Coherence Protection and High Frequency Magnetometry using an Ensemble of V_B^- in hexagonal Boron Nitride

Charlie J. Patrickson
Simon Baber, Shi Guo, Valentin Haemmerli, Blanka B. Ga´al, Andrew J. Ramsay, Isaac J. Luxmoore

Department of Engineering, University of Exeter, Exeter, EX4 4QF, UK

Cp728@exeter.ac.uk

Abstract

Quantum sensors defined by paramagnetic spin defects have emerged as a leading platform for ambient magnetometry. Spin defects in two-dimensional hexagonal boron nitride provide the capability for nanoscale sensor-source distance, where surface noise is minimised by the naturally terminated lattice. Instead, inhomogeneous noise is dominated by the nuclear spin bath of the III-V host. In this contribution we demonstrate a continuous concatenated dynamical decoupling (CCDD) scheme that provides robust protection [1] against these dephasing mechanisms, whilst also enabling high frequency magnetometry [2]. Using an ensemble of boron vacancies in hexagonal boron nitride, we use CCDD to define a protected qubit subspace, improving spin coherence by two orders of magnitude. We use this in an AC magnetometry protocol, detecting frequencies in the range of ~ 10 − 150 MHz and ±150 MHz of the electron spin resonance. Finally, we modify the scheme for phase detection of AC signals [3], which we use in a quantum heterodyne scheme to record a 2.31 GHz signal to a precision of ±0.118 Hz over a 10 s measurement. This work adds a new technique to the quantum magnetometry toolbox and establishes the viability of spin defects in 2D materials for quantum sensing.

References

[1] A. J. Ramsay et al., Nat. Comms., 14, (2023) 461
[2] C. J. Patrickson et al., npj. Quantum inf., 10 (2024) 5
[3] C. J. Patrickson et al., arXiv, 2406.17142

Figures

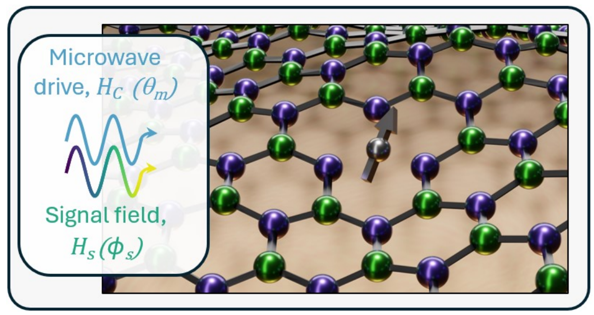

Figure 1: Diagram of a single boron vacancy in hexagonal boron nitride. The CCDD microwave drive, H_C, and signal field, H_S, are applied via a coplanar waveguide.

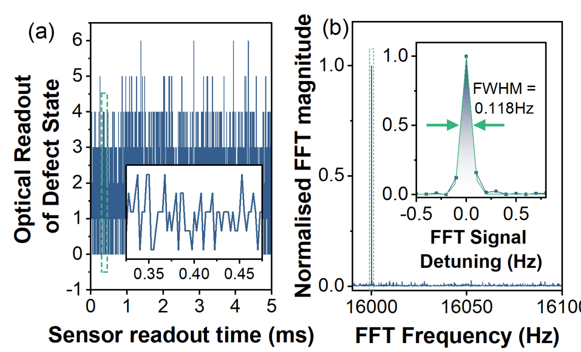

Figure 2: (a) Experimental photon time trace of a CCDD quantum heterodyne measurement, recording a 2.310008 GHz, 29 μT signal. An average of 1.8 photons were collected per readout. (b) FFT of the autocorrelated data taken from (a). The inset shows a Gaussian fit providing a SNR of 235, with the FWHM giving a frequency resolution of 0.118 Hz.