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**Decoherence in Quantum Spin Systems**

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Understanding decoherence of quantum spin systems strongly coupled to a bath of environmental spins (spin bath) is important for many areas of physics, such as spintronics, quantum computing, nuclear and electronic magnetic resonance. Decoherence is a complex non-equilibrium many-body phenomenon, and for many interesting situations, exact numerical simulations are needed. We have developed highly efficient and accurate numerical techniques of solving the time-dependent Schrödinger equation for quantum many-spin systems. We used these techniques to directly model the evolution of the central spin system and its environment. I will demonstrate usefulness of this approach for several experimentally and theoretically important cases, where the many-body correlations between the system and the bath are particularly important. I will present, among others, our studies of the NMR spin echo of Si:dopant systems, and our investigation of decoherence by a spin bath in the regime of quantum chaos. Moreover, I will present our results on decoherence of an electron spin by a bath of nuclear spins in a quantum dot, which has been recently studied in experiments, and discuss novel numerical approaches based on techniques borrowed from quantum optics. This work was supported by US DOE, and NSA, ARDA and ARO.