Spin-orbit coupling and spin relaxation of hole states in [001]- and [111]-oriented quantum dots of various geometry

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In this contribution, we investigate the effect of spin-orbit coupling on spin-admixture mechanisms in self-assembled InAs/GaAs quantum dots grown on [001]- and [111]-oriented substrates belonging to symmetry point groups: C_{2v}, C_{3v} and D_{2d}. We calculate spin relaxation rates between the hole states of lowest Zeeman doublet. We also identify the irreducible representations linked to the states and discuss the selection rules, which govern the avoided-crossing pattern in magnetic-field dependence of the energy levels.

The states are calculated using 8-band $\boldsymbol{k}{\cdot}\boldsymbol{p}$ model [2, 3], where the magnetic field enters via Peierls substitution according to gauge invariance theory [4]. We account for the hole-phonon coupling within the long-wavelength limit, while relaxation rates are found using standard Fermi golden rule.

The obtained spin-flip rates indicate that the [111]-oriented structure offers one order of magnitude longer relaxation times compared to the usual [001]-oriented self-assembled QD (Fig.). We also show that important contribution to the coupling between some of the states comes from the shear strain. On the other hand, we demonstrate no coupling between s- and p-shell states in the [111]-oriented structure.

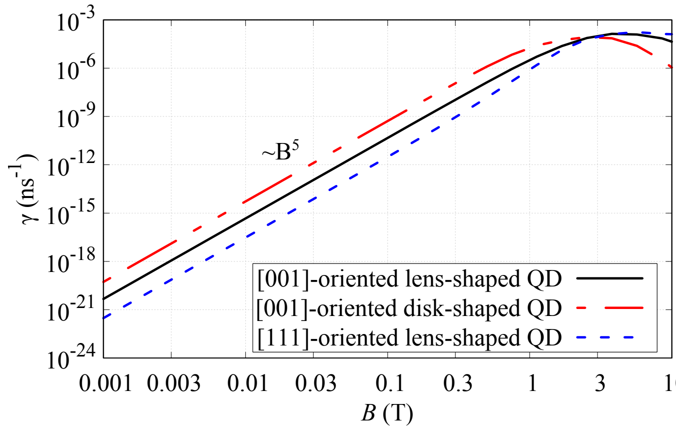

Fig. Phonon-induced spin relaxation rate in the lowest-energy Zeeman doublet as a function of axial magnetic field.

References

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