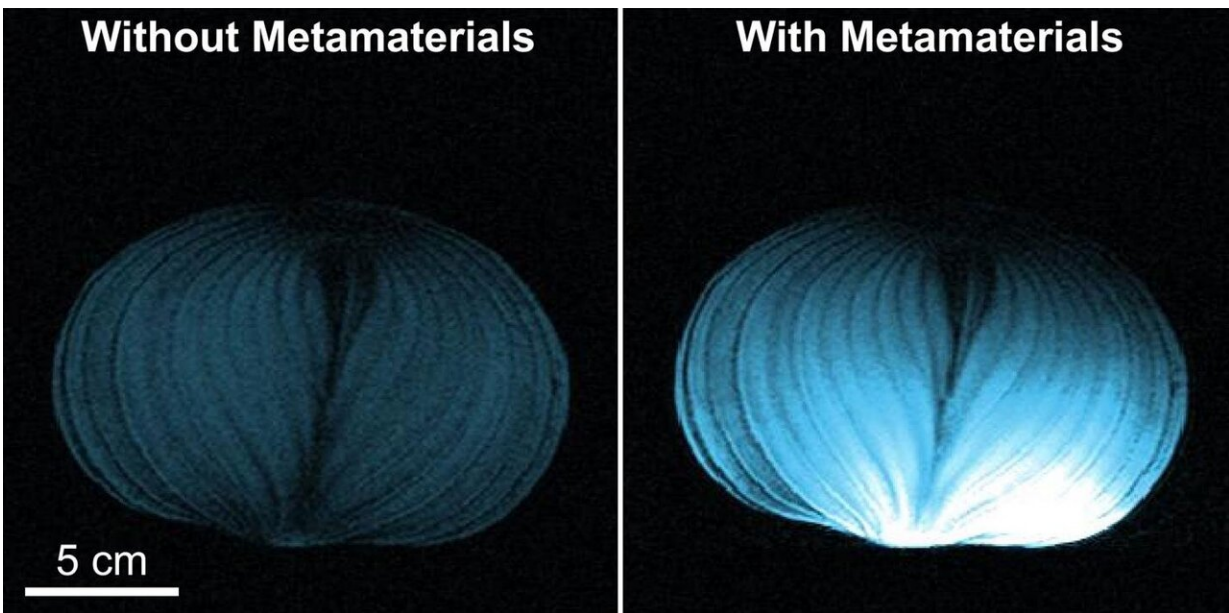


Researchers design 'intelligent' metamaterial to make MRIs affordable and accessible

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Two MRI images of an onion: the image on the right shows enhancement produced by an intelligent metamaterial developed by Xin Zhang and colleagues. Image courtesy of Zhang et al. Credit: Zhang et al.

Boston University researchers have developed a new, "intelligent" metamaterial—which costs less than ten bucks to build—that could revolutionize magnetic resonance imaging (MRI), making the entire MRI process faster, safer, and more accessible to patients around the world. The technology, which builds on previous metamaterial work by

the team, was described in a new paper in *Advanced Materials*.

MRI is used by clinicians to diagnose [medical problems](#) by spotting abnormalities that could indicate anything from a torn meniscus to muscular dystrophy. But MRIs are expensive and take a long time—often the greater part of an hour for a single scan. Finding enough MRI time for waiting patients can be a problem, even in US hospitals, but in hospitals in countries like India, waiting periods of a year or more can put patients' lives at risk.

So how do we speed up the MRI process without jeopardizing the quality of imaging? Xin Zhang, a BU College of Engineering professor of mechanical engineering and a Photonics Center professor, and a team of researchers that includes Stephan Anderson, a Boston Medical Center radiologist and BU School of Medicine professor of radiology, and Xiaoguang Zhao, a MED assistant research professor of radiology, are getting creative with metamaterials to solve the problem.

MRI works by generating a powerful magnetic field and sending [radio](#) waves into a patient's body. "An MRI's magnetic field is many thousands of times stronger than the Earth's magnetic field," says Zhao. "A precisely orchestrated series of higher-energy radio waves are sent into the human body, and the tissues emit lower-energy radio waves that are received by the MRI to produce an image."

The quality of MRI images depends to a great extent on what's called "signal-to-noise ratio," or SNR. The higher the SNR, the better the image, and the most direct way to improve the SNR is to turn up the magnetic field. Unfortunately, any increase in the magnetic field also increases complexity and cost of the MRI, as well as potential risks to patients, whose tissue, and particularly, whose implanted medical devices, are literally heated up by the radiation. For that reason, radiologists who would like to get a better look inside a body cannot

simply turn up the magnetic field strength.

So Zhang and her collaborators developed a new magnetic metamaterial that, when placed beside the body part that is the target of a scan, boosts the energy emitted by the patient's body, increasing SNR and improving MRI imaging. The magnetic metamaterial, which is made of simple copper wiring and plastic, was published in March 2019 in *Nature's Communications Physics*.

Now, Zhang, Anderson, Zhao, and other team members have taken their development one big step further, developing what they call an "intelligent" metamaterial that selectively boosts the low-energy emissions from the patient's body, and literally turns itself off during the millisecond bursts of high-energy transmission from the machine.

Zhang says that the intelligent metamaterial amplifies SNR by 10-fold, which greatly enhances image quality and reduces scan time, opening up a new way to obtain crisper MRI images at very low cost.

"Shortening MRI examinations is paramount to maximizing the capacity," says Anderson. "Not to mention revenue, as well as the overall patient experience of this powerful imaging technology."

"The intelligent metamaterial consists of an array of metallic helical resonators closely packed with [a passive sensor]," says Zhao. "When the high-energy radio waves are coming in, the metamaterial detects the high energy level and 'turns off' the resonance automatically. With low-energy radio excitation, the metamaterial [turns on] the resonance and enhances the magnetic component of the radio wave."

That off-time, while only milliseconds long, allows clinicians to use the intelligent metamaterial to enhance the energy sent back to the MRI. It also diminishes the patient's overall exposure to radio wave radiation and

mitigates potential safety concerns, easing the path toward adoption of this technology in clinical imaging.

"We can now build smart materials that can interact with [radio waves](#) intelligently, enhancing the wanted signal while letting the unwanted signal go," says Zhang.

The researchers estimate that the metamaterial array, developed with the support of the National Institute of Biomedical Imaging and Bioengineering, should cost less than \$10 to construct. Even though the current magnetic metamaterial prototype is a flat, thick layer, they expect to adapt it to a flexible, ultra-thin MRI enhancement sheet. Integrated with clinical MRI systems, they say, their newly discovered magnetic [metamaterials](#) have the potential to usher in a quantum leap in the performance of MRI.

More information: Xiaoguang Zhao et al, Intelligent Metamaterials Based on Nonlinearity for Magnetic Resonance Imaging, *Advanced Materials* (2019). [DOI: 10.1002/adma.201905461](https://doi.org/10.1002/adma.201905461)

Guangwu Duan et al. Boosting magnetic resonance imaging signal-to-noise ratio using magnetic metamaterials, *Communications Physics* (2019). [DOI: 10.1038/s42005-019-0135-7](https://doi.org/10.1038/s42005-019-0135-7)

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