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One of the ultracompact, lightweight coils engineered by BU researchers to wirelessly and passively enhance MRI imaging.



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MAKING MRI MORE GLOBALLY ACCESSIBLE

► Studies demonstrate how precisely engineered, low-cost structures can be used to boost the power and speed of medical imaging | BY KAT J. MCALPINE, PHOTOS BY JACKIE RICCIARDI

BY ALLOWING clinicians to look noninvasively inside the human body, magnetic resonance imaging (MRI) has become a medical mainstay. But not everyone has benefited equally: the most powerful modern MRI tech is typically bulky, rigid, and expensive, limiting its use and impact in low-resource and remote areas.

BU engineer Xin Zhang is leading a team that's working to democratize access to MRI, developing devices that can make scans faster, cheaper, and more accurate. To do it, they've turned to metamaterials—precisely engineered structures that use ordinary building blocks, such as copper, fabric, and plastic, to manipulate electromagnetic waves and radio frequencies.

Their work has led to a string of breakthrough devices that can sharpen and speed up MRI imaging of knees, ankles, spines, and other parts of the body. Each new metamaterials tool and method—from resonators that manipulate magnetic fields to wearable, jewelry-like bracelets that cut background noise—is capable of dramatically boosting the power of

MRI. The researchers have reported their findings in a series of recent journal articles.

"How can we improve MRI technology to enable clear imaging that's also affordable, accessible, and tolerable for patients?" says Zhang, a College of Engineering Distinguished Professor of Engineering. "This is a practical problem I've been interested in for a long time."

Zhang, who has studied the use of metamaterials in a range of fields, began focusing on their potential to improve medical imaging in 2016. Within a few years, she and her team had developed what she calls an "intelligent metamaterial" to speed up scans,



as well as a tunable helmet to channel an MRI machine's magnetic field to deliver clearer images of the brain and drastically cut scanning time.

In one of the latest papers, published in *Advanced Science*, they build on that work with computationally designed, wearable metamaterials that can be fitted to any part of the body. In the article, the researchers show examples of how the metamaterials could be used to improve scans of the ankle. Because they "readily conform to a patient's knee, ankle, head, or any part of the body in need of imaging...while ensuring an optimal resonance frequency," the researchers write, the new tech could facilitate "the widespread adoption of metamaterials in clinical MRI applications."

In their earlier work, the team was able to manually design the helmet to fit over the human head. But in the latest study, says Ke Wu (ENG'23), first author

The BU team's freestanding metamaterials could be used to enhance scans of a range of body areas, including wrists.

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of the paper and a postdoctoral fellow in Zhang's lab, "we recognized that free-form deployable metamaterials fitted to other parts of the body would require computational aid."

Wu developed algorithms and programs capable of analyzing a 3D scan of a part of the body and, within less than a second, calculating the geometry and arrangement of helical resonators—structures made of plastic and thin copper coils—that can manipulate the magnetic field of MRI. Critically, these arrays of coils help to improve the signal-to-noise ratio (SNR) of MRI of the target area, reducing the fuzziness of imaging that's caused when background electromagnetic signals seep into view.

In related work published in an *Advanced Materials* paper, Zhang's team demonstrated an alternative wearable metamaterial design for MRI that replaces copper and plastic coils with loops made from coaxial cables—the same cables used to bring you the internet. Coaxial cables are designed to transmit and shield high-frequency electrical signals from their surroundings, preventing unintended loss of signal. "This material has inherent advantages because it is lightweight,

flexible, and restricts the electrical field to exactly where you want it," says Xia Zhu (ENG'26), first author of the paper.

Zhu created fabric-based wearable metamaterials—each using only about \$50 of supplies—designed to bring loops of coaxial cables as close as possible to the part of the body undergoing a scan. In the paper, the team illustrates a potential knee scan: a pad of lightweight fabric, covered with a handful of coils, bending to the curve of the patient's leg as they lie in the MRI machine.

Pushing even further, the team sought to develop an entirely wireless, formfitting wearable metamaterial that could boost SNR and passively tune and amplify the MRI signal.

In a paper published in *Science Advances*, Zhang's team demonstrated that the coaxial cables can be arranged into freestanding cuffs without additional support materials—no fabric needed. They prototyped rings and cuffs sized to enhance MRI scans of the spine, the wrist, and a single finger—and in every experiment proved their seemingly simple design could amplify SNR and enable crisp MRI.

A STARTLING DISCOVERY IN THE DEEP SEA

► Rocks are generating oxygen in the dark, raising questions about extraterrestrial life

BY JESSICA COLAROSS

MORE THAN 12,000 feet below the surface of the Pacific Ocean, in a region known as the Clarion-Clipperton Zone, million-year-old rocks cover the seafloor. These rocks, known as polymetallic nodules, seem lifeless. But nestled among the nooks and crannies on their surfaces are tiny sea creatures and microbes, many uniquely adapted to life in the dark. A team of scientists that includes BU experts has discovered these deep-sea rocks are also producing oxygen.

The discovery is a surprise, considering oxygen is typically created by plants and organisms with help from the sun. About half of all the oxygen we breathe is made near the surface of the ocean by phytoplankton that photosynthesize just like land-dwelling plants. Since the sun is needed to carry out photosynthesis, finding oxygen production at the bottom of the sea—where there is no light—flips conventional wisdom on its head. The discovery was so unexpected that scientists involved in the study first thought it was a mistake.

"This was really weird, because no one had ever seen it before," says Jeffrey Marlow, a College of Arts & Sciences assistant professor of biology.

As an expert in microbes that live in the most extreme habitats

Zhang says this thin, lightweight, and flexible metamaterial, embedded in textile, ensures a comfortable and unrestricted MRI experience. By manipulating the magnetic field of MRI, the tech can improve the quality of scans.

