Spin-orbit coupling and magnetic field dependence of carrier states in a self-assembled quantum dot

K. Gawarecki

Department of Theoretical Physics, Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland

We present a theoretical study related to the influence of spin-orbit coupling on the magnetic field dependence of the carrier states in a single InGaAs quantum dot [1]. As shown in the literature [2], the Fock-Darwin model fails to describe the hole p-shell, giving incorrect state ordering with respect to the spin. On the other hand, the correct structure can be reproduced by an effective Hamiltonian that accounts for an interplay of Zeeman effect and spin-orbit coupling [2]. In this contribution we study the importance of several spin-orbit coupling mechanisms including the Dresselhaus, Rashba and shear strain related coupling. We show that the complicated energy level structure arising from 14 $\boldsymbol{k}\cdot\boldsymbol{p}$ model can be very well fitted in terms of the effective model.

Finally, we compare the magnitude of the hole g-factors calculated within various $\boldsymbol{k}\cdot\boldsymbol{p}$ approaches and show that the 8 and 14 band $\boldsymbol{k}\cdot\boldsymbol{p}$ models give very similar results. The model is based on the compilation of several methods: the electron and hole states are calculated using 8-band and 14-band $\boldsymbol{k}\cdot\boldsymbol{p}$ [3]. The strain field is accounted for in terms of the continuous elasticity method. We include piezoelectric field up to the 2nd order in strain tensor elements [4]. Magnetic field enters via Peierls substitution according to gauge invariance theory [5]. Then, the magnetic field dependence of exciton states are calculated using configuration interaction approach.

[1] K. Gawarecki, arXiv:1711.06934 (2017).

[2] M. Valín-Rodríguez, A. Puente, and L. Serra, Phys. Rev. B **69**, 085306 (2004).

[3] R. Winkler, Spin-Orbit Coupling Effects in Two- Dimensional Electron and Hole Systems, Vol. 191 of Springer Tracts in Modern Physics (Springer, Berlin, 2003).

[4] G. Bester, X. Wu, D. Vanderbilt, and A. Zunger, Phys. Rev. Lett. **96**, 187602 (2006),

[5] T. Andlauer, R. Morschl, and P. Vogl, Phys. Rev. B **78**, 075317 (2008).