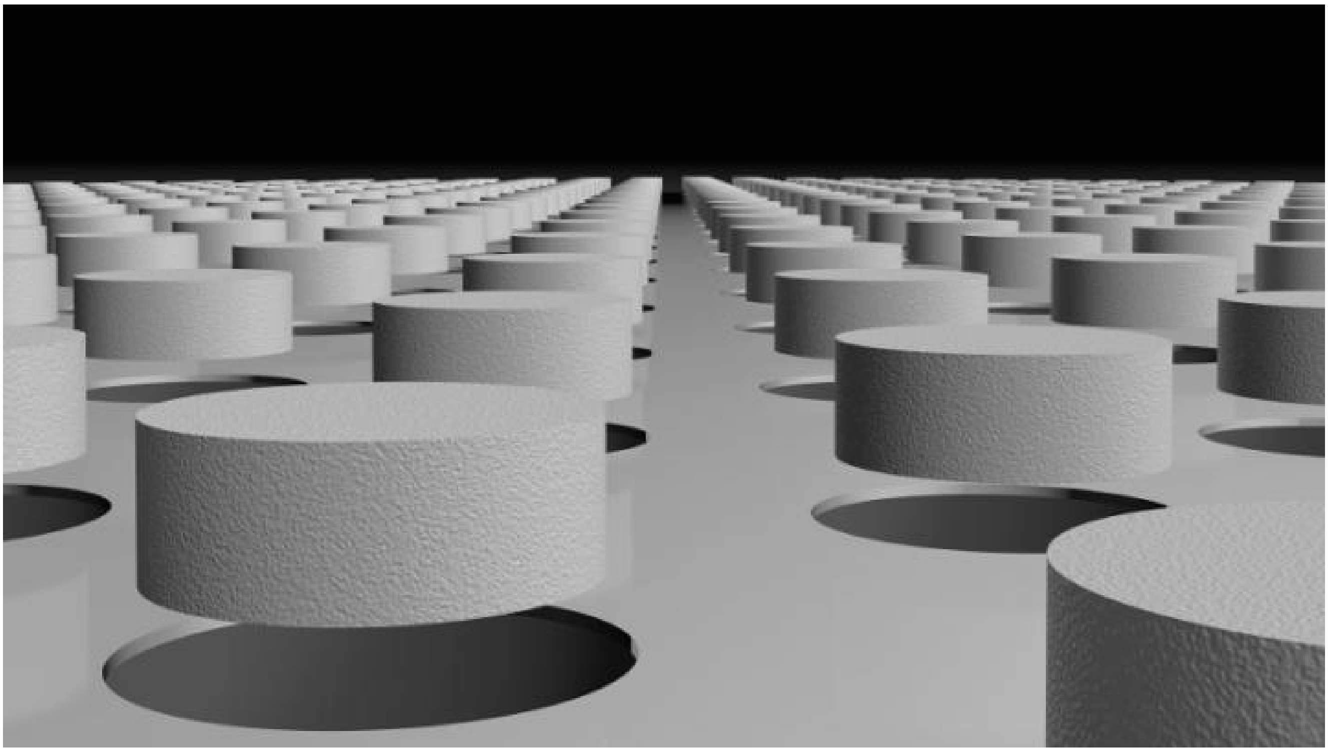
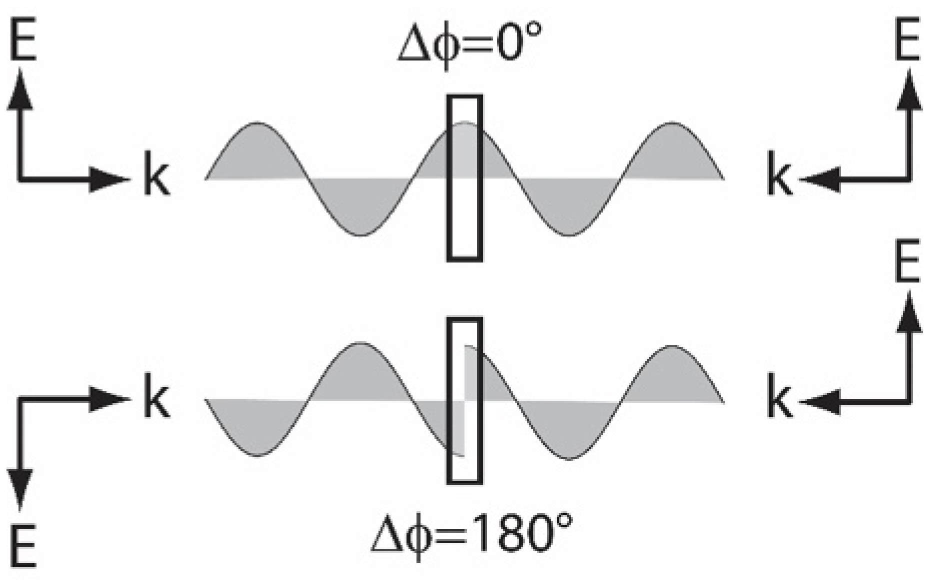
With a Few Tweaks, a Near-Perfect Absorber Can Become a Time-Reversed Laser

DURHAM, N.C., Feb. 19, 2019 — With small adjustments, a near-perfect absorber of electromagnetic waves can be changed into a coherent perfect absorber (CPA), a device that absorbs coherent light and shows near-zero reflectance and high absorption. A CPA, also known as a time-reversed laser, absorbs all of the energy from two identical electromagnetic waves in synchrony. The waves are absorbed as they enter the material from either side at precisely the same time.



The width, height, and spacing of the cylinders depicted here dictate how the metamaterial described in the new paper absorbs electromagnetic energy. Courtesy of Kebin Fan, Duke University.

This metamaterial features a zirconia ceramic built into a surface dimpled with cylinders, like the face of a Lego brick. After computationally modeling the metamaterial's properties, the researchers found that they could create a basic CPA from the metamaterial by altering the cylinder size and spacing.



Traditional "reverse lasers" can only absorb energy when the incoming electromagnetic waves are perfectly aligned, as in the top example. Courtesy of Kebin Fan and Willie Padilla, Duke University.

In contrast to existing CPAs, which work in one mode only, the CPA created by the Duke team has two overlapping modes, enabling it to absorb both aligned and misaligned waves. By changing the material's parameters so that the two modes no longer overlapped, the researchers were able to create a CPA just like the CPAs currently described in the literature, but with more versatility. "Typical CPAs have only one variable, the material's thickness," said professor Kebin Fan. "We have three: the cylinders' radius, height, and periodicity. This gives us a lot more room to tailor these modes and put them in the frequency spectrum where we want them, giving us a lot of flexibility for tailoring the CPAs." By increasing the cylinder height in the metamaterial from 1.1 to 1.4 mm, the researchers gave the device the ability to switch between absorbing all phases of electromagnetic waves and absorbing only waves occurring in sync with each other. The team believes that it could be possible to engineer a material that can make this switch dynamically. “We haven’t done that yet. It is challenging, but it’s on our agenda,” said professor Willie Padilla. In principle, the researchers said, a device could be engineered that measures not just the intensity of incoming light like a normal camera, but also its phase. “If you’re trying to figure out the properties of a material, the more measurements you have, the more you can understand about the material,” Padilla said. “And while coherent detectors do exist … they’re extremely expensive to build through other technologies.”

The demonstrated system and theory could open the way to a new class of absorbers for future applications in hyperspectral imaging and energy harvesting.

For more information:
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