Laser-driven MRI scanner promises portability

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Magnetic resonance imaging no longer requires a roomful of equipment - including superconducting magnets that must be cooled to extreme temperatures.

A multidisciplinary team from Lawrence Berkeley National Laboratory in California, and the University of California, Berkeley, both in the US, have developed a highly sensitive laser detector that produces magnetic resonance images at room temperature using low-power, off-the-shelf magnets.

MRI works by measuring minute magnetic signals from atomic nuclei whose "spins" have been aligned using external magnetic fields. As different atoms react differently, this provides a unique way to image tissue inside the human body or analyse many other materials.

However, conventional MRI scanners use induction coils with limited sensitivity to pick up magnetic signals. This requires powerful magnetic fields that must be generated using costly, cryogenically cooled superconducting magnets.

Atomic alignment

Dmitry Budker, and colleagues in the physics department at the University of California, provided part of an alternative solution by developing a radically different detector. It uses polarised laser light to align rubidium atoms in a vapour.

The atomic alignment changes in response to faint magnetic signals and the same laser can measure these slight changes. This means much less powerful magnets can be used to align atomic nuclei for imaging. "It's a particularly simple technique," Budker says. "All we deal with are laser beams, which are easy to manipulate and detect."

The team's so-called "magneto-optical detector" is nearly as sensitive as a superconducting quantum interference device (SQUID), which uses quantum-tunnelling effects to detect magnetic fields. But SQUIDs, like conventional MRI scanners, require ultra-low temperatures. "Our detector is basically a room-temperature technology," Budker says.

A team led by Berkeley chemist Alexander Pines produced a second key innovation, by developing a means of encoding and detecting the magnetic signal in separate locations. In an experimental set-up, water flowing through a tube was exposed to a magnetic field at one point. The magnetic signals from atomic nuclei in the water were then measured approximately a second later using the laser detector at another point. Separating these processes makes it possible to improve the sensitivity of the detector further. "That has orders-of-magnitude advantages," Pines adds.

Handheld devices

Postdoctoral researcher Shoujun Xu led a group that then integrated the two innovations, building a table-top machine capable of producing room-temperature magnetic resonance images. "We got rid of the cryogenics," Xu told **New Scientist**. "That's important because superconducting magnets cost millions of dollars."

Both Xu and Pines say the apparatus could be scaled down to handheld size and he envisions further miniaturisation, for use in a microfluidic system incorporating a laser detector. The team foresees various applications, from imaging minerals and fluids to biochemical and medical analysis.

Michael Romalis, an atomic physicist at Princeton University in New Jersey, US, applauds the team's work. "The really exciting thing is that it combines optical magnetometry and remote nuclear magnetic resonance," he says. "It opens the possibility of making something very portable and simple for many applications."

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