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Nanoscale MRI of electron spins at millikelvin temperatures

GEERT WIJTS, ANDREA VINANTE, OLEKSANDR USENKO, ARTHUR DEN HAAN, LAURENS SCHINKELSHOEK, TJERK OOSTERKAMP, Leiden University — Magnetic Resonance Imaging by Atomic Force Microscopy (MRI-AFM) combines the non-destructive subsurface sensitivity of an MRI scanner with the high spatial resolution of an Atomic Force Microscope. It is a powerful technique to detect a small number of spins that relies on force detection by an ultrasoft, magnetically tipped cantilever and selective magnetic resonance manipulation of the spins. In order to minimize the thermomechanical noise of the cantilever and to increase spin polarization, MRI-AFM should be carried out at ultralow temperatures. Therefore, we developed a SQUID-based detection technique, which avoids heating of the cantilever and the spin sample. Using this technique, we demonstrate the manipulation and detection of dangling bond paramagnetic centers on a silicon surface at temperatures as low as 30 millikelvin. The fluctuations of these unpaired electron spins are supposedly linked to $1/f$ magnetic noise and decoherence in SQUIDs as well as in several superconducting and single spin qubits. We find evidence that spin diffusion plays a key role in the dynamics of spins at low temperatures.

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