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# Effects of external perturbations on light absorption by light/heavy hole excitons in a semi-parabolic quantum well

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ABSTRACT

The effects of electric, magnetic, and intense terahertz laser fields on optoelectronic properties are investigated in a GaAs/$Al_xGa_{1-x}As$ semi-parabolic quantum well. The binding energy, exciton light absorption coefficients, interband transition energies, and dipole elements in the matrix are studied within the structure of the parabolic band and effective-mass approximations. The transition energy difference between the ground-state electron energy level and the ground-state heavy hole (light hole) energy level and matrix elements are carried out as functions of external perturbations with a constant well size. The results exhibit that the exciton binding energies of heavy and light holes reduce as long as the laser dressing parameter is larger. The optical absorption of light hole exciton in the system is stronger than the heavy hole exciton. And the excitonic energies, transition energies, and absorption coefficients are much more sensitive and controlled by changing the external perturbations.



## 1. Introduction

Quantum size effects can be observed in any reduced dimensional system due to the confinement of charge carriers in various directions. It is well-known that when the symmetry of the confinement potential of the systems is broken, the quantum confinement effect will enhance the electronic and optical properties of these systems. The triangular QW is the most typically asymmetrical 2D low-dimensional system. Also, the SPQW is another kind of asymmetrical structure that has attracted the attention of many researchers recently. These asymmetrical structures lead to the formation of discrete energy subbands. As a result, the electronic and corresponding optical properties of the system alter drastically, and their novel properties can be applied in efficient optical devices. The quantum effects are more pronounced when the wavelength of charge carriers is comparable with the spatial confinement length. To understand the fundamental physics associated with the optoelectronic properties of the charged carriers in low-dimensional systems, many theoretical and experimental research activities have been performed [1–5]. Practically, any low-dimensional semiconductor system can be fabricated with the desired sizes thanks to modern technologies such as molecular beam epitaxy, organic vapor deposition, electron lithography, and so on. The optical responses, in these systems, have contributions from different electronic energy band processes. The interband optical transition takes place between the occupied and unoccupied states when the system is irradiated with an electromagnetic signal. Then, the response related to electron-hole pairs in the system can be modified by taking into consideration of spatial confinement and external perturbations such as electric fields, magnetic fields, hydrostatic pressure, intense laser fields, and temperature.

Among the many optical properties investigated, light absorption has received much attention. The third-order nonlinear optical transition has been investigated theoretically with and without the exciton effects in many quantum well systems. With the use of the compact density matrix method, optical transitions were analyzed showing that the absorption coefficient is enhanced with the inclusion of exciton effects [6] provided the change of profile of any quantum well can lead to significant changes in subband energies and related wave functions, a diversity of properties is obtained. Eventually, the various-shaped quantum wells are given quite attention for different potential applications. The optical absorption coefficients have been studied in the GaAs/GaAlAs symmetric coupled quantum wells showing that structural parameters strongly affect the optoelectronic parameters [7].

Nonlinear optical properties are considerably enhanced in semi-parabolic quantum wells (SPQWs) due to their asymmetric con-

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