

# QDsiM: a simulation toolkit for optimizing realistic quantum diamond magnetometry experimentation

Prabhat Anand<sup>(1)</sup>

John S. Sandeep<sup>(1)</sup>, Satyam Pandey<sup>(1)</sup>, Sayari Majumder<sup>(1)</sup>, Pranit Terse<sup>(2)</sup>, Pralekh Dubey<sup>(2)</sup>, M Girish Chandra<sup>(1)</sup>, Sourav Chatterjee<sup>(1)</sup>, Phani Peddibhotla<sup>(2)</sup> and Fedor Jelezko<sup>(3)</sup>

<sup>1</sup>Tata Consultancy Services Ltd, India

<sup>2</sup>Indian Institute of Science Education and Research (IISER) Bhopal, India

<sup>3</sup>Ulm University, Germany

[anand.prabhat@tcs.com](mailto:anand.prabhat@tcs.com)

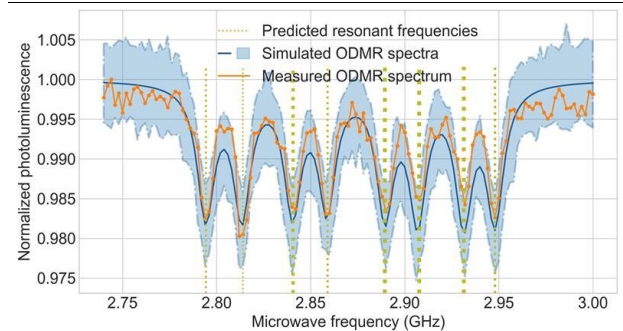
## Abstract

Nitrogen-vacancy (NV) centres in diamond are versatile quantum sensors capable of measuring multiple physical properties (e.g., electromagnetic fields and temperature) with high sensitivity and robustness, under ambient conditions. To enable practical, resource-efficient field deployments, we present QDsiM, a prototype simulation toolkit that models, analyses, and optimizes closed-loop NV magnetometry implementations while considering realistic experimental nonidealities. Building upon the seven-level model [1] of single NV center, we extend the analysis to NV ensemble in a noisy environment, capturing both spin and photodynamics of NVs. By analysing the spectral broadening mechanism as discussed in [2], we modelled the dependence of spin transition rates on the microwave (MW) frequency. The simulated fluorescence, modulated by a MW drive, is propagated through the optical assembly, followed by a lock-in amplifier and Proportional-Integral (PI) controller that continuously tracks resonant frequencies. As illustrated in Figs. 1–2, QDsiM's outputs closely reproduce experimental measurements from the setup in [3], supporting its deployment to reliable, data-driven optimization of sensor parameters and post-processing techniques. Hence, QDsiM can accelerate the path from benchtop characterization to application-specific, real-world diamond magnetometer deployments.

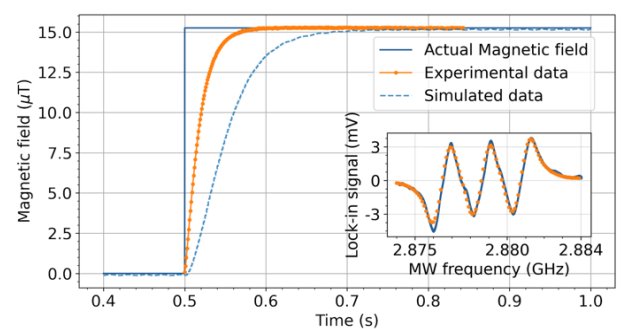
## References

- [1] J-P Tetienne *et al.* (2012) *New J. Phys.* **14** 103033
- [2] Dreau A *et al.* (2011) *Phys. Rev. B* **84** 195204
- [3] P. Dubey *et al.* (2026) *Appl. Magn. Reason.* **57** 6
- [4] Simone Magaletti *et al.* (2024) *New J. Phys.* **26** 023020

## Figures



**Figure 1:** A simulated continuous-wave optically detected magnetic resonance (ODMR) for a static magnetic field of 3.2 mT, with addition of photon shot noise is compared against its corresponding measurement using the same experimental settings. A good agreement can be observed in both linewidth and contrast along with 0.01% mean absolute error in predicted resonant frequencies. Parameters, intrinsic to NV ensembles, were taken from [2,4].



**Figure 2:** Comparison between the simulated and experimentally measured magnetic field, derived from the voltage response of the PI controller module, over time depicted for a step-change in magnetic field by 15.2  $\mu\text{T}$ . The slight mismatch between the two PI signals can be attributed to the assumptions for the lock-in filter and photoluminescence response in the simulation. The inset plot shows a good match between the corresponding lock-in signals.