Making a better invisibility cloak

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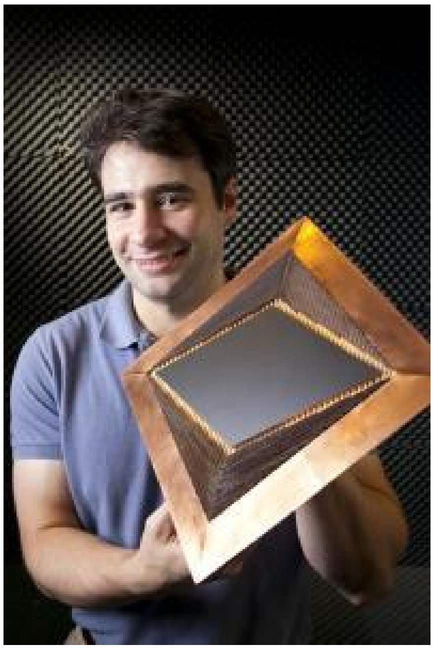

This is Nathan Landy with cloaking device. Credit: Duke University Photography

The first functional "cloaking" device reported by Duke University electrical engineers in 2006 worked like a charm, but it wasn't perfect. Now a member of that laboratory has developed a new design that ties up one of the major loose ends from the original device.

These new findings could be important in transforming how light or other waves can be controlled or transmitted. Just as traditional wires gave way to fiber optics, the new meta-material could revolutionize the transmission of light and waves.

Because the goal of this type of research involves taming light, a new field of transformational optics has emerged. The results of the Duke experiments were published online Nov. 11 in the journal Nature Materials.

The Duke team has extensive experience in creating "meta-materials," man-made objects that have properties often absent in natural ones. Structures incorporating meta-materials can be designed to guide electromagnetic waves around an object, only to have them emerge on the other side as if they had passed through an empty volume of space, thereby cloaking the object.

"In order to create the first cloaks, many approximations had to be made in order to fabricate the intricate meta-materials used in the device," said Nathan Landy, a graduate student working in the laboratory of senior investigator David R. Smith, William Bevan Professor of electrical and computer engineering at Duke's Pratt School of Engineering.

"One issue, which we were fully aware of, was loss of the waves due to reflections at the boundaries of the device," Landy said. He explained that it was much like reflections seen on clear glass. The viewer can see through the glass just fine, but at the same time the viewer is aware the glass is present due to light reflected from the surface of the glass. "Since the goal was to demonstrate the basic principles of cloaking, we didn't worry about these reflections."

Landy has now reduced the occurrence of reflections by using a different fabrication strategy. The original cloak consisted of parallel and intersecting strips of fiberglass etched with copper. Landy's cloak used a similar row-by-row design, but added copper strips to create a more complicated—and better performing—material. The strips of the device, which is about two-feet square, form a diamond-shape, with the center left empty.

When any type of wave, like light, strikes a surface, it can be either reflected or absorbed, or a combination of both. In the case of earlier cloaking experiments, a small percentage of the energy in the waves was absorbed, but not enough to affect the overall functioning of the cloak.

The cloak was naturally divided into four quadrants. Landy explained the "reflections" noted in earlier cloaks tended to occur along the edges and corners of the spaces within and around the meta-material.

"Each quadrant of the cloak tended to have voids, or blind spots, at their intersections and corners with each other," Landy said. "After many calculations, we thought we could correct this situation by shifting each strip so that it met its mirror image at each interface.

"We built the cloak, and it worked," he said. "It split light into two waves which traveled around an object in the center and re-emerged as the single wave with minimal loss due to reflections."

Landy said this approach could have more applications than just cloaks. For example, meta-materials can "smooth out" twists and turns in fiber optics, in essence making them seem straighter. This is important, Landy said, because each bend attenuates the wave within it.

The researchers are now working to apply the principles learned in the latest experiments to three dimensions, a much greater challenge than in a two-dimensional device.

More information: "A full-parameter unidirectional metamaterial cloak for microwaves," Nathan Landy and David R. Smith; *Nature Materials*, Nov. 12, 2012. DOI: 10.1038/nmat3476

Provided by Duke University

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