Shielding Noises From Spins

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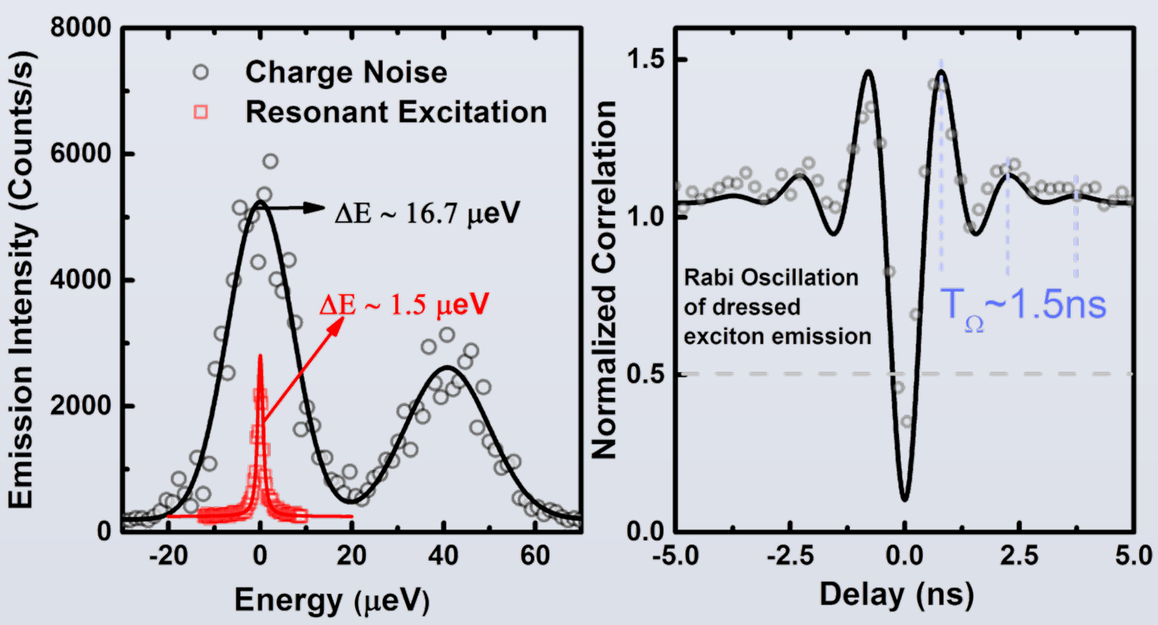
Abstract

Electrons in InAs/GaAs quantum dots are strong candidates for qubits due to quantum confinement of the spin ½ system. However, electrons couple with nearby nuclear spins and the fluctuating electrostatic environment, these impose an undesired bottleneck on the performance of a quantum spin device.

We show that the fluctuating charge and spin environment may be circumvented to an extent. Compared to InAs/GaAs quantum dots, two-dimensional materials may be used to minimise nuclear spin noise; combined with careful sample design a low-decoherence platform is envisioned.

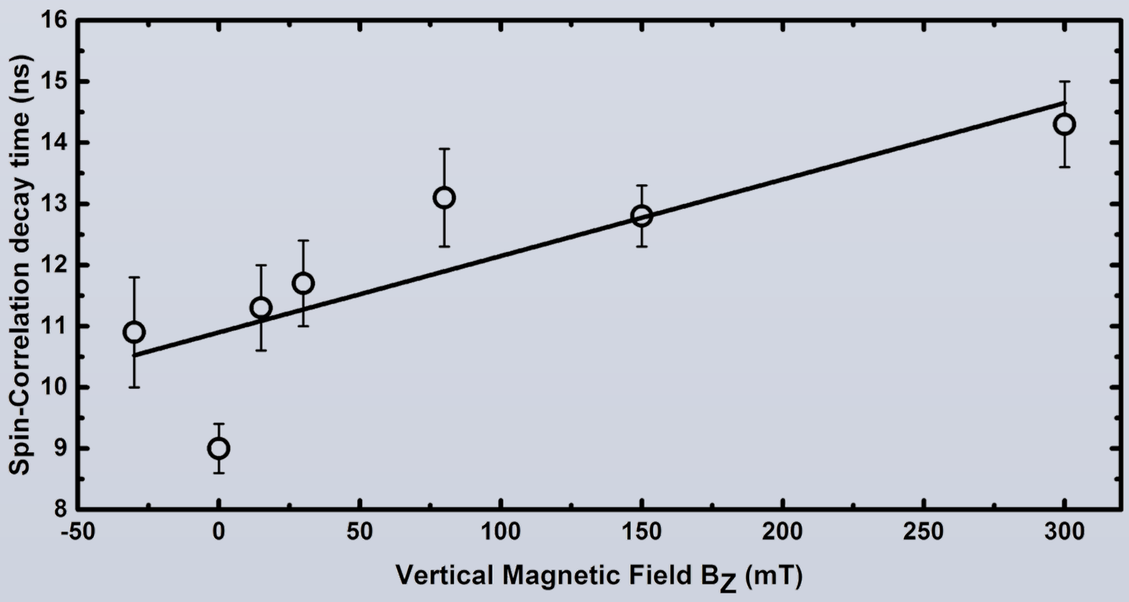
Electrostatic Fluctuations

Illuminating semiconductor heterostructures above the bandgap causes spectral diffusion in the emission spectrum. Despite this, narrow-linewidth single photons can still be generated if the electron-hole pair is created using resonant excitation.

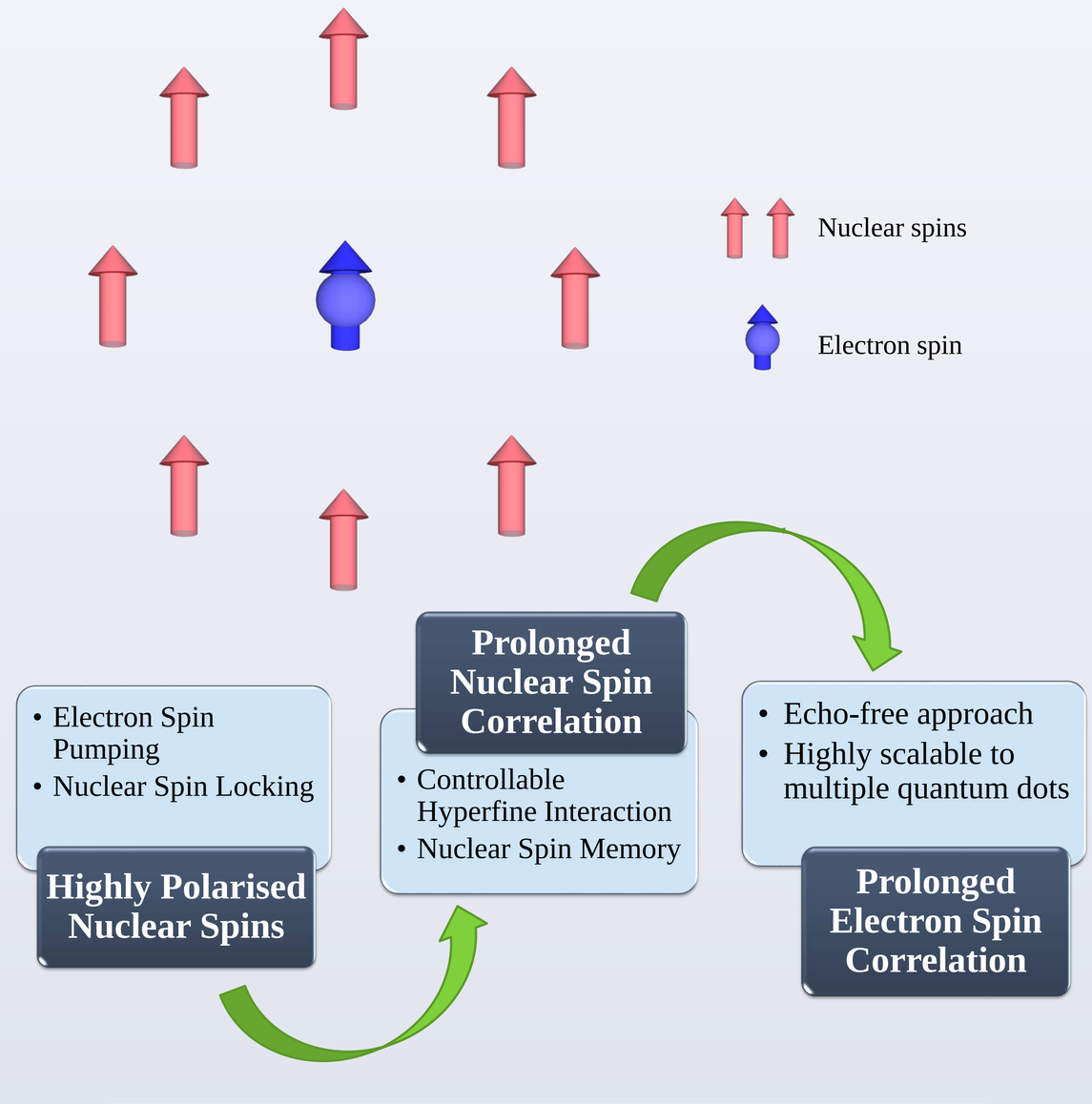


Nuclear Spin Fluctuations

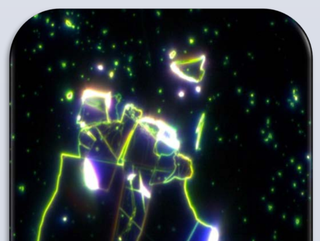
Approximately a hundred thousand nuclear spins live around the electron, this many body effect leads to a loss of electron spin polarisation each time a photon is emitted. Applying a magnetic field along the optical axis reduces this loss, but the electrons could benefit greatly if the nuclear spin temperature can be reduced.



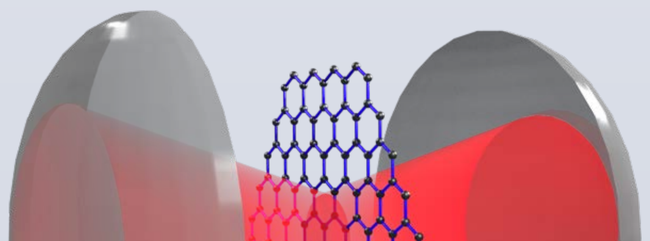
Minimisation of Spin Noise



Compared to InAs/GaAs, monolayer materials may help to eliminate the spin noise. The challenge is to engineer photonic waveguides and resonant cavities, to give similar optoelectronic and spintronic capabilities as InAs/GaAs. At the Quantum Technology Centre at Lancaster University we aim to solve this problem.



Monolayer Graphene on hexagonal Boron Nitride



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