'Invisibility cloaks' could break sound barriers

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Contrary to earlier predictions, Duke University engineers have found that a three-dimensional sound cloak is possible, at least in theory.

Such an acoustic veil would do for sound what the "invisibility cloak" previously demonstrated by the research team does for microwaves--allowing sound waves to travel seamlessly around it and emerge on the other side without distortion (http://www.physorg.com/news80488753.html).

"We've devised a recipe for an acoustic material that would essentially open up a hole in space and make something inside that hole disappear from sound waves," said Steven Cummer, Jeffrey N. Vinik Associate Professor of Electrical and Computer Engineering at Duke's Pratt School of Engineering. Such a cloak might hide submarines in the ocean from detection by sonar, he said, or improve the acoustics of a concert hall by effectively flattening a structural beam.

As in the case of the microwave cloak, the properties required for a sound cloak are not found among materials in nature and would require the development of artificial, composite metamaterials (For more about metamaterials, see http://www.ee.duke.edu/~drsmith/neg_ref_home.htm).

The engineering of acoustic metamaterials lags behind those that interact with electromagnetic waves (i.e. microwaves or light), but "the same ideas should apply," Cummer said.

The report by Cummer's team is expected to appear in *Physical Review Letters* on Jan. 11.

In 2006, researchers at Duke and the Imperial College London used a new design theory to create a blueprint for an electromagnetic invisibility cloak. Only a few months later, the team demonstrated the first such cloak, designed to operate at microwave frequencies.

Cummer and David Schurig, a former research associate at Duke who is now at North Carolina State University, later reported in The New Journal of Physics a theory showing that an acoustic cloak could be built. But that theory relied on a "special equivalence" between electromagnetic and sound waves that is only true in two dimensions, Cummer said. A report by another team had also suggested that a 3-D acoustic cloak couldn't exist. It appeared they had reached a dead end.

Cummer wasn't convinced. "In my mind, waves are waves," he said. "It was hard for me to imagine that something you could do with electromagnetic waves would be completely undoable for sound waves."

This time, he started instead from a shell like the microwave cloak his team had already devised and attempted to derive the mathematical specifications required to prevent such a shell from reflecting sound waves, a key characteristic for achieving invisibility. On paper, at least, it worked.

"We've now shown that both 2-D and 3-D acoustic cloaks theoretically do exist," Cummer said. Although the theory used to design such acoustic devices so far isn't as general as the one used to devise the microwave cloak, the finding nonetheless paves the way for other acoustic devices, for instance, those meant to bend or concentrate sound. "It opens up the door to make the physical shape of an object different from its acoustic shape," he said.

The existence of an acoustic cloaking solution also indicates that cloaks might possibly be built for other wave systems, Cummer said, including seismic waves that travel through the earth and the waves at the surface of the ocean.

Source: Duke University