Identification and mitigation of quantum relaxometry temporal artifacts

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Quantum sensing protocols based on measuring spin-relaxation rates of probe solid-state qubits are showing great promise for a range of biological and condensed matter sensing applications. Advantages of these techniques include the lack of requirement for applied external DC or RF fields. Such approaches have been employed using nitrogen vacancy (NV) centre defects in both nanodiamond [1] and single crystal [2, 3, 4] platforms; while many fields also use NMR relaxometry to obtain bulk sample information [5, 6, 7]. Many practical implementations of these approaches, however, introduce artifacts and systematic uncertainties that severely impact parameter estimation, and lead to inaccurate monitoring of external stimuli.

In this talk, I will introduce a general theoretical framework that explains the origin of these perverse behaviours in terms of experimentally controllable parameters. Using rigorous theoretical and experimental results, we account for the origin and implications of these artifacts, while proposing and demonstrating strategies for their mitigation.

Finally, I will discuss the implications of these systematic errors in other fields where quantum state preparation is vital. Given the ubiquity of quantum relaxation measurements in many topical areas of research, ranging from photovoltaics to biomedical magnetic resonance techniques, a thorough understanding of the limitations of this technique and strategies for improvement are of critical importance.

[1] A. Akther and E. Walsh, *Anal. Chem.* **93.48**, 16133-16141 (2021)

[2] J-P. Tetienne *Physical Review B* **87.23**, (2013)

[3] L. T. Hall, *Nat Comms*, (2016)

[4] D. A. Simpson, *Nat Comms*, (2017)

[5] D.P. Cistola *TrAC* **83**, 53-64 (2016)

[6] F. Jaeger *European Journal of Soil Science* **60.6**, 1052-1064 (2009)

[7] J. V. Bayer *The Open Magnetic Resonance Journal* **3.1**, 15-26 (2010)