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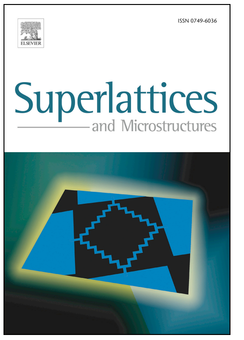

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Solitons in two attractive semiconductor nanowires

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Abstract
In this paper, by using two semiconductor nanowires attracted to each other by means of Lorentz force, we construct through similarity transformations, explicit solutions to the coupled nonlinear Schrodinger equations (CNSE) with potentials as a function of time and spatial coordinates. We find explicit solutions of electrons and holes such as periodic, bright and dark solitons. We also study the instability of the modulation (MI) of (CNSE) and note that the velocity of the electrons influences the gain MI spectrum.

Keywords: Semiconductor nanowires, coupled nonlinear Schrodinger equations, Soliton, Modulation instability.

1.Introduction

Used daily in electronic gadgets, that surround us, semiconductors are ubiquitous in nowadays technology. They are used in the conception of electronic devices such as diodes, transistors, thyristors, integrated circuits just to name a few which are the support of many electronic systems. The main goals of actual technology is the reduction of the geometry of electronic devices so to reduce their energy and material consumption. The incoming of nanotechnology by the discovery of carbon nanotube in 1991 by the Japanese physicist Sumio Lijima [1] and its realization by Ebbesen and Ajayan in 1992 , has given birth to a new approach about using semiconductor: semiconductor like nanostructure. The physics of nanostructure is that interdisciplinary field of research, which use, theoretical and experimental methods to determine the physical properties of materials in the nanoscale size range. Those properties encompass the structural, electronic, optical, and thermal behavior of nanomaterials. These also include electrical and thermal conductivity, the forces between nanoscale objects; and their transition from classical to quantum behavior [2].

There are so many quantum or nanodevices. Some of the most famous are those based on semiconductor materials. Generally, semiconductor nanostructures are divided into: semiconductor quantum wire, semiconductor quantum well and semiconductor quantum dot [3]. The main principle of nanostructures construction relies on the reduction of dimensionality. This leads to the confining of electrons and holes yielding a dramatic change in their behaviors. Thence, in a quantum well, carriers are confined in one dimension, where they possess two degrees of freedom [3,4]. In quantum wire the confinement is extended to two dimensions and the degree of freedom is reduced to one [3-5]. Carriers in quantum dot do not possess any degree of freedom for they are confined in all the three spatial dimensions [3,4]. The confinement are generally achieved by applying potentials which could be either infinite, periodic or random. This leads the carrier, to behave quantumly.

It has been asserted that classical magnetic fields can control the quantum behavior of particles [6,7].This has been demonstrated by experimental work achieved on atoms by classical magnetic fields [8,9]. Also, recently classical magnetic field has be used through Lorentz force acting on n-relativistic spin quantum bits to generate a quantum logic gate [10]. In addition, Monica Tanase [11-12], Lin and co-workers have respectively assembled nanowires using a magnetic field and a Direct current electric field. Moreover, Lorentz force has been used to generate artificially superconductors by pairing two spatially separated holes carriers moving in two leads [13].

Semiconductors are nonlinear and dispersive media in which some interesting phenomena can occur, for example the propagation of solitons. Ramy El-Ganainy and co-workers have demonstrated that optical solitons can propagate in AlGaAs nanowires [14]. To the best of our knowledge, due to the fact that electrons and holes in semiconductors are subject to linear Schrödinger equation, it is difficult to study theorically solitary carriers behaviors in semiconductors nanowires. Therefore, we think about coupling carriers of two adjacent nanowires by mean of Lorentz forces. This artificial interaction leads to derive a nonlinear equation modelling the behaviors of carriers.

Most physical phenomena are modeled by nonlinear partial differential equations such as: Korteweg-de Vries equation, Sine-Gordon equation, Nonlinear Schrodinger equation, Ginzburg-Landau equation just to name a few.