Microwave-Driven NV^- Hyperpolarisation of ^{13}C for Benchtop NMR

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Nuclear magnetic resonance (NMR) spectroscopy and imaging have been widely applied in the field of clinical diagnostics as means of non-invasive probing of samples at the molecular level. Whilst being extensively implemented to determine the structures of small molecules and biomacromolecules in chemical, biomedical, and pharmaceutical research, NMR spectroscopy forms the fundamental basis of Magnetic Resonance Imaging (MRI)[1]. However, the sensitivity of magnetic resonance spectroscopy is inherently limited by low signal-to-noise ratios attributed to the weakly polarised atomic populations probed. Numerous existing platforms for high-resolution NMR utilise cryogenic cooling and strong magnetic fields in the order of tens of tesla, imposing significant cost requirements and limiting miniaturisation capabilities [2]. In the present research we propose a dynamic nuclear polarisation (DNP) technique for hyperpolarising an atomic sample of ^{13}C, employing Nitrogen-Vacancy (NV^-) centres in bulk diamond as polarisation mediators. NV^- centres, characterised with long coherence times and optical accessibility, emerge as a versatile platform with numerous applications in quantum information, high-resolution sensing and nano-scale imaging [2]. Consequently, these point-defects transpire as ideal candidates for overcoming the intrinsic sensitivity limitations of conventional NMR. Within this framework we aim to harness NV^- mediated dynamic nuclear polarisation to hyperpolarise ^{13}C nuclei, employing microwave-driven transitions through the natural level anti-crossings arising in a diamond lattice at specific crystal orientations and magnetic field strengths. To realise this approach, we are developing a benchtop NMR platform for integrated hyperpolarisation and detection, anticipating orders-of-magnitude signal enhancements ($\sim 10^5$) under ambient conditions.

[1] C. Hilty, D. Kurzbach and L. Frydman, *Nat. Protoc.* **17**, 1621–1657 (2022).
[2] J. King, K. Jeong, C. Vassiliou *et al.*, *Nat. Commun.* **6**, 8965 (2015).

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