Magnetometry of Single-Molecule Magnets Using Industrial Silicon-Based Spin Qubits

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Silicon-based spin qubits are a promising platform for quantum computing and nanoscale sensing due to their long coherence times and scalability within semiconductor technology.
Here we explore the application of a silicon spin qubit as a quantum magnetometer for detecting the magnetic properties of single-molecule magnets (SMMs), specifically terbium-phthalocyanine (TbPc2). These SMMs provide great potential for the implementation of quantum digits [1].
Characterizing the silicon spin qubit, we demonstrate relaxation times of 394ms and coherence times T_2* of 3.1µs. By employing the novel technique of simultaneous spin-readout and manipulation by rapid adiabatic passage, we track shifts in the qubit's resonance frequency induced by the local magnetic dipole fields of TbPc2. Our results reveal a magnetic hysteresis shift of 35 MHz along the easy axis of the SMM and an angular-dependent resonance shift confirming the anisotropy of the TbPc2 crystal. Additionally, we observe a thermal relaxation time of 107 min at 48mK, highlighting slow magnetic switching dynamics.
These findings establish silicon spin qubits as effective quantum sensors for magnetic sensing applications.

References

[1] C. Godfrin et al, PRL 119, 187702-1 (2017)

Figures

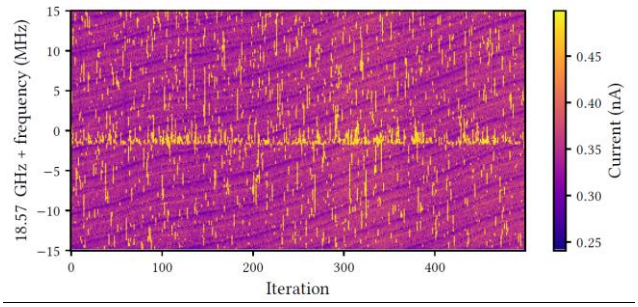

Figure 1: Single-shot measurements of the novel continuous spin-readout and RF manipulation. The applied frequency chirp is mapped onto a 150ms time trace. The measurement is displayed along the y-axis, where blips appear as high-current events (yellow), indicating a clear resonant signal due to rapid adiabatic passage. Randomly distributed blips are primarily attributed to thermal excitation of the electron spin.

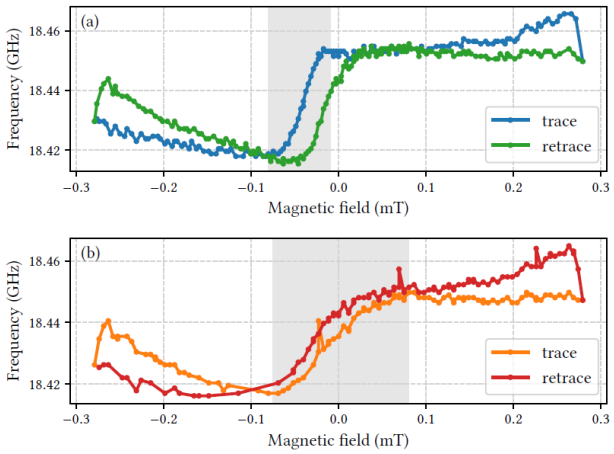

Figure 2: Frequency shift as a function of the applied magnetic field along the easy axis of the SMM. Each data point corresponds to 50 single-shot measurements. The trace shows the forward and backward (retrace) direction. The data tracks the resonance shift induced by the TbPc2 crystal for 48mK (upper panel) and 210mK (lower panel).