Electrically-Read Nuclear Spin Qubits Using NV Electron Spins

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Nuclear spins in semiconductors are prominent candidates for quantum technologies, including quantum computation, communication, and sensing. Nuclear spins in diamond are particularly attractive due to their extremely long coherence lifetime and the possibility to control and read them via near-by electron spin of the nitrogen-vacancy (NV) centre.

Building on our recent results of photoelectric detection of magnetic resonances (PDMR) [1,2], we demonstrate the electrical readout of a unit composed of a single 14N nuclear spin coupled to the NV electron employing two-qubit gates. The electron spins are polarised at the NV Excited State Level (ESLAC) Both MW assisted, and MW-free readout is used.

This demonstration is a step towards larger-scale integrable diamond quantum processor devices using electrical spin-state readout in solid-state devices.

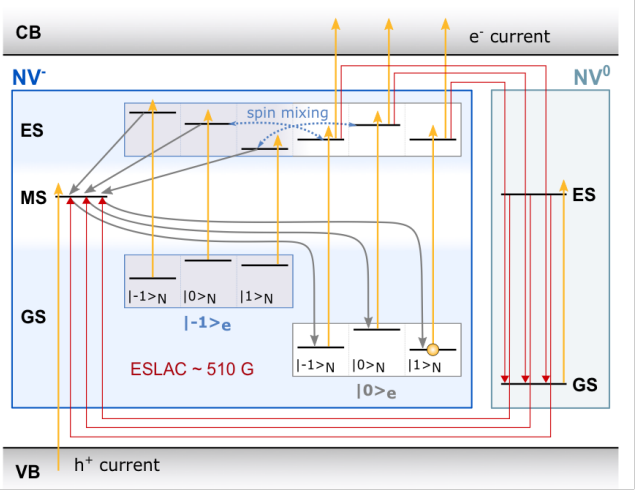

Figure 1: Schema of PDMR detection at ESLAC. a) Under the application of the magnetic field (510 G for ESLAC), the NV- centre-ground state (GS) energy levels are well separated, whereas the excited state (ES) at ESLAC becomes nearly degenerate, resulting in spin mixing between the states with the equivalent total spin projection quantum number. The spin mixing combined with the electron spin polarisation to Ms(0) through the metastable state (MS) [grey arrows] results in the spin polarisation to the Ms(0) electron and Ms(1) nuclear spin state. The yellow arrows depict optical transitions induced by the application of the yellow-green laser. The Ms(0) spin sublevel in the ES is more likely to be excited by the second photon and contribute to the photocurrent by promoting the NV electron to the diamond conduction band (CB)

References

[1] P Siyushev, M Nesladek, E Bourgeois, *et al.*, Science **363**, 728 (2019)

[2] M Gulka, *et al.*, Nat. Commun. (2021), in press