A New Approach for Atomic Scale Spin Detection using a Diamond-based Scanning Probe Sensor

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Scanning tunneling (STM) and atomic force microscopy (AFM) are powerful tools for the investigation of magnetism at the atomic and molecular scale [1, 2]. While these techniques have shown resolutions down to single spin detection, they have fundamental limits. In STM experiments the resolution is limited by the energy broadening of the tunneling electrons due to their fermionic nature putting the needs for increased sensitivity to very low temperatures. In AFM experiments the detection of the tiny magnetic exchange interaction require more and more arduous to handle soft cantilevers.

Here now a new approach using a nitrogen-vacancy (NV) color center in diamond might overcome these boundaries. The NV center is one of the few solid-state systems where the spin state can be optically measured and manipulated [3]. By attaching a nanodiamond containing this "probe spin" to the tip of a non-contact AFM the controlled coupling between the NV and nearby spins on the sample can be achieved, allowing an indirect observation of these spins via the fluorescence signal from the NV [4]. This approach provides an unprecedented sensitivity by exploiting the quantum nature of the NV spin, enabling the coherent manipulation by pulsed detection schemes well known from EPR- and NMR-spectroscopy. In this case the sensitivity is limited by the coherence time of the NV, which exceeds 1ms in pure diamond [5]. This corresponds to an energy resolution on the order of peV.

We report on our efforts developing such a Scanning Probe Spin Sensor and present details of the experimental setup along with first experimental data.

References

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