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Parabolic–Gaussian Double Quantum Wells Under a Nonresonant Intense Laser Field

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Abstract: In this paper, we investigate the electronic and optical properties of an electron in both symmetric and asymmetric double quantum wells that consist of a harmonic potential with an internal Gaussian barrier under a nonresonant intense laser field. The electronic structure was obtained by using the two-dimensional diagonalization method. To calculate the linear and nonlinear absorption, and refractive index coefficients, a combination of the standard density matrix formalism and the perturbation expansion method was used. The obtained results show that the electronic and thereby optical properties of the considered parabolic–Gaussian double quantum wells could be adjusted to obtain a suitable response to specific aims with parameter alterations such as well and barrier width, well depth, barrier height, and interwell coupling, in addition to the applied nonresonant intense laser field.

Keywords: parabolic–Gaussian potential; double quantum well; intense laser field

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1. Introduction

It is very important to construct the ideal potential energy function of diatomic and/or polyatomic molecules. The greater the number of parameters in the potential energy function, the better the fit with the experimental results. The potential energy function proposed by Morse in 1929 [1] was used to study diatomic and polyatomic molecules [2]. In addition, potential energy functions such as Rosen–Mors, Manning–Rosen, Schiöberg, Tietz, and modified Lennard–Jones that are used for diatomic molecules were also established and successfully used to directly fit the experimental results to some diatomic molecules [3–6]. Double quantum wells such as quartic [7], Konwent [8], Razavy [9], and Manning [10] were also some proposed potential energy functions to probe diatomic molecules.

Quantum wells are widely applied to light-emitting devices and lasers. Quantum-well-based light-emitting diodes (QW-LEDs) use a quantum-well structure to improve their performance. There are several types of QW-LEDs, including single-quantum-well (SQW), multiple-quantum-well (MQW), and superlattice LEDs. QW-LEDs have several advantages over traditional LEDs. Because the quantum well is so thin, it restricts the motion of electrons and holes, which improves the efficiency of the recombination process that produces light, resulting in brighter and more efficient LEDs. QW-LEDs also have a narrower emission spectrum than that of traditional LEDs, rendering them useful in applications where specific light colors are required, such as in traffic lights and electronic displays. They are also used in high-speed optical communication systems where their narrow spectral width and high modulation speed are important. The tuneability of the inherent band gap of III nitride materials renders them attractive for white light-emitting diodes (WLEDs) that are considered the next-generation solid-state lighting sources. In