Zero- to Ultralow-Field Nuclear Magnetic Resonance Spectroscopy via Optical Magnetometry

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Zero- to ultralow-field nuclear magnetic resonance (ZULF NMR) is an emerging alternative magnetic resonance modality where measurements are performed in the absence of an applied magnetic field [1]. Unlike conventional NMR, in which 'external' spin interactions – couplings to fields originating from the experimental apparatus – are dominant, ZULF NMR presents a regime dominated by 'internal' spin interactions – couplings to fields originating from the sample itself. By eliminating the need for a large magnetic field to encode chemical information in the form of chemical shifts, ZULF NMR avoids some problems encountered by conventional high-field NMR, such as broadening from susceptibility gradients in complex materials, limited RF penetration into conductive samples, and truncation of nuclear spin interactions that do not commute with the Zeeman interaction [2].

I will discuss recent developments by our group toward improving the sensitivity and applicability of ZULF NMR. These include new detector configurations, implementation of commercial sensors, nuclear spin hyperpolarization methods, and searches for physics beyond the Standard Model.

[1] J.W. Blanchard and D. Budker. Zero- to Ultralow-Field NMR. *eMagRes*, 2016, 5, 1395.
[2] J.W. Blanchard, et al. (2015) *Phys. Rev. B* **92** (22), 220202.