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https://www.gesundheitsindustrie-bw.de/en/article/press-release/new-technique-could-make-mri-more-precise

New technique could make MRI more precise

A team of researchers at the University of Stuttgart has developed a new method that could make MRI even more precise by eliminating "dead time," a key limiting factor in the measurement process, thereby enabling the detection of signals that are lost using conventional methods. This method opens up new possibilities for medical diagnostics and non-destructive materials testing. The research team presents the new approach in Science Advances.

Setting dead time to zero

"You can think of the dead time as a brief blind spot during imaging," says Prof. Jens Anders, director of the Institute of Smart Sensors (IIS) at the University of Stuttgart. "We're dealing with very short time frames here. But those are precisely what matter," says Anders. During this short period, the MRI receiver channel is not yet sensitive enough to detect weak signals, which may be lost if they decay too quickly after the excitation pulses required for MRI. Anders and his team are therefore taking a different approach. Instead of quickly switching back and forth between transmission and reception, their method allows for simultaneous excitation and detection. "To do that, you have to understand how and what is measured during an MRI scan," says Anders.

Signal processing in MRI

Magnetic resonance imaging uses the magnetic properties of nuclear spins such as those of protons in water molecules. "To put it simply, you can think of the proton spins as tiny bar magnets," says Anders. Without an external magnetic field, they are disordered. As soon as they are exposed to a magnetic field, they align with the field.

A radiofrequency pulse excites the protons and moves their spins out of equilibrium so that the spins can be measured. After the pulse, the spins gradually return to their equilibrium state. In the process, the spins induce an electrical signal in the MRI receive coil; this signal decays at different rates depending on the tissue. Measurements immediately following excitation are particularly difficult with conventional systems because of the dead time. This is precisely where Anders and his team come in.

Paradigm shift: simultaneous excitation and measurement

"During the excitation pulse, a large amount of electromagnetic energy is stored in the resonant circuit of the receive coil. By comparison, the actual spin signal is minuscule. In conventional systems, this energy must first decay before the weak spin signal can be measured again," says Michal Kern, Group Leader at the IIS and co-author of the paper. "With our approach, we don't wait for it but rather shift the energy to a different frequency. This process is many orders of magnitude faster and even allows for detection during the excitation pulse. We demonstrated that this results in virtually no dead time during the measurement," says Anders.

From the laboratory to practical application

This method offers a decisive advantage for imaging tissues with very rapidly decaying spin responses (e.g., lung tissue). With conventional measurement methods, signals like these can be lost during the dead time. In collaboration with Ulm University Hospital, the researchers are refining their approach for medical applications.

Together with Charité in Berlin and the Helmholtz-Zentrum Berlin Anders and his team are testing their method for electron paramagnetic resonance (EPR). The signals measured in this process decay much more rapidly and can therefore be detected only to a limited extent using conventional methods. The goal is to explore new possibilities for the diagnosis and treatment of skin cancer. "The basic concept behind this process is patented and offers potential for a future spin-off," says Prof. Klaus Lips, a co-author at HZB.

Using EPR, researchers can investigate how many free radicals are present in a blood sample and track how quickly they are broken down, providing insight into underlying disease processes. Materials research can also benefit from the new measurement method, which the Materials Testing Institute (MPA; Materialprüfungsanstalt) at the University of Stuttgart is currently using to investigate the porosity of materials.

The method could also be used outside laboratories and workshops (e.g., for safety inspections of highway bridges). As part of the Q NOVA project, funded through the Quantum^{BW} Innovation Campus, Anders and his team are further developing the measurement method described in the paper and working to adapt the technology for use in compact and cost-effective systems for practical applications.

Publication:

Zhibin Zhao, Michal Kern, Weiyi Zhang, Qing Yang, Katja Drerup, Felix Schuderer, Samuel Wazynski, Bernhard Blümich, Klaus Lips, Klaus Scheffler, Jens Anders: *Concurrent excitation and detection in magnetic resonance using voltage-controlled oscillators,* Science Advances
DOI: 10.1126/sciadv.aeg6581

Press release

17-Sept-2026
Source: University of Stuttgart

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