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**Decoherence: Intrinsic, Extrinsic, and Environmental**[1]

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Environmental decoherence times have been difficult to predict in solid-state systems. In spin systems, environmental decoherence is predicted to arise from nuclear spins, spin-phonon interactions, and long-range dipolar interactions [1]. Recent experiments have confirmed these predictions quantitatively in crystals of $Fe_8$ molecules [2]. Coherent spin dynamics was observed over macroscopic volumes, with a decoherence $Q$-factor $Q_\phi = 1.5 \times 10^6$ (the upper predicted limit in this system being $Q_\phi = 6 \times 10^7$). Decoherence from dipolar interactions is particularly complex, and depends on the shape and the quantum state of the system. No extrinsic "noise" decoherence was observed. The generalization to quantum dot and superconducting qubit systems is also discussed. We then discuss searches for "intrinsic" decoherence [3,4], coming from non-linear corrections to quantum mechanics. Particular attention is paid to condensed matter tests of such intrinsic decoherence, in hybrid spin/optomechanical systems, and to ways of distinguishing intrinsic decoherence from environmental and extrinsic decoherence sources.

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