Universität Stuttgart

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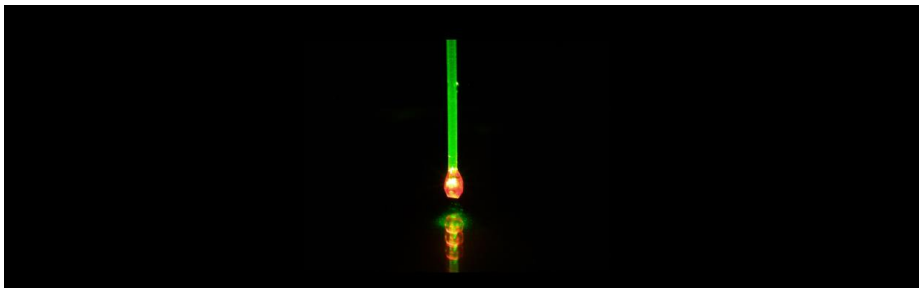
Sharper images in magnetic resonance tomography

Diamonds detect the magnetic fingerprint of molecules

Molecules reveal themselves by their magnetic fingerprint. This is exploited in magnetic resonance tomography, which is widespread in medicine. Due to the magnetic field of nuclear spins, images of the body can be generated, or the composition of molecules can be determined. Until now, a large sample volume was required, preventing details from being observed on a scale below one millimeter. A team, lead by Prof. Jörg Wrachtrup from the University of Stuttgart, used atomic scale quantum sensors and achieved detection of molecular signatures with a trillion times better sensitivity. The renowned journal SCIENCE is reporting about the results in their recent edition.

Conventional sensors are too large in order to detect the magnetic resonance signal from small volumes. The sizes of single molecules, like proteins, are on the nanometer scale. Hence, they cannot be investigated by the aforementioned method. Quantum sensors in diamond,



Diamond illuminated with green laser light. Due to the fluorescence light of the quantum sensors in diamond, it appears red. Photo: University of Stuttgart/ PI3

based on single electron spins, offer a solution. Because of their atomic size, they can be brought a few nanometers close to the molecules and

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thereby increase the sensitivity, enabling the detection of even the smallest molecules. In previous studies, the group from Stuttgart and an American team (H. Jonathon Mamin et. al IBM, Almaden Research Center) managed to detect nuclear spin signal on the nanometer scale. For real applications, the measurements were not sufficient as they did not capture the slightly different resonance frequencies arising from internal interactions of the molecules.

The quantum sensor in diamond could be developed further: With the ten thousand times larger frequency resolution, the composition of two liquids could be investigated on the molecular scale. The researchers added a quantum memory to the quantum sensor allowing them to differentiate between the signatures of different molecules.

Until now the properties had to be deduced from averaged fingerprints of many molecules. The novel sensor however permits even the detection of single molecules, e.g. proteins, and the investigation of their dynamics. The resolution of the magnetic resonance tomography could be improved, and potentially be applied to early diagnosis of cancerous tumors. In addition to this, quantum sensors in diamond could play a key role in miniaturizing Nuclear Magnetic Resonance (NMR) spectrometers and reduce their cost considerably.

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