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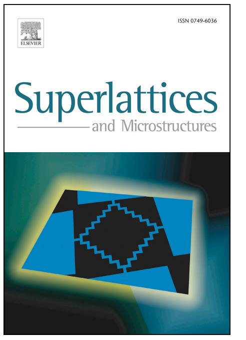

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Spin-Orbit Coupling and Applied Magnetic Field Effects on Electromagnetically Induced Transparency of a Quantum Ring at Finite Temperature

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Abstract

A wide variety of semiconductor nanostructures have been fabricated and studied experimentally and alongside theoretical investigations show the great role they have in new generation opto-electronic devices. However, mathematical modeling provide important information due to their definitive goal of predicting features and understanding of such structures' behavior under different circumstances. Hence, in the current work, the effects of applied magnetic field, temperature and dimensions of the structure on the electromagnetically induced transparency (EIT) of a GaAs quantum ring are studied while both Rashba and Dresselhaus spin-orbit interactions (SOI) are taken into account. The Schrödinger equation is solved in cylindrical coordinate with axial symmetry and in order to study the EIT, the imaginary (absorption) and real (refractive index) parts of susceptibility as well as the group velocity of the probe light pulse are investigated. The absorption and refractive index plots show that, for a specific frequency of probe field the absorption vanishes and refractive index becomes unity (known as EIT) while around such frequency the group index is positive (sub-luminal probe propagation) and for higher and lower frequencies it alters to negative (super-luminal probe propagation). The numerical results reveal that the EIT frequency, transparency window and sub(super)-luminal frequency intervals shift as we change applied magnetic field, temperature and also the structure dimensions.

Keywords: Rashba and Dresselhaus SOIs, Electromagnetically Induced Transparency, Temperature Dependency, Zeeman Effect, Cylindrical Symmetry.

1. Introduction

Quantum coherence and interference effects are significantly important and provide great knowledge about the interaction between electromagnetic pulse and medium [1, 2]. While electromagnetic pulses passing through medium, one of the most fascinating optical responses is Electromagnetically Induced Transparency (EIT) in multi-level systems, which is based on quantum interference effects leading to coherence between the states that results in omitting the absorption and refraction of the incident electromagnetic beam at a specific frequency [3, 4, 5]. Recently, modifying the group velocity of a light pulse has become extremely important in optical communication and quantum information processing and its potential applications such as optical memories, optical switches, optical buffering, data synchronization and optical signal processing have attracted many researchers interest. Although the majority of works have investigated the EIT in atomic medium, semiconductor nanostructures have great benefits as well. For instance, isolation of definite number of quantum dots (QD) is more convenient while the adjustment of semiconductor nanostructures electronic and optical properties are achievable by application of external agents such as magnetic field, temperature as well as variation of dimensions [6, 7, 8, 9, 10, 11, 12].

As a great result of progress in nano-technology, electronic and opto-electronic devices are becoming smaller, faster and more efficient mostly due to use of low-dimensional semiconductors which can

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