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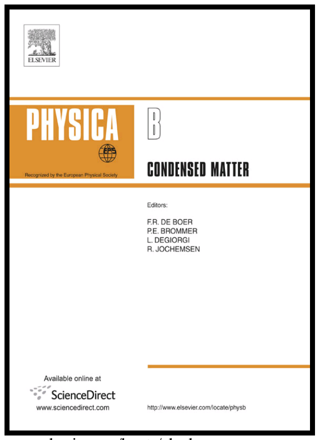

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Linear and nonlinear magneto-optical properties of an off-center single dopant in a spherical core/shell quantum dot

E. Feddi[a,†], A. Talbi[b], M. E. Mora-Ramos[c,1], M. El Haouari[d], F. Dujardin[e], C. A. Duque[f]

[a] *LaMCScI, Group of Optoelectronic of Semiconductors and Nanomaterials, ENSET, Mohammed V University in Rabat, Morocco*
[b] *Laboratoire Optoélectronique et Physico-chimie des Matériaux, Faculté des Sciences, Université Ibn Tofail, Kenitra, Morocco*
[c] *Centro de Investigación en Ciencias-IICBA, Universidad Autónoma del Estado de Morelos, Av. Universidad 1001, CP 62209 Cuernavaca, Morelos, Mexico*
[d] *Centre Régional des Métiers de l'Education et de Formation (CRMEF), Tanger, Morocco.*
[e] *LCP-A2MC, Institut de Chimie, Physique et Matériaux, Université de Lorraine, Metz, France*
[f] *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*

Abstract

Using the effective mass approximation and a variational procedure, we have investigated the nonlinear optical absorption coefficient and the relative refractive index changes associated to a single dopant confined in core/shell quantum dots considering the influences of the core/shell dimensions, externally applied magnetic field, and dielectric mismatch. The results show that the optical absorption coefficient and the coefficients of relative refractive index change depend strongly on the core/shell sizes and they are blue shifted when the spatial confinement increases so this effect is magnified by higher structural dimensions. Additionally, it is obtained that both studied optical properties are sensitive to the dielectric environment in such a way that their amplitudes are very affected by the local field corrections.

Keywords: core-shell quantum dots; magnetic field effects; impurity binding energy; nonlinear optical properties

1. Introduction

For some years now, the study of semiconductor quantum dots (QDs) has become a productive field of scientific research [1, 2, 3, 4, 5, 6]. Their unexpected properties have uncovered many advantages for prospective applications in the design and development of new photonic and optoelectronic devices of interest to many different areas: light-emitting diodes [7, 8, 9], photovoltaics [10, 11], lasers [12, 13, 14], biosensors and biological markers [15, 16, 17, 18]. In these quasi-zero dimensional structures, the energy levels are quantized and largely depend on the dot size. As a consequence, optical transitions can be controlled either by changing the shape/size or by applying external perturbations such as electric and magnetic field or hydrostatic pressure. Thanks to the rapid development of the crystal growth techniques as well as the progress of chemical fabrication processes, a new generation of quantum nanostructures has been manufactured —they are named core-shell quantum dots (CSQDs). These structures are composed of two semiconductor materials with different band alignment. They are spatially arranged in such a way that the core, with a larger band gap, which plays the role of a substrate, is coated by a spherical shell of the material with the smaller band gap, or vice versa. For more details about the types and characteristics of these novel heterostructures we refer the readers to Ref. [19], and references therein.

Doping with impurity atoms is considered as a very important influencing factor in the control of optical response of semiconductors. As a small quantum mechanical system, the carrier-donor-impurity complex in QDs has attracted

[1]Corresponding author: memora@uaem.mx (M. E. Mora-Ramos)
†: e.feddi@um5s.net.ma (E. Feddi)