Joint press release of the German Consortium for Translational Cancer Research and Freiburg University Hospital

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Nuclear magnetic resonance without expensive magnets

Nuclear magnetic resonance spectroscopy and imaging (MRI) have become indispensable in modern medical diagnosis and treatment. Yet despite the advanced nature of this technology, it is very expensive and has thus reached only a fraction of its potential. Now an international, interdisciplinary research team headed by medical physicist Dr. Jan-Bernd Hövener of a partnering site of the German Consortium for Translational Cancer Research (DKTK) of Medical Physics in Freiburg has succeeded in developing a novel, low-cost MRI method called continuous hyperpolarization. It facilitates obtaining high-resolution magnetic resonance images in low magnetic fields produced by small magnetic coils. This may be a crucial step toward making special MRI applications available in the future even for mobile and remote use. The scientists' work appears in the renowned journal "Nature Communications."

Magnetic resonance imaging (MRI) is a method that is typically used to produce cross-section pictures of structures in the body's soft tissues, such as organs. When exposed to a strong, artificially produced magnetic field, some of the hydrogen atoms in body tissues line up in a parallel state; when they are then exposed to radio frequency waves, they begin to oscillate. Depending on the structure and water content of the tissue under investigation, the hydrogen atoms that have thus been excited emit different signals; these are used to create a cross-section image through computational methods. The hydrogen atoms subsequently return to their original, unordered state. Due to the properties of tissues and atoms, the conventional technique can align and quantify only a very small portion of the hydrogen atoms – one in seven billion. The remaining atoms are invisible in MRI. Clinical MRI systems use very expensive special magnets to generate a magnetic field that is 100,000 times stronger and thus increases the alignment of hydrogen atoms, but this still produces an imagine of a few out of every million hydrogen atoms. More than 99,999 % remain invisible in MRI scans.

This prompted Hövener and his colleagues from the University Radiological Hospital in Freiburg, Germany, to take a different approach to enhancing the MRI signal. They used a method called hyperpolarization, which causes a magnetic alignment of a much greater proportion of the hydrogen atoms. The method also overcomes problems of previous attempts to employ hyperpolarization, namely that each atom could be polarized only once. The MR image itself destroys its alignment, making it impossible to obtain multiple images. To avoid this problem, the researchers from Freiburg and their colleagues from the Centre for Hyperpolarisation in York, U.K., used a form of hydrogen called parahydrogen, whose nuclei are in a specific quantum state. Parahydrogen can magnetically align other molecules by means of a chemical reaction; it can do so over and over in an appropriate magnetic field. This continuous polarization effect, based on previous work by researchers from York and Freiburg, is available for an unlimited time; it recovers after every measurement and thus facilitates repeated MR images. The signal thus emitted is 100 times stronger than in current MRI systems, even in a very low magnetic field, as can be produced, for example, using a simple battery.

“It is exciting to investigate this novel physical effect,” says Hövener, who undertakes research at the Medical Physics Department of Diagnostic Radiology at the University Medical Center Freiburg and is a member of the German Consortium for Translational Cancer Research. He foresees numerous applications in chemistry and molecular biology. So far the scientists’ experiments have been restricted to the test tube, but tests in cell cultures and animal models will be the next step. As a long-term goal, Hövener hopes to exploit continuous hyperpolarization in biomedical research: “Hydrogen gas seems to be well tolerated by humans. Medical diagnosis may benefit tremendously from its use, but it is still a long way to get there.” He thinks that possible applications in the future may include low-cost MRI systems to be used in medical screening as well as portable MRI scanners for on-site diagnoses.

Hövener J.-B., Schwaderlapp N., Lickert T., Duckett S.B., Mewis R.E., Highton L.A.R., Kenny S.M., Green G.G.R., Leibfritz D., Korvink J.G., Hennig J., von Elverfeldt D. A hyperpolarized equilibrium for magnetic resonance. Nature Communications, 2013.doi: 10.1038/ncomms3946

In the German Consortium for Translational Cancer Research (DKTK), the German Cancer Research Center (DKFZ) joins up with university hospitals all over Germany. Assembled around a core at the DKFZ in Heidelberg, the consortium unites twenty high-ranked institutes from seven partner sites: Berlin, Dresden, Essen/Dusseldorf, Frankfurt/Mainz, Freiburg, Munich and Tubingen, all specialized in research and treatment focused on oncological diseases. The DKTK was founded to promote translational research, bringing together scientists, physicians and associates to work jointly toward the main goal of enhancing the translation of research from bench to bedside. New approaches in prevention, diagnostics and treatment will be applied to cancer in common translational centers at all partner sites. Patients will be recruited at all partner sites for innovative studies to be carried out by the consortium as a whole. All the data from this work will be collected in a universal system. The harmonization of techniques and methods used in laboratories will ensure identical standards for all researchers and physicians in the consortium. A joint infrastructure will make them available for joint research. With the school of oncology, the consortium is additionally dedicating itself to the education of new physicians and scientists. Talented young people will be trained in cancer medicine and translational cancer research in a common effort involving all members. The German Consortium for Translational Cancer Research is a joint initiative of the Federal Ministry of Education and Research, the participating German states, German Cancer Aid and the German Cancer Research Center. It is one of the six German Centers for Health Research (DZG).

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