MRI machine at the nanoscale breaks world records

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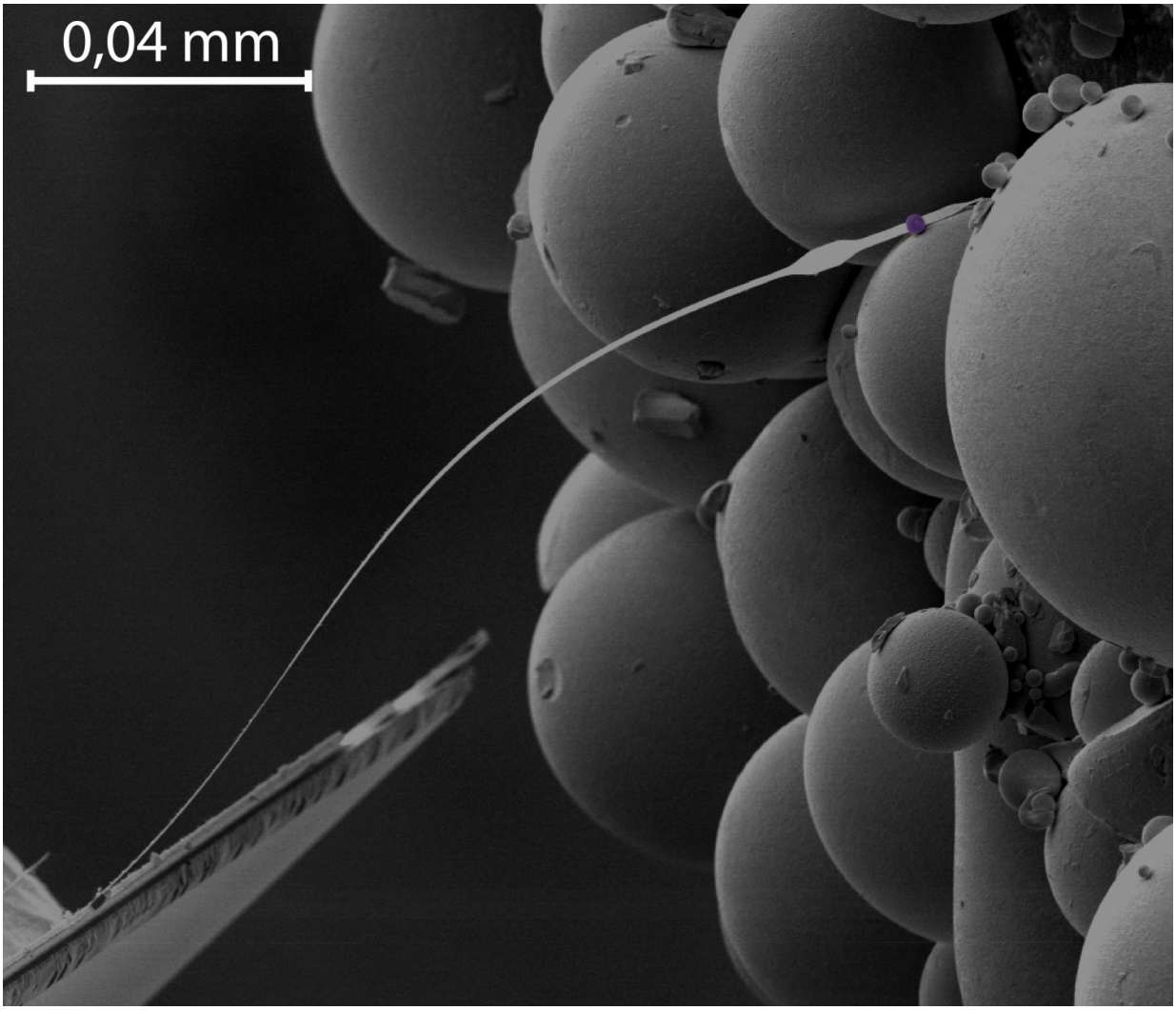

NMR microscope, consisting of a thin wire and a small magnetic ball (fake colour purple). The purple ball induces a uniform magnetic field, so that the surrounding atomic nuclei all line up with their axis pointing in the same

direction. The researchers send radio waves through their sample, causing some nuclei to flip the other way, and measure how long it takes before they flip back again. Credit: Leiden Institute of Physics

A new nuclear magnetic resonance (NMR) microscope gives researchers an improved instrument to study fundamental physical processes. It also offers new possibilities for medical science—for example, to better study proteins in Alzheimer's patients' brains. The development has been reported in *Physical Review Applied*.

If you get a knee injury, physicians use an MRI machine to look into the joint and determine the problem. The body's atomic nuclei are electrically charged and spin around their axis. Just like small electromagnets, they induce their own magnetic field. By placing the knee in a uniform magnetic field, the nuclei line up with their axis, pointing in the same direction. The MRI machine then sends specific radio waves through the knee, causing some axes to flip. After terminating this signal, those nuclei flip back under excitation of a small radio wave. Those waves reveal the atoms' location, and provide physicians with an accurate image of the knee.

MRI is the medical application of NMR, which is based on the same principle and was invented by physicists to conduct fundamental research on materials. One of the things they study with NMR is the so-called relaxation time. This is the time scale at which the nuclei flip back and it gives a lot of information about a material's properties.

Microscope

To study materials on the smallest of scales, physicists have developed NMR microscopes, with which they study the mechanics behind physical

processes at the level of a group of atoms. Now, Leiden Ph.D. students Jelmer Wagenaar and Arthur de Haan have built an NMR microscope, together with principal investigator Tjerk Oosterkamp, that operates at a record temperature of 42 milliKelvin—close to absolute zero. In their research reported in *Physical Review Applied*, they tested the technology by measuring the relaxation time of copper, and achieved a thousand times higher sensitivity than existing NMR microscopes—also a world record.

Alzheimer's

The microscope provides physicists the means to conduct fundamental research on many physical phenomena, like systems displaying strange behavior in extreme cold. And as NMR eventually led to MRI machines in hospitals, NMR microscopes have great potential too. Wagenaar says, "One example is that you might be able to use our technique to study Alzheimer's patients' brains at the molecular level, in order to find out how iron is locked up in proteins."

More information: Probing the nuclear spin-lattice relaxation time at the nanoscale, J. J. T. Wagenaar, A. M. J. den Haan, J. M. de Voogd, L. Bossoni, T. A. de Jong, M. de Wit, K. M. Bastiaans, D. J. Thoen, A. Endo, T. M. Klapwijk, J. Zaanen and T.H. Oosterkamp, *Physical Review Applied* arxiv.org/abs/1603.04238

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