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Electron spin decoherence by interacting nuclear spins in quantum dot I: Quantum theory WANG YAO, Department of Physics, University of California, San Diego, R.-B. LIU, Department of Physics, University of California, San Diego and Department of Physics, The Chinese University of Hong Kong, LU J. SHAM, Department of Physics, University of California, San Diego — We present a quantum theory to the electron spin decoherence by a nuclear pair-correlation method for the electron-nuclear spin dynamics under a strong magnetic field and low temperature. The theory incorporates the electron nuclear hyperfine interaction, the intrinsic nuclear interactions, and the nuclear coupling mediated by the hyperfine interaction with the electron in question. Results for both single electron spin free-induction decay (FID) and ensemble electron spin echo will be discussed. Single spin FID is affected by both the intrinsic and the hyperfine-mediated nuclear interactions, with the dominance determined by the dot size and external field. The spin echo eliminates the hyperfine-mediated decoherence but only reduces the decoherence by the intrinsic nuclear interactions. Thus, the decoherence times for FID and spin echo are significantly different. Electron spin decoherence is explained in terms of the quantum entanglement with the pair-flip excitations in the nuclear spin environment. This work was supported by NSF DMR- 0403465, NSA/ARO, and DARPA/AFOSR.

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