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Spin resonance spectroscopy with a transmission electron microscope

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- **Introduction**

Coherent spin resonance methods such as nuclear magnetic resonance and electron spin resonance spectroscopy have led to spectrally highly sensitive, non-invasive quantum imaging techniques. However, despite their spectral sensitivity, these techniques are limited in spatial resolution.

- **Objectives & methods**

Here, I will present a spin resonance spectroscopy approach developed for transmission electron microscopy [1,2] and will explain different techniques to sense with electrons for microwave manipulated spin states of the sample. Our approach utilizes microwave excitation at GHz frequencies, while employing the free-space electron beam as a signal receiver to sense spin precession [1]. Spin state polarization is achieved via the magnetic field of the TEM's polepiece, while a custom-designed microresonator (microwave antenna) integrated into a TEM sample holder drives spin transitions [2].

- **Results and Conclusion**

This could enable state-selective observation of spin dynamics on the nanoscale and indirect measurement of the environment of the spin systems, providing information on, for example, atomic structure, local chemical composition and neighbouring spins.

[1] P. Haslinger, S. Nimmrichter, and D. Rätzel, *Spin Resonance Spectroscopy with an Electron Microscope*, Quantum Sci. Technol. **9**, 035051 (2024).

[2] A. Jaroš, J. Toyfl, A. Pupić, B. Czasch, G. Boero, I. C. Bicket, and P. Haslinger, *Electron Spin Resonance Spectroscopy in a Transmission Electron Microscope*, arXiv:2408.16492 1 (2024).