing," said Daniel Mittleman, professor of engineering at Brown and senior author of a paper describing the new device. "This is, to our knowledge, the first time anyone has demonstrated a viable strategy for multiplexing in the terahertz range."

The research was published September 14 in *Nature Photonics*.

Today's cellular and Wi-Fi networks rely on microwaves to carry voice conversations and data. But the increasing demands for data transfer are quickly becoming more than microwaves can handle. Terahertz waves have a much higher frequency and therefore more potential bandwidth. Scientists and engineers have only recently begun exploring the potential of terahertz waves, however. As a result, many of the components for a terahertz wireless network—including multiplexers—have not yet been developed.

The multiplexer that Mittleman and his colleagues have been working on

makes use of what's known as a leaky wave antenna. In this case, the antenna is made from two metal plates placed in parallel to form a waveguide. One of the plates has a small slit in it. As terahertz waves travel down the waveguide, some of the radiation leaks out of the slit. It turns out that terahertz waves leak out a different angles depending on their frequency.

"That means if you put in 10 different frequencies between the plates—each of them potentially carrying a unique data stream—they'll come out at 10 different angles," Mittleman said. "Now you've separated them and that's demultiplexing."

On the other end, a receiver could be tuned to accept radiation at a particular angle, thus receiving data from only one stream.

"We think it's definitely a reasonable solution to meet the needs of a terahertz communication network," said Nicholas Karl, a graduate student at Brown and the paper's lead author. Karl led the experiments on the device with fellow graduate student Robert McKinney. Other authors on the study are Rajind Mendis, a research professor at Brown, and Yasuaki Monnai from Keio University in Tokyo.

One of the advantages to the approach, the researchers say, is that by adjusting the distance between the plates, it's possible to adjust the spectrum bandwidth that can be allocated to each channel. That could be especially useful when such a device is deployed for use in a data network.

"For example, if one user suddenly needs a ton of bandwidth, you can take it from others on the network who don't need as much just by changing the plate spacing at the right location," Mittleman said.

The group plans to continue its work to refine the device. A research

group from Osaka University is collaborating with Mittleman's group to implement the device in a prototype terahertz network they're building.

"This is a first-generation, proof-of-concept device," Karl said. "There are still things we can do to improve it and we'll continue to study it."

Mittleman hopes that the work will challenge other researchers to start developing components for terahertz networks.

"The biggest impact this may have is it may just be the kick that people need to start thinking about this issue," Mittleman said. "That means they'll start coming up with clever ideas that are entirely different from this one."

More information: Frequency-division multiplexing in the terahertz range using a leaky-wave antenna, *Nature Photonics*, DOI: 10.1038/nphoton.2015.176

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