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Decoherence on Quantum Spin Systems

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The main problem blocking development of solid-state qubits is decoherence, caused in insulators by nuclear spins, paramagnetic impurities, phonons, and flux noise. Decoherence rates are calculated for several real spin systems, including Fe_8 molecules and the $LiHo_xY_{1-x}F_4$ rare earth magnets. A generic result is a "coherence window"- over a small range of transverse applied fields the decoherence rate will drop by 4-6 orders of magnitude, allowing qubit operation. "Disentanglement rates" for *pairs* of coupled magnetic qubits also show coherence windows. Predictions for linewidths and lineshapes in ESR and microwave experiments on the Fe_8 and $LiHo_xY_{1-x}F_4$ systems are given, both in low applied fields (where the dynamics is incoherent) and in the coherence window. Dipolar interactions between many spins are also included. Since the qubits strongly entangle with the nuclear spin environment, the effect of qubit dynamics on the nuclear T_1 and T_2 is evaluated. Conduction electrons can be introduced into the environment of many quantum nanomagnets, creating tunable Kondo and RKKY couplings with the qubits (in addition to the phonons, photons, and nuclear spins). The disentanglement rate for 2 qubits is evaluated, along with their contribution to the electronic noise spectrum.

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