The role of the intraband dipole moment in the luminescence from highly elongated quantum dots

M. Gawełczyk[1,2], P. Machnikowski[1]

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

[2]*Department of Experimental Physics, Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology, Wybrzeże Stanisława Wyspiańskiego 27, 50-370 Wrocław, Poland*

We study the role of intraband dipole moment matrix elements in the luminescence from highly in-plane elongated quantum dots. We show that in case of large structures a substantial intraband contribution favoring polarization along the axis of elongation may arise and has a strong influence on the polarization of emitted light.

Considering heavy-hole excitons in quantum dots one finds four degenerate states, two of which are bright and supposed to emit circularly polarized light, which for structures with an in-plane asymmetry becomes elliptical and inclined towards the direction of elongation due to the light-hole admixture in the hole ground state [1]. The presence of an electron-hole exchange interaction lifts the degeneracy between bright and dark states and for structures without rotational symmetry also splits the bright doublet. Calculation of interband dipole moments, commonly considered far dominant in nanostructures [2], for these states indicate that they should couple to light polarized linearly along two orthogonal axes defined by the structural anisotropy of the dot. This, however, is not the case in a recent experiment [3] where only one of the linear polarizations is shown to be efficiently preserved between quasi-resonant excitation and emission.

We explain this fact taking into account the intraband contribution to the dipole moment which, being of macroscopic origin, depends only on carrier wave function envelopes, and therefore orients along the elongation of the nanostructure in case of both bright states regardless of their unit-cell-level properties. Such contribution strongly affects optical properties of one of the bright states that was supposed to couple to light polarized linearly across the dot and in consequence produces an asymmetry between coupling of excitons to the two orthogonal polarizations.

[1] A. Musiał, P. Kaczmarkiewicz, G. Sęk, P. Podemski, P. Machnikowski, J. Misiewicz, S. Hein, S. Höfling, A. Forchel, Phys. Rev. B **85**, 035314 (2012),
[2] J. Andrzejewski, G. Sęk, E. OReilly, A. Fiore, and J. Misiewicz, J. Appl. Phys. **107**, 073509 (2010)
[3] M. Syperek, Ł. Dusanowski, M. Gawełczyk, G. Sęk, A. Somers, J. P. Reithmaier, S. Höfling, J. Misiewicz, Appl. Phys. Lett. **109**, 193108 (2016)