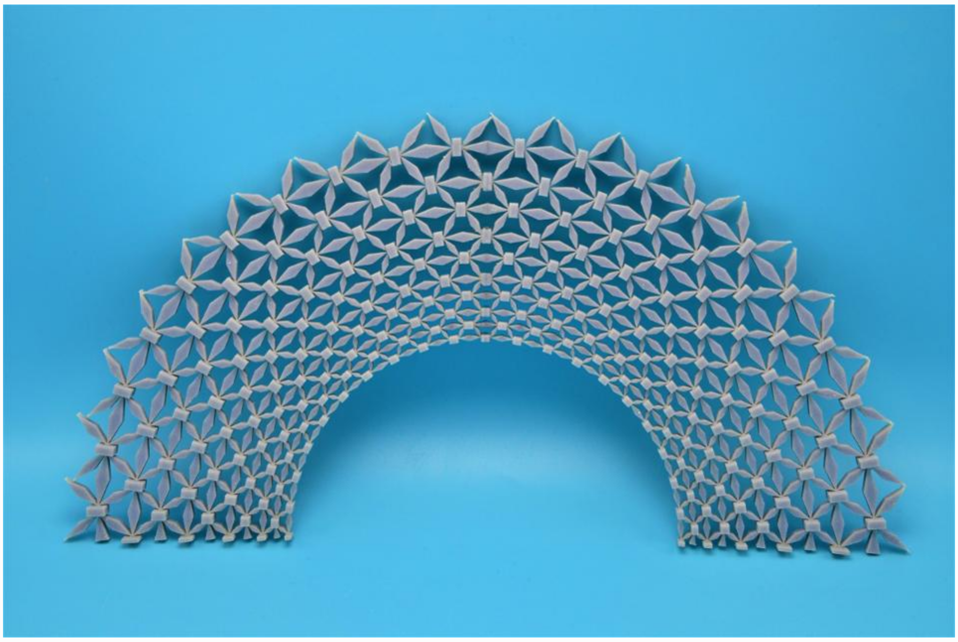
EDITORS' PICK | May 29, 2020, 12:14pm EDT

The Army Is Funding Research Into A Structural Cloak Of Invisibility To Protect Soldiers, Vehicles And More

Eric Tegler Contributor
Aerospace & Defense



This University of Missouri-developed structured lattice-type material protects against damage from ... [+] UNIVERSITY OF MISSOURI

Harry Potter acolytes are familiar with his special cloak, a magical artifact that renders the wearer invisible. But invisibility doesn't just apply to things you can't see. Noise that we are shielded from is effectively invisible, as are physical shocks that we don't feel.

The U.S. Army Research Laboratory (ARL) has taken an interest in research by the University of Missouri into crafting cloak-like structures that can steer mechanical wave energy around objects, protecting them from blasts, shockwaves, earthquakes or vibration. The structures aren't merely deflectors like armor. Instead, they have the potential to make a component, a submarine, or a bridge effectively invisible to mechanical energy.

The research is basic science at this point but it's promising enough that ARL is funding it for at least a year to come.

"We're interested in planting these seeds within the Army because we think there could be a lot of fascinating applications," says Dr. Dan Cole, a program manager at ARL's Army Research Office. "If you're able to cloak mechanical vibrations from different areas within a structure, that could have implications for soldier protection, vehicle protection, even autonomous vehicles."

How The Cloak Works

U.S. Army's New Drone Swarm May Be A Weapon Of Mass Destruction

The Turks Shot Down A Russian Bomber In 2015. Now Russia's Buying New Planes That Can Defend Themselves

Airline Summer Schedules Begin Thursday — United's Newark Hub Embodies The New Reality

Think of the term "cloak" as you might with stealth. The F-117, F-22 and F-35 all have special coatings to absorb radar waves, preventing them from bouncing back to a receiver, effectively making the airplanes invisible to radar. In this case the cloak isn't a thin absorptive coating.

Instead, a specially designed lattice-work structure which can conform to different shapes is draped over the structure that needs protection. The lattice design incorporates a complex combination of shapes, gaps, and curves - structural geometry that breaks the symmetry of the surface, steering mechanical waves around the object it cloaks.

"The idea is to [enclose] objects in this material," says Guoliang Huang, professor of mechanical and aerospace engineering at the University of Missouri. "If the object is cloaked, then a [mechanical] wave from any direction will be bent along this material passing around it, basically making the object invisible."

Essentially, it's an exercise in structural engineering Huang explains. There is no chemical or molecular manipulation of the material which for the purposes of lab experiments is a polymer. It could alternately be a metal or ceramic. The shaping is the key and you won't find it in nature. That makes it a "metamaterial."

The possibility of cloaking against light waves was examined in the late 1990s as was the concept of doing the same with acoustic waves. About 15 years ago, researchers extrapolated the idea to solid objects and mechanical waves. That led to interest in forms which mechanical energy didn't encounter in the physics of the natural world.

But rendering a solid invisible to mechanical energy is a bigger challenge, Huang says.

"A mechanical wave is much more complicated because it has multiple modes. We have longitudinal waves, we also have sheer waves – they simultaneously move forwards and backwards and side-to-side."

Guoliang Huang, Professor in the Mechanical and Aerospace Engineering Department at the University ... [+] UNIVERSITY OF MISSOURI

Dr. Huang asserts that his team's metamaterial design could be "a nearly perfect protective device." In addition to its conformal character it is potentially scale-able. In fact the professor affirms that he could cloak a one meter-sized object right now. Getting bigger than that would be an effort, he admits.

“If you want to [mechanically] cloak a submarine, then you need to cover its whole area. So far, it’s theoretically possible but it’s difficult to fabricate. We still have a lot of work to do.”

What To Cloak

Dan Cole calls the Missouri metamaterial “potentially foundational.” He came to his current post from ARL’s Vehicle Technology Directorate at Aberdeen Proving Ground. There, research discussions commonly centered on aerospace structures, on helicopters and fatigue life.

“We spend a lot time replacing components within those structures. If you can develop [material] that can shield or cloak mechanical vibration, even at particular frequencies, then you could potentially reduce fatigue damage to sensitive parts.”

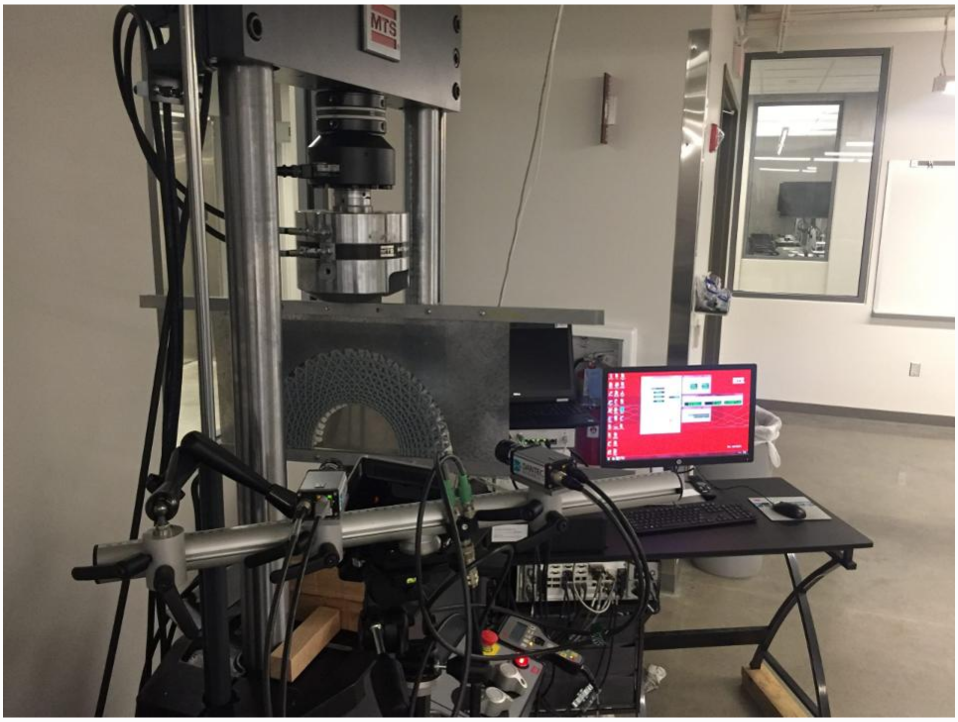
Dr. Huang says that’s possible. His team has investigated both active and passive cloaking, the former a broadband solution that covers all mechanical waves and the latter a tailored solution wherein the metamaterial can be tuned to protect structures (like components) from specific mechanical wave frequencies.

Cloaking smaller objects like components or pieces of soldier equipment - helmets, armor vests, boots, communications gear or weapons – would seem a logical early application for metamaterial once the science advances enough to get there. It could yield ancillary benefits as well.

“If designers could incorporate this lightweight lattice structure you could potentially make a vehicle lighter,” Cole says.

For larger systems like airplanes or ships, it may be enough to cloak select substructures to make the whole more tolerant to fatigue or battle damage.

“We can design the material to steer the wave, this mechanical energy, in a specific direction or position where we could then put damping material and the energy would be damped-out,” Huang offers.



Lab equipment used by MU researchers to refine and study lattice-type metamaterial structures. UNIVERSITY OF MISSOURI

The University of Missouri researchers have so far demonstrated their lattice-work structure’s effectiveness in protecting against two-dimensional mechanical waves (like those present in an earthquake). The next phase will look at the structure's efficacy against three-dimensional wave forms.

It's worth nothing that some of the co-authors of the cloaking study published in the journal of the American Physical Society are Chinese with at least one Chinese institution, the Dalian University of Technology, a public research university located in Dalian and Panjin in Liaoning province, China.

As to whether that's a concern, Army spokesman, Tom Moyer would only say, "Army sponsored basic research grants, as public assistance instruments of the Federal government, are not presently subject to restrictions on foreign participation in the sponsored research."

University of Missouri spokesman, Christian Basi, also points to the public grant process and adds that the research has been published in a publicly available peer review journal. "So this would not necessarily be looked at as being withheld for intellectual property reasons."

However he says that the University is "very aware" of academic espionage concerns and regularly discusses them with the FBI and other federal agencies.

As metamaterial research becomes applied research it will surely be done behind a Cloak of Invisibility.


Eric Tegler