Quenching Spin Decoherence in Diamond through Spin Bath Polarization

National High Magnetic Field Laboratory

High-Field Electron Magnetic Resonance User Program, Florida State University

The coupling between electron spins and their environment is a poorly understood subject of significant interest. In classical magnetism, this coupling leads to dissipation and damping of spin precession. In the quantum case, interaction with the environment leads to loss of quantum information. Overcoming decoherence is, thus, critical to spin-based quantum information processing. One way to mitigate this decoherence is to bring the surrounding spin bath into a well-known quantum state that exhibits little or no fluctuations. However, full polarization of the spin bath is experimentally challenging.

The nitrogen-vacancy (N-V) impurity center in diamond is one of the most promising solid-state spin systems (see [1]). By observing that the decoherence time, T_2, of the N-V center saturates ~250μs at 8.5T and 2K, we have demonstrated that one can strongly polarize the spin bath and quench its decoherence. This work demonstrates that low-temperature, high-frequency pulsed electron paramagnetic resonance spectroscopy provides access to a new regime of spin decoherence in solids.

[1] Takahashi, S.; Hanson, R.; van Tol, J.; Sherwin, M.S. and Awschalom, D.D., ***Phys. Rev. Lett.*** **101**, 047601 (2008)

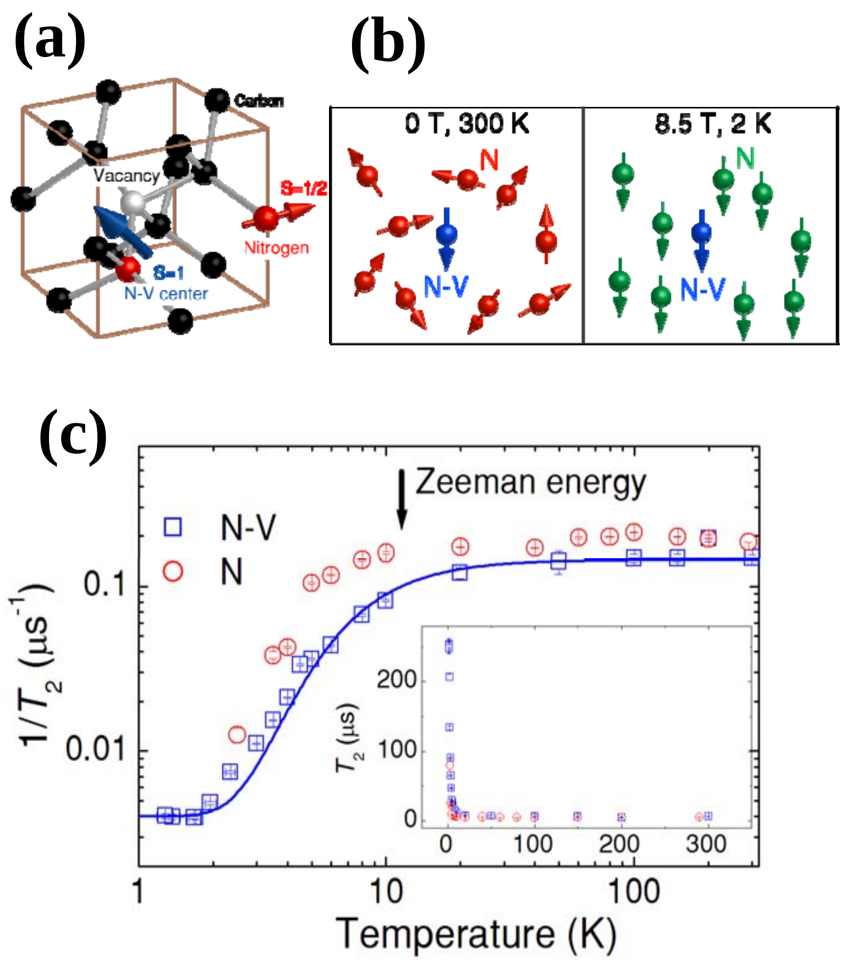

Fig. (a) N-V and N center (b) N spin bath at 0 T, 300 K and 8.5 T, 2 K. (c) Spin decoherence time, T_2, as a function of temperature.

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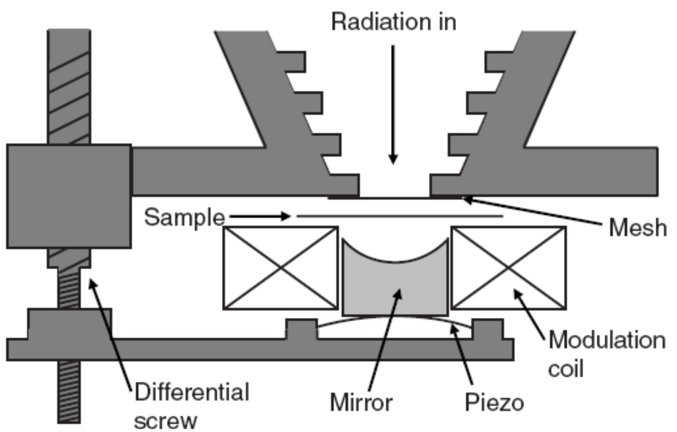

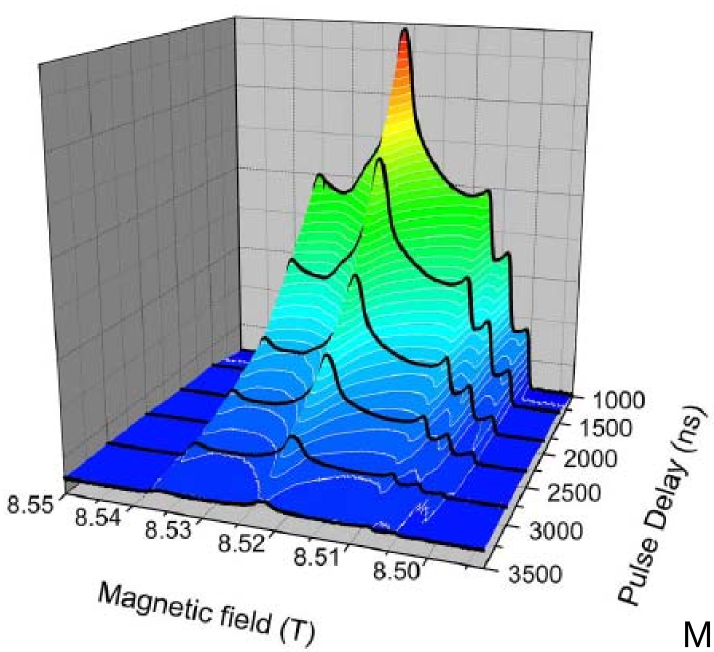

Instrument development: The group has developed a unique high-frequency pulsed electron paramagnetic resonance (EPR) spectrometer, which is now available to the general user community. Indeed, the results on isolated spins in diamond were obtained with this instrument, which employs a Fabry-Perot cavity (top left), enabling time resolution of 100ns at 110GHz, and 600ns at 334GHz. The lower plot (left) shows the decay of an electron spin echo in TEMPOL at 15K, recorded at several different high-magnetic fields.

The EMR users' program has also extended its high-frequency coverage for continuous-wave EPR to ~900GHz in the 25T wide bore resistive magnets, as well as at certain discrete frequencies up to ~1.2Hz in the 45T hybrid magnet.

Users and collaborators: Almost 130 users and collaborators contributed to the EPR sections of the most recent NHMFL annual reports. Of these, roughly 20% were graduate students and 20% were postdocs. In addition, 20% were female and 20% were from underrepresented groups. Several local students also obtained PhDs as a result of thesis work performed in the NHMFL EMR group.

Morley, G.W.; Brunel, L.-C. and van Tol, J., *Rev. Sci. Instrum*. **79**, 064703 (2008).