Intrinsic bi-directional dynamic nuclear polarization by optically pumped trions in quantum dots

WEN YANG, L. J. SHAM, University of California, Department of Physics — We develop a microscopic theory for dynamic nuclear polarization (DNP) in a quantum dot through dipolar interaction between the nuclear spins and the hole spin in the optically generated trion in the Faraday configuration. In sharp contrast to other uni-directional DNP mechanisms where the resulting nuclear field always increases or decreases the electronic excitation energy, our theory shows that the DNP induced by the trion is bi-directional: for the laser frequency on the blue (red) side of the trion excitation, the nuclear field tends to increase (decrease) the trion excitation energy into resonance with the laser frequency. As a result, the sharp Lorentzian trion absorption line is broadened nearly symmetrically into a round top with abrupt edges, where bistable states of the nuclear polarization manifest as hysteretic loops. This intrinsic bi-directional DNP mechanism serves as an alternative explanation to the recently observed bi-directional hysteretic enhancement of trion absorption in single InGaAs quantum dot [C. Latta et al., Nature Phys. 5, 758 (2009)], attributed to competition between two uni-directional DNP mechanisms. Our work is supported by NSF-PIF and ARO/IARPA. [1] Bi-directional DNP by the trion was first discovered and explained in a recent work in the Voigt configuration [X. D. Xu et al., Nature 459, 1105 (2009)].

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Date submitted: 15 Nov 2009
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