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Hole-induced Dynamic Nuclear Polarization in Quantum Dots[1]

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— We present a microscopic theory showing that through the non- collinear hole-nuclear dipolar hyperfine interaction, an optically excited heavy hole in a quantum dot can induce a steady-state nuclear polarization. The preferential direction of the nuclear spin flip is set by the energy mismatch of relevant transitions instead of thermal relaxation. The induced nuclear polarization shows a sign dependence on the product of the nuclear Zeeman splitting and the frequency detuning of the pumping laser, leading to bidirectional hysteretic locking of the optical absorption peak onto resonance or bidirectional hysteretic shift of the peak away from zero detuning. This sheds light on a puzzling observation of bidirectional hysteretic locking of the neutral exciton absorption peak in Faraday geometry [C. Latta et al., Nature Phys. 5, 758 (2009)]. By solving the Fokker-Planck equation for the nuclear polarization distribution, we found a 10-fold suppression of the steady- state nuclear fluctuation, in reasonable agreement with the single pump experiment in Voigt geometry [X. Xu et al., Nature 459, 1105 (2009)].

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