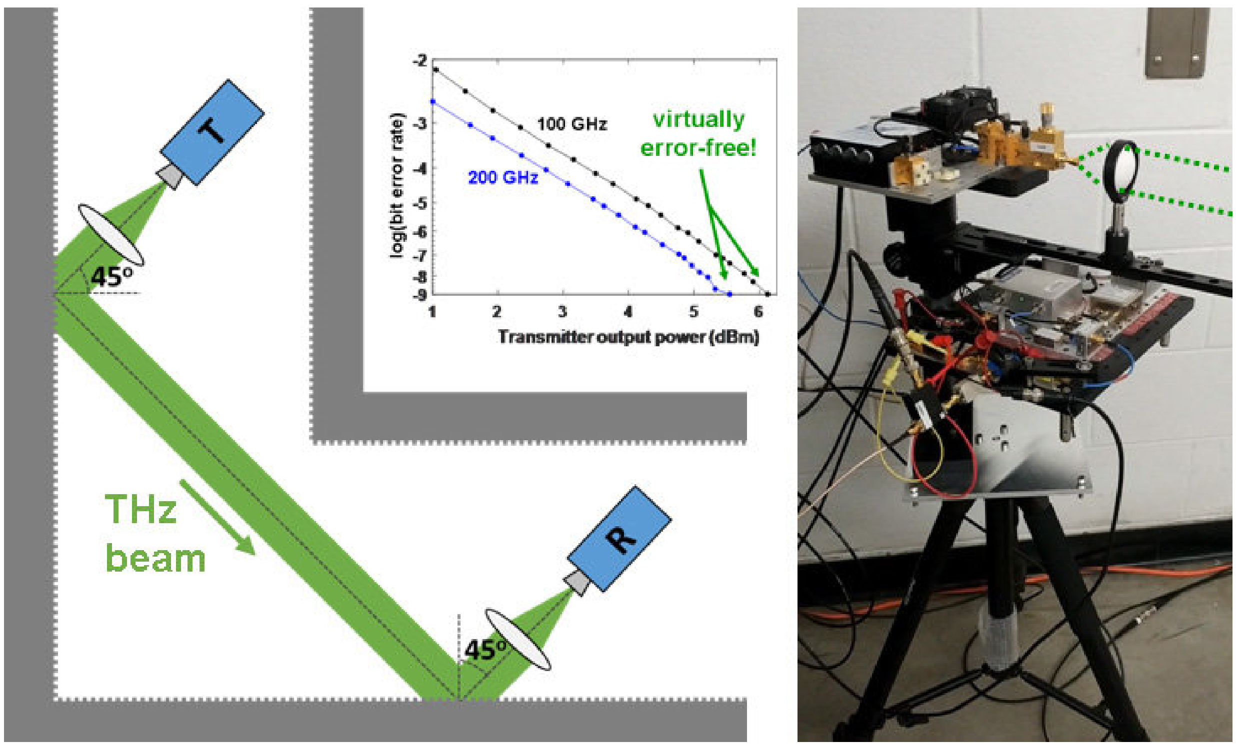
Researchers take terahertz data links around the bend

February 6 2018, by Kevin Stacey



New research shows that non-line-of-site terahertz data links are possible because the waves can bounce off of walls without losing too much data. Credit: Mittleman lab / Brown University

An off-the-wall new study by Brown University researchers shows that terahertz frequency data links can bounce around a room without dropping too much data. The results are good news for the feasibility of future terahertz wireless data networks, which have the potential to carry many times more data than current networks.

Today's cellular networks and Wi-Fi systems rely on microwave radiation to carry data, but the demand for more and more bandwidth is quickly becoming more than microwaves can handle. That has researchers thinking about transmitting data on higher-frequency terahertz waves, which have as much as 100 times the data-carrying capacity of microwaves. But terahertz communication technology is in its infancy. There's much basic research to be done and plenty of challenges to overcome.

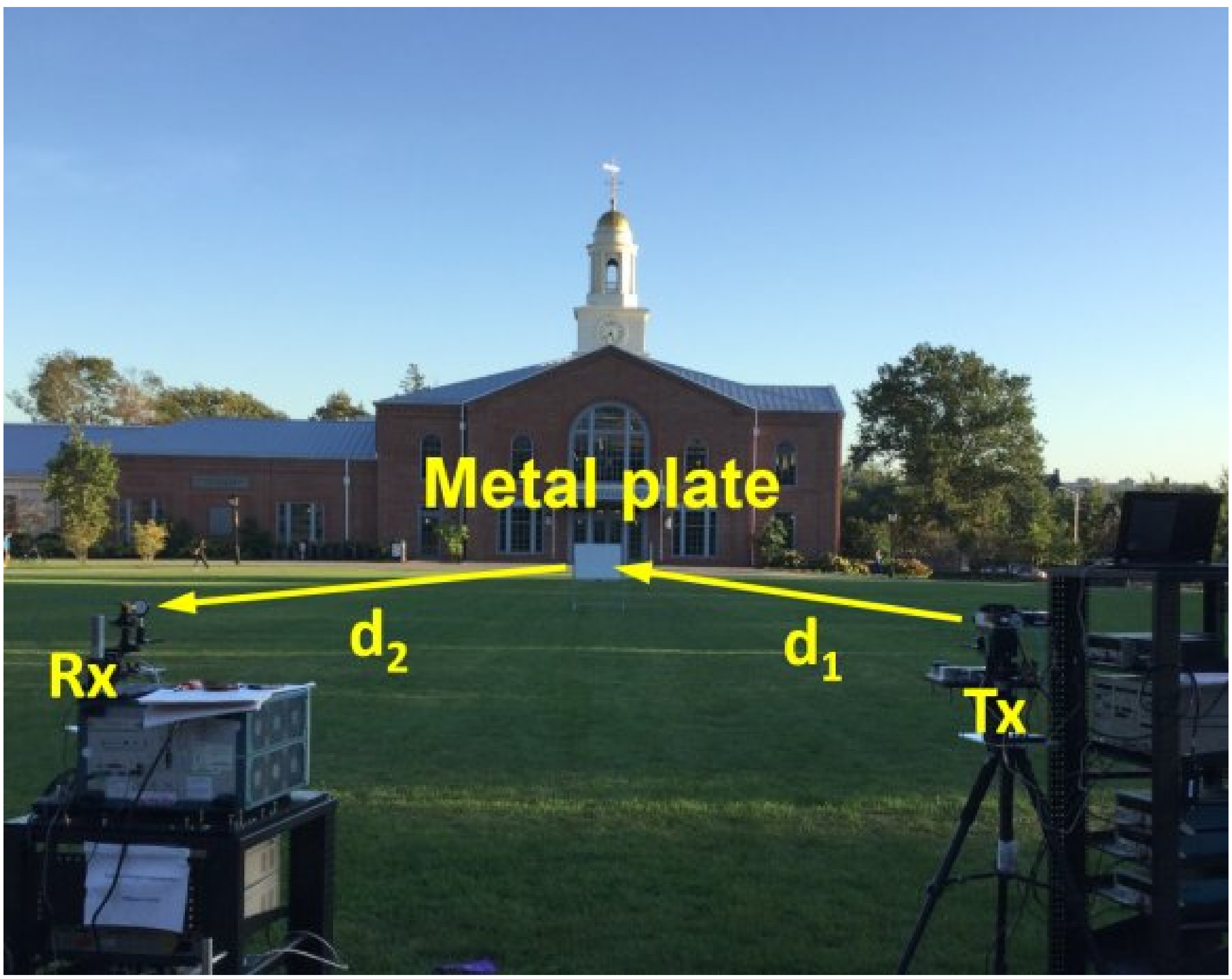
For example, it's been assumed that terahertz links would require a direct line of sight between transmitter and receiver. Unlike microwaves, terahertz waves are entirely blocked by most solid objects. And the assumption has been that it's not possible to bounce a terahertz beam around—say, off a wall or two—to find a clear path around an object.

"I think it's fair to say that most people in the terahertz field would tell you that there would be too much power loss on those bounces, and so non-line-of-sight links are not going to be feasible in terahertz," said Daniel Mittleman, a professor in Brown University's School of Engineering and senior author of the new research published in *APL Photonics*. "But our work indicates that the loss is actually quite tolerable in some cases—quite a bit less than many people would have thought."

For the study, Mittleman and his colleagues bounced terahertz waves at four different frequencies off of a variety of objects—mirrors, metal doors, cinderblock walls and others—and measured the bit-error-rate of the data on the wave after the bounces. They showed that acceptable bit-error-rates were achievable with modest increases in signal power.

"The concern had been that in order to make those bounces and not lose your data, you'd need more power than was feasible to generate," Mittleman said. "We show that you don't need as much power as you might think because the loss on the bounce is not as much as you'd think."

In one experiment, the researchers bounced a beam off two walls, enabling a successful link when transmitter and receiver were around a corner from each other, with no direct line-of-sight whatsoever. That's a promising finding to support the idea of terahertz local-area networks.



In an effort to better understand the architecture needed for future terahertz data networks, Brown University researchers investigate how terahertz waves propagate and bounce off of objects both indoors and out. Credit: Mittleman Lab / Brown University

"You can imagine a wireless network," Mittleman explained, "where someone's computer is connected to a terahertz router and there's direct line-of-sight between the two, but then someone walks in between and blocks the beam. If you can't find an alternative path, that link will be shut down. What we show is that you might still be able to maintain the link by searching for a new path that could involve bouncing off a wall somewhere. There are technologies today that can do that kind of path-finding for lower frequencies and there's no reason they can't be developed for terahertz."

The researchers also performed several outdoor experiments on terahertz wireless links. An experimental license issued by the FCC makes Brown the only place in the country where outdoor research can be done legally at these frequencies. The work is important because scientists are just beginning to understand the details of how terahertz data links behave in the elements, Mittleman says.

Their study focused on what's known as specular reflection. When a signal is transmitted over long distances, the waves fan out forming an ever-widening cone. As a result of that fanning out, a portion the waves will bounce off of the ground before reaching the receiver. That reflected radiation can interfere with the main signal unless a decoder compensates for it. It's a well-understood phenomenon in microwave transmission. Mittleman and his colleagues wanted to characterize it in the terahertz range.

They showed that this kind of interference indeed occurs in terahertz waves, but occurs to a lesser degree over grass compared to concrete.

That's likely because grass has lots of water, which tends to absorb terahertz waves. So over grass, the reflected beam is absorbed to a greater degree than concrete, leaving less of it to interfere with the main beam. That means that terahertz links over grass can be longer than those over concrete because there's less interference to deal with, Mittleman says.

But there's also an upside to that kind of interference with the ground.

"The specular reflection represents another possible path for your signal," Mittleman said. "You can imagine that if your line-of-site path is blocked, you could think about bouncing it off the ground to get there."

Mittleman says that these kinds of basic studies on the nature of terahertz data transmission are critical for understanding how to design the network architecture for future terahertz data systems.

More information: Jianjun Ma et al, Invited Article: Channel performance for indoor and outdoor terahertz wireless links, *APL Photonics* (2018). DOI: 10.1063/1.5014037

Provided by Brown University