Research could lead to security scanners capable of detecting explosives

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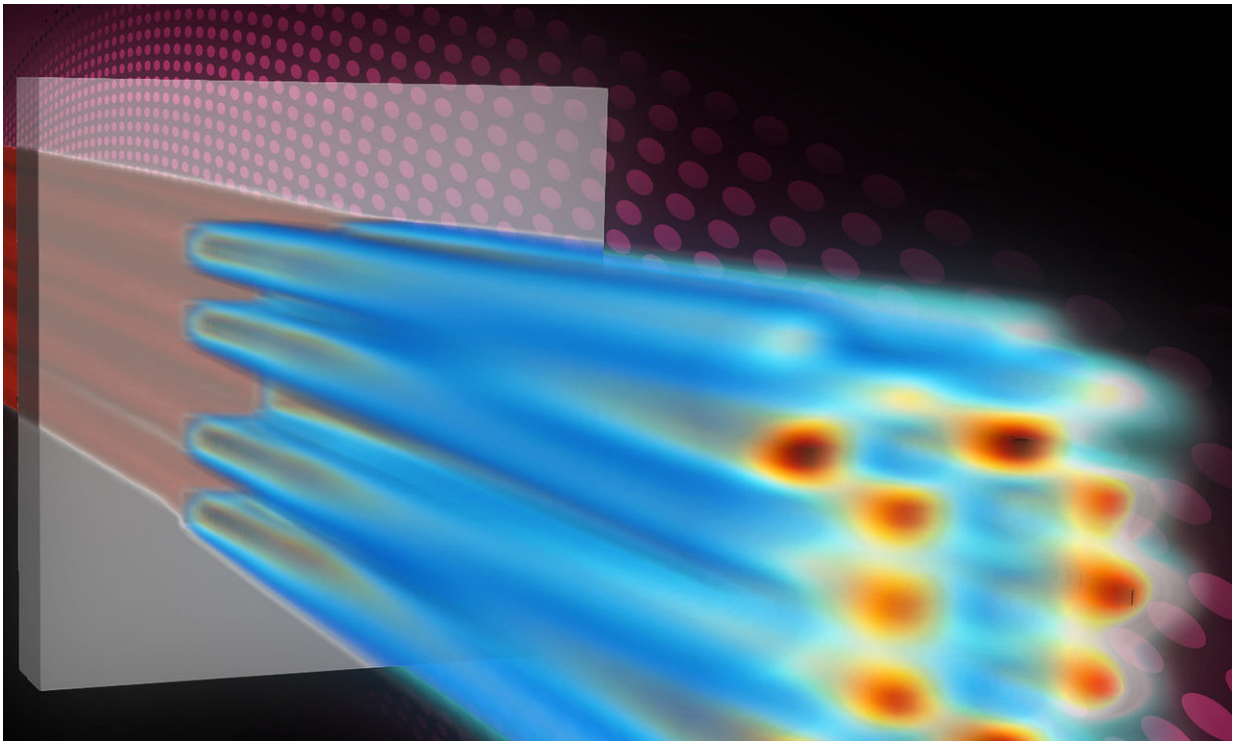

The cover of *ACS Photonics* journal featuring the researcher's work Credit: University of Sussex/*ACS Photonics*

Using a single pixel camera and Terahertz electromagnetic waves, a team of Physicists at the University of Sussex have devised a blueprint which could lead to the development of airport scanners capable of detecting explosives.

Miss Luana Olivieri, Ph.D. student and Dr. Juan Sebastian Totero Gongora, a Research Fellow in Experimental Photonics of the Emergent Photonics Lab directed by Professor Marco Peccianti and Dr. Alessia Pasquazi, have found an innovative way to capture with high accuracy, not just the shape of an object, but also its chemical composition using a special "single point" camera capable of operating at Terahertz (THz) frequencies.

Although their work is mostly theoretical at this stage -they introduced a novel imaging concept named Nonlinear Ghost Imaging- their ability to capture a more detailed image to previous studies has landed them a prestigious front-page feature of the scientific journal, *ACS Photonics*.

Dr. Juan Sebastian Totero Gongora said: "Our approach produces a new type of image which is quite different from what you would get from a standard single-pixel camera as it provides much more information on the object. Compared to prior single pixel images, we also demonstrated that our resolution is inherently higher."

Lying between microwaves and infrared in the electromagnetic spectrum, Terahertz radiation has a much larger wavelength to visible light. It can easily penetrate several common materials like paper, clothes and plastics leading to the development of technology within security scanning and manufacture control which allows people to see inside objects and wrapping.

The radiation provokes a different response from biological samples though, allowing researchers to classify materials which are almost indistinguishable with visible light.

Scientists believe that THz waves could have enormous potential in developing critical applications such as explosives detection, medical diagnostics, quality control in manufacturing and food safety.

The challenge, however, lies in the development of reliable and cost-effective cameras as well as the ability to identify objects smaller than the wavelength.

But, by taking a different approach to previous studies in this field, the team of the Emergent Photonics Lab may have found a way to overcome these limitations.

While previous research has illuminated objects with many patterns of laser light in just one colour to extract an image, the researchers illuminated an object with patterns of THz light which contain a broad spectrum of colours.

A single pixel camera (rather than a standard one containing multiple pixels as sold on the high street) can capture the light reflected by the object for each pattern. In the team's study, they found that the camera can detect how the pulse of light is altered in time by the object (even if the THz pulse is an extremely short event). By combining this information with the known shape of the patterns, the shape of the object and its nature are revealed.

The technique may recall the way the brain develops understanding in the vision by focusing separately on different elements and then fusing the relevant information.

Professor Marco Peccianti added: "This is a really significant development and we're really happy that *ACS Photonics* decided to lead with our research on their front cover. Previous approaches to THz single-pixel cameras cannot preserve the complete information on an object but we understood where the issue lay and identified a way to extract a more complete image.

"We hope that a similar system to ours could be used in real-life

applications in biology, medicine and security to determine the chemical composition of an object and its spatial distribution in just one step."

The team's findings are a considerable improvement on established technologies and could have a huge impact beyond the field of THz cameras.

For instance, their technique could be used to design high-resolution cameras in other frequency ranges which could then become part of technology for collision sensors, body scanner or ultra-rapid radars for self-driving cars.

The researchers are now following up on their research, which is largely based on simulations, to experimentally demonstrate their device.

'Time-Resolved Nonlinear Ghost Imaging by Luana Olivieri, Juan S. Totero Gongora, Alessia Pasquazi and Marco Peccianti was published in *ACS Photonics* on 15th August 2018.

More information: Luana Olivieri et al, Time-Resolved Nonlinear Ghost Imaging, *ACS Photonics* (2018). DOI: 10.1021/acsphotonics.8b00653

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