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Basic properties and quantum control of diamond qubits

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Abstract

Room temperature solid state defect qubits are relatively rare. Spin-lattice relaxation poses an ultimate limit to the coherence times of the qubits in the given material. Understanding the underlying microscopic mechanisms is essential to discover qubits that can operate under ambient conditions. We show for the exemplary diamond nitrogen-vacancy (NV) center by means of first principles simulations that – in contrast to textbook cases – the electron-spin coupling is governed by Raman scattering due to second-order spin-phonon interactions at elevated temperatures. The applicability of this finding to other defect spin systems will be discussed. Further addressing NV centers, a more than four-fold improvement in sensitivity compared to that possible with non-resonant illumination has been recently demonstrated at cryogenic temperatures. In these experiments, nuclear spin relaxation under resonant excitation to polarize the 14N host was leveraged that can be important in low temperature magnetometer applications. We explain the single- and double-quantum jumps in these experiments by transverse hyperfine and quadrupolar couplings in the excited state. Furthermore, we present recent results on inversion-symmetric defect qubits in diamond that could be important for quantum communication and low-temperature quantum sensing applications.