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Quantum sensor-enabled optical magnetic resonance microscopy

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Abstract

Nitrogen vacancy (NV) centers in diamond have emerged as a promising platform for nano- and microscale sensing. In my talk, I will demonstrate the capability of NV centers for microscale NMR microscopy. Unlike conventional magnetic resonance imaging (MRI), which typically relies on k-space sampling and magnetic field gradients for spatial encoding of nuclear magnetic resonance (NMR) signals, NV centers can directly translate local NMR signals into an optical signal.

In the first approach, we use a camera that enables real-space NMR imaging with micron-scale spatial resolution over a wide field of view. This novel optical NMR microscopy technique is capable of imaging NMR signals within a model microstructure, achieving a spatial resolution of approximately 10 μm over a field of view of $235 \times 150\ \mu m^2$. Each camera pixel captures a full NMR spectrum, providing comprehensive data on signal amplitude, phase, and local magnetic field gradients. [1]
In the second part of my talk, I will present a novel NV-readout scheme where we use a fast scanning laser spot to cancel common noise and enable few-pixel imaging without the need for a camera. [2]

The integration of optical microscopy with NMR opens new avenues for diverse applications in the physical and life sciences, such as imaging water and metabolic processes in single cells or tissue samples, studying battery

materials, or facilitating high-throughput NMR analysis.

[1] K. D. Briegel, N. R. von Grafenstein*, J. C. Draeger*, P. Blümler, R. D. Allert, D. B. Bucher. Optical Widefield Nuclear Magnetic Resonance Microscopy. https://arxiv.org/abs/2402.18239

[2] J. P. Leibold*, N. R. von Grafenstein*, X. Chen, L. Müller, K. D. Briegel, and D. B. Bucher. Time-space encoded readout for noise suppression and scalable scanning in optically active solid-state spin systems. https://doi.org/10.48550/arXiv.2408.14894