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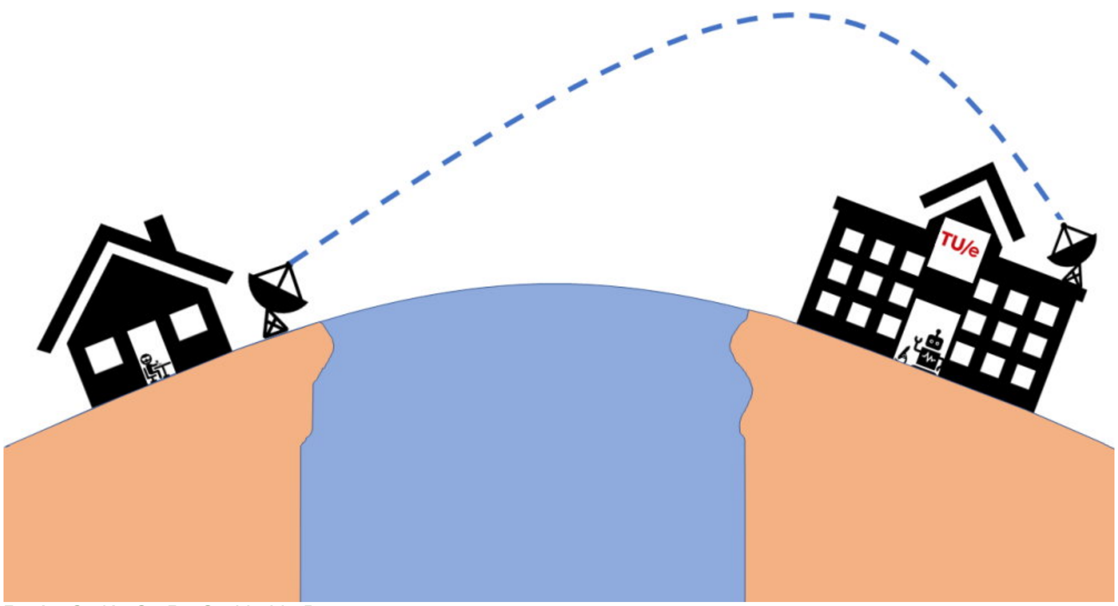

BACKGROUND

TUE’s remote labs enhance experimental setups from home

Martijn Boerkamp is a science journalist with a strong background in high-tech R&D. He’s also the CTO and co-founder of the startup Inphocal.

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Zoom, Teams and Hangouts: for many people around the world, these online platforms have become the new method of communicating during the pandemic. Physical work, however, was either stopped or continued with restrictions and health risks. New online methods, like the remote lab setups from Eindhoven University of Technology, can help solve that problem and make physical presence a thing of the past.

Small buzzing sounds, movements of translation stages and mirrors, polarizers rotating, lasers turning on and off. It's a research setup in action. But the lab is dark and empty, and nobody's there to push the buttons. This setup belongs to Niels van Hoof, Applied Physics PhD student at Eindhoven University of Technology (TUE). He managed to have complete remote control over his laboratory setup. "I only have to physically change my sample from time to time," says Van Hoof. His setup is used to study the properties of metamaterials. These are surfaces with very tiny structures that scatter light in a controlled way, which give them unusual properties. They can be used, for example, as better sensors or high-frequency switches for communication.

"The setup is unique. There's only one in the world," notes Van Hoof proudly. "We call it a terahertz near-field microscope. We use terahertz light: electromagnetic radiation with wavelengths between 0.1 mm infrared and 1.0 mm microwave. By using a very short laser pulse – 100 femtoseconds – and an emitter, a THz pulse is produced that shines onto the metamaterial sample, which then resonates with THz light frequencies. We then analyze the resulting THz field on the sample's surface with a second laser pulse and a special near-field detector. Ultrafast measurements of this THz field result in a lot of information, such as intensities and phases at various locations, which we measure with super precision – 100 times smaller than a conventional setup."

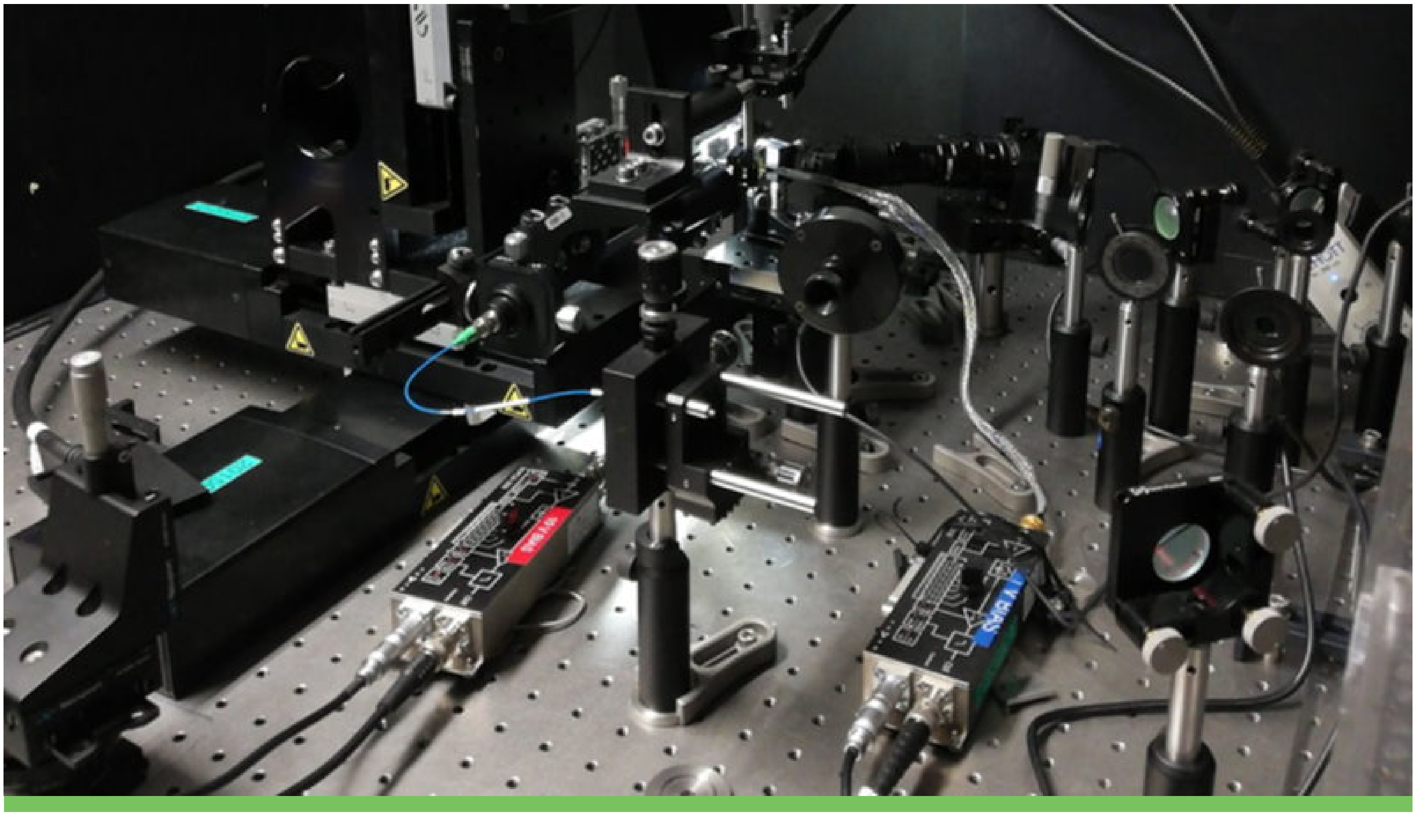
TUE PhD student Niels van Hoof running measurements from home. Credit: Niels van Hoof

"I actually needed to have a setup that can run day and night: the longer I measure, the better my results are," elaborates Van Hoof. During his PhD, he had the challenging task of building a setup for long measurement runs. Van Hoof explains that this was the first motivation in developing a setup that could be controlled remotely, applying small upgrades over the years. He didn't do it completely by himself. Together with a software engineer, the setup was made robust. Van Hoof: "In the end, I could run long measurements, so the extra effort was worth it."

Better results

"I was already preparing for a long measurement to complete my paper when they called to tell me the university was going into a lockdown at 7 pm," remembers Van Hoof. "I left my dinner and cycled to the university as if my life depended on it." He was just in time to place a sample in his setup before the university shut its doors. His timing was perfect, as he optimized his setup for long measurement runs just a few weeks prior. This meant that his experiments could continue from home, running day and night for an entire month. "Measuring around the clock and zero travel time meant getting a lot of extra work done," says Van Hoof excitedly.

After analyzing the results, Van Hoof made a surprising discovery: fewer people in the lab actually lead to getting better results. "This wasn't something we aimed for when we started it," states Van Hoof. "But it does make sense. People cause small disturbances. Every person in the lab gives off some body heat, switching the lights on and off, vibrations due to doors opening and closing and footsteps, even the small airflow of people's movement causes disturbances. Having nobody around really boosted our measurement results." His final paper, containing the improved measurements from the remote setup, is currently under review by a scientific journal.



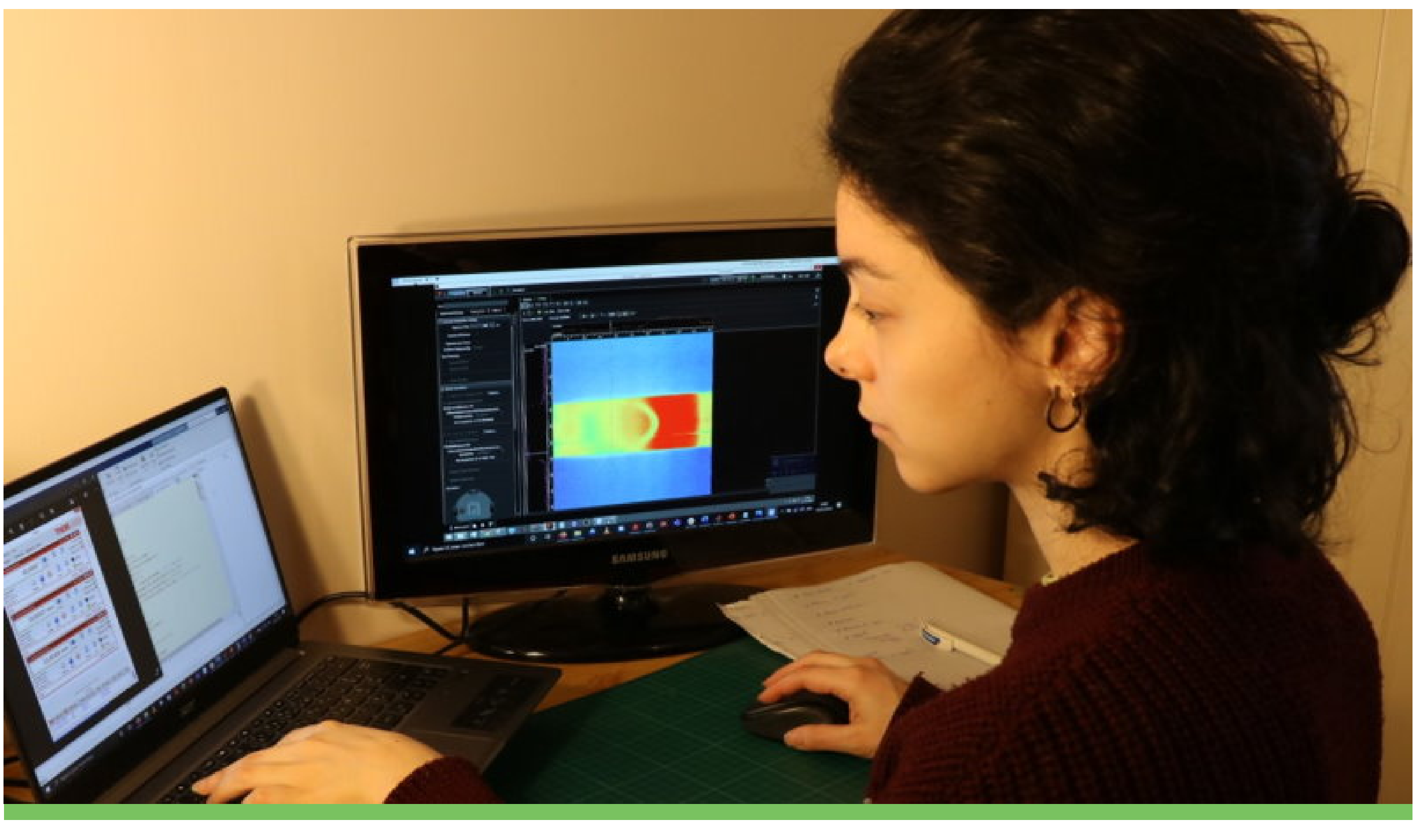
Van Hoof's remote setup for a so-called terahertz near-field microscope. Credit: Niels van Hoof

The positive results created excitement within TUE's Surface Photonics group, led by Van Hoof's supervisor, professor Jaime Gómez Rivas. "Now that they've seen the success of the remote setup, everybody wants one," affirms Gómez Rivas. "We now have five remote-controlled setups, and soon we'll have five more. Only one person is required to keep ten setups running by physically changing samples when needed. The most important change was our mindset. Running experiments 24/7 requires a higher level of organization. There's no room for trial and error anymore. But it's worth it in the long run: we get more work done and get better quality results."

International collaboration

Travel restrictions no longer get in the way of doing research in his group, Gómez Rivas points out. "The pandemic's first wave restricted travel to Eindhoven for a French master's student. The group then quickly built another remote setup so that she could perform her research from a distance. With the second wave, we're experiencing similar travel restrictions. But now, we're able to offer a complete remote master's thesis research project to a Portuguese student. On top of that, we also overcome other restrictions, such as the physical limit of people allowed in a lab, as we can now have five people doing lab work remotely."

"Teaching practical lessons from a distance is also no longer a problem," explains Gómez Rivas. "Practical lessons taught at the university often require complicated setups that make it challenging to teach them remotely. But students working on our remote setups solves the situation. They work in an actual lab, where they can control a setup, do real experiments and analyze the data – all from any place outside the lab."



Using a remote setup, French master's student Laura Paggi could perform her research from a distance. Credit: Laura Paggi

"We actually interacted more with our international collaborations during the pandemic than we did before," tells Gómez Rivas.

"Before the pandemic, our Japanese collaborators were traveling to Eindhoven to do measurements on our setups or were sending samples and waiting until we measured them to discuss the end result. Now, we've made it possible to do these measurements remotely, from anywhere in the world, even allowing them to measure directly from Japan." Now, Gómez Rivas is looking for new ways to extend this concept and give other research groups, or even companies, the chance to use this setup in their own research. "We definitely need to upgrade our setups to allow for universal user-friendliness. But it's an exciting path forward and we can't wait to see where it will lead to."

Gómez Rivas encourages more people to follow in his group's footsteps. "The Covid situation already taught us how to interact remotely via tools like Zoom and Teams. We proved we could also get actual lab work done as well – without traveling daily or traveling around the world. It's much better for the environment, plus it saves time and money. It can also build and strengthen international collaborations. This should be the future of research. The time to act is now and the tools are available. We don't have to wait for the future to arrive to make physical presence a thing of the past."

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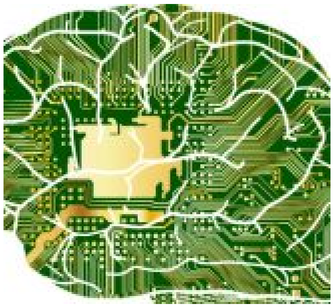

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