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Nuclear spin polarization and coherence in semiconductor nanostructures[1]

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We have studied the mechanism of dynamical nuclear spin polarization by hyperfine interaction in the spin-blocked vertical double quantum dot system[2]. We have calculated hyperfine transition rates between nuclear spin levels and solved the master equations for the nuclear spins in the double quantum dot. Specifically, we incorporated energy shifts and state mixing due to nuclear quadrupole coupling, which is present because of doping-induced local lattice distortion and strain in the vertical quantum dots. Our results show that doping-induced nuclear quadrupole coupling, together with hyperfine interaction, can cause significant nuclear spin relaxation in the quantum dot system under appropriate conditions (such as tunnel broadening of electronic levels). Therefore, we have found a new channel for nuclear spin relaxation/depolarization in strained material systems at low temperatures. We have also studied internal nuclear spin dynamics in quantum dots and quantum wells through dipolar coupling[3]. Our results show strong influences of any inhomogeneity in the hyperfine coupling on the nuclear spin dynamics. Our studies thus demonstrate theoretically the complexities of coupled electron-nuclear spin dynamics in semiconductor nanostructures.

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[2]C. Deng and X. Hu, cond-mat/0402428. To appear in Phys. Rev. B.

[3]C. Deng and X. Hu, cond-mat/0312208. Submitted to Phys. Rev. B; C. Deng and X. Hu, cond-mat/0406478. To appear in IEEE Trans. Nanotech.