Absorption SERF magnetometer for zero- and ultra-low-field nuclear magnetic resonance

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Zero- and ultra-low-field (ZULF) nuclear magnetic resonance (NMR) is a rapidly developing new incarnation of NMR. Observation of nuclear spins at ZULF enables research ranging from chemical analysis and medical imaging to searches for exotic physics. However, studies of spin dynamics at fields below 100 nT require an alternative to conventional pick-up coils. Due to their performance, optically-pumped magnetometers are the best solution overall.

Building the state-of-art magnetometer for ZULF NMR detection often seems to be beyond the capabilities of NMR groups. Herein, we present a lean and efficient ZULF NMR setup using a single-beam rubidium magnetometer based on measuring transmitted light intensity. Despite its simplicity, our setup can produce higher resolution ZULF NMR spectra than setups [1, 2] using QuSpin, a high-end commercial magnetometer. We demonstrate our setup performance by showing improved resolution of formic acid and pyridine spectra in comparison to previous works [1, 2, 3]. Common technical problems, their solutions, and the semi-automatic approach to optimization of the system are discussed.

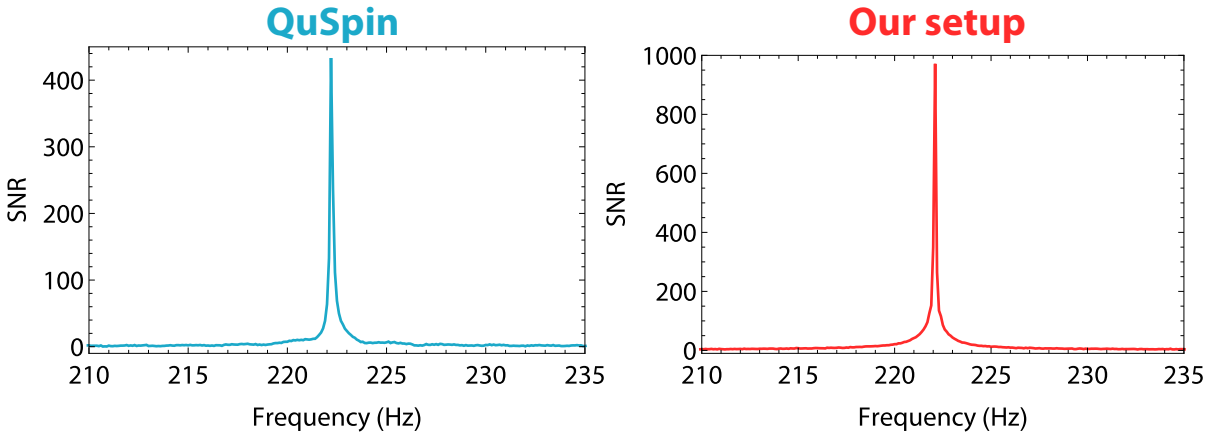

Figure 1. ZULF spectra measured with QuSpin [2] and our magnetometer.

[1] J. Blanchard, W. Teng, J. Eills, Y. hu, and D. Budker. Zero- to Ultralow-Field Nuclear Magnetic Resonance J-Spectroscopy with Commercial Atomic Magnetometers. Journal of Magnetic Resonance. **314:106723** (2020).

[2] P. Put, S. Pustelny, D. Budker, E. Druga, A. Pines, and D. Barskiy, High-resolution NMR Chemosensing Using Portable Zero-field Spectrometer (manuscript in preparation)

[3] T. Theis, M. Ledbetter, G. Kervern, J. Blanchard, P. Ganssle, M. Butler, Hyun Shin, D. Budker, and A. Pines. Zero-Field NMR Enhanced by Parahydrogen in Reversible Exchange. Journal of the American Chemical Society **134 (9)**, 3987-3990 (2012).