Hiding in plain sight

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A couple years ago, researchers introduced a new material that they said could make any object invisible to both radar and the human eye. Invisibility cloaking would have a major impact on defense technology, they explained, but there was only one problem: The current materials used in this novel application were only capable of hiding the object from a single frequency wave.

"Somebody comes in with another frequency," said Hossein Mosallaei, an associate professor of electrical and computer engineering, "they'll get it like that." He snapped his fingers.

It's a problem of bandwidth, he said. But in a paper recently published in the journal *IEEE Transactions on Antennas and Propagation*, Mosallaei and his team overcome that problem.

New materials like those that enable cloaking, as well as a host of other applications, are called metamaterials: collections of so-called "inclusions"—metal rings, for example, or wires—that are organized so that the whole affords unique properties not found in nature.

One of these properties—called permeability, or the magnetic polarization of the atoms within—is only found in materials with low excitation frequencies. But the miniature devices that have come to define our technological culture operate at high frequencies. Metamaterials developed in labs like Mosallaei's have been able to achieve the uncommon feat of permeability at high excitation frequencies.

But, still, a problem remained: The materials only retained those properties at a single frequency, just like the aforementioned cloaking material. Researchers have theorized dozens of new applications with novel combinations of permeability and its sister property, permittivity (the electric polarization of the atoms in a material). From miniaturized antennas to cloaking to extremely high-resolution imaging to concepts we can't yet fathom, almost none of these will be of great use until metamaterials become operable at a wide range of frequencies.

In the recent paper, Mosallaei's team incorporated active electronic circuits into the metamaterials as yet another "inclusion." Just like permeability, the circuit components want to operate at specific frequencies. Forcing them together into the confined space of the metamaterials has the effect of canceling out this frequency dependency. The bandwidth problem disappears. This is achieved in the microwave spectrum where work is currently in progress to exploit the similar concept in higher frequencies and in the visible band.

The new approach could have implications for a variety of applications. Invisibility cloaking, Mosallaei said, is just the beginning.

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