Exciton states in conical quantum dots under applied electric and magnetic fields

Carlos Alberto Duque

Grupo de Materia Condensada-UdeA, Instituto de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Antioquia UdeA, Calle 70 No. 52-21, Medellín, Colombia

* Corresponding author: *cduque_echeverri@yahoo.es*

Abstract

Using the effective mass and parabolic band approximations, and the finite element method, we calculate the combined effects of axially applied electric and magnetic fields on the electronic properties of cone-shaped quantum dots. Once the one particle eigenvalue equations have been solved, both for electrons and holes, the available information on energies and wave functions is used as input in order to calculate the electron and hole positions along the axial axis, the overlap integral, the ground state exciton lifetime, and the exciton Coulomb interaction; all these properties are obtained as a function of the applied electric and magnetic fields. The main findings are: 1) the electric field separates the electrons and holes in opposite positions of the structure, giving rise to indirect excitons with a quite significant lifetime, 2) the magnetic field is a useful tool to increase by several orders of magnitude the exciton lifetime, mainly when it is superimposed on the electric field effect, 3) for spatially direct excitons, the magnetic field reinforces the Coulomb integral giving rise to a redshift of the photoluminescence energy transition, 4) the magnetic field effects are much more visible on electrons than on the holes, and finally 5) the electric field allows to tune the evolution of the structure from a quantum dot to a quantum ring. Our results on the photoluminescence energy transition are in excellent agreement with previously reported experimental measurements [Phys. Status Solidi RRL 2018, 1800245 (4pp) (2018)].