# Theory of spin dynamics and magneto-optical response in charge-neutral coupled quantum wells

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## Abstract

In this contribution, we provide a model of the electron and hole spin dynamics in a double quantum well [1], taking into consideration the phonon-mediated carrier tunneling between quantum wells, enhanced by an electric field, spin decoherence, as well as the spin-orbit interaction present in materials with bulk inversion asymmetry. Taking into account also the presence of an in-plane or tilted magnetic field, we provide the full description of the magneto-optical response of the system. We simulate the results of the time resolved Kerr rotation measurement, which is performed currently on such structures thanks to the presence of long-living spins and absence of intrinsic dephasing [2] typical for the initialization of spin in doped structures.

In our model, spin precession in the magnetic field is treated exactly, while the dissipative dynamics (spin relaxation, dephasing, carrier tunneling, and recombination) is described in the Markov limit by the universal Lindblad superoperator in the master equation for the density matrix evolution. Moreover, we include the Dresselhaus spin-orbit coupling, which leads to the mixing of states with different angular momenta and to the tunneling of carriers accompanied by a spin-flip. To obtain the direct correspondence with experimentally measured quantities we employ the numerical solution for the density matrix and construct substantial dynamical variables such as spin polarization and coherences for each of QWs.

We reproduce the experimentally known fact of the extension of the spin polarization lifetime caused by the charge separation, which occurs in such structures. Moreover, we provide a number of qualitative predictions concerning the necessary conditions for this effect to occur, as well as about possible channels of its suppression. We consider also the impact of the magnetic field tilting resulting in nontrivial spin dynamics. Finally, we discuss the relevance of the spin-orbit interaction effects for typical systems.

[1] M. Gawełczyk, P. Machnikowski, arXiv:1407.4529 (sent to *Phys. Rev. B*).
[2] M. Gawełczyk, P. Machnikowski, *Phys. Rev. B* **87**, 195315 (2013).
[3] M. Syperek, D. R. Yakovlev, A. Greilich, J. Misiewicz, M. Bayer, D. Reuter, and A. D. Wieck, *Phys. Rev. Lett.* **99**, 187401 (2007).
[4] C. Gradl, M. Kempf, D. Schuh, D. Bougeard, R. Winkler, C. Schüller, and T. Korn, *Phys. Rev. B* **90**, 165439 (2014).