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Research articles

Spin polarization rate calculation for T-shaped double quantum dots coupled to (C- terminated ScC(1 1 1) surface) leads

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ABSTRACT

The device considered in our study is the T-shaped double quantum dots system embedded between two ferromagnetic (C-terminated ScC (1 1 1) surface) leads. The theoretical treatment is achieved using the time-evolution operator approach. The role of the time-dependent external field, spin-dependent coupling interaction and energy spacing on the dots in spin transport through the device considered in our study has studied. The spin accumulation on the quantum dots, the spin and total currents and the spin polarization rate of the device have calculated. The imprint of the leads density of states is very obvious in the time window calculation which increases with the energy spacing and the frequency of the time-dependent external field. Our results indicate that time-dependent external field and spin-dependent coupling interaction play important role in manufacturing full spin polarization and controlling the spin polarization rate in the device. Controlling the spin transport features have many potential applications in spin-based quantum devices such as quantum computing and spin filter devices.

1. Introduction

Over the past 20 years, considerable literature has appeared around nano-spintronics and witnessed a dramatic increase in interest by scientists. The application of nanotechnology in this field has opened the door to new horizons and novel phenomena [1]. Traditionally, the classic method of spin generation in QD system points out to the spin injection technique, which constantly based on the application of ferromagnetic contact or magnetic field [2–6].

Generally, the tunneling effects, quantum interference, and quantized energy levels can often have key roles in the charge and spin transport processes [1,2]. The modern emerging field deals with the effective manipulation of the electron's charge and spin, this will led to add a spin degree of freedom to the conventional charge-based technology, which has the prospective features of multi-functionality [7]. Recently, spin-polarized in semiconductor quantum dots (QDs) is considered one of the phenomenon which has offered major attention because it is the pivotal component in the generated field of spintronics and many quantum computation schemes [8,9]. Moreover, the future objective of generating and control both spins in QD systems can create a promising style to nano-spintronics tools, particularly, in quantum computer units and quantum data. All of these potentials can led to suggest a great number of theoretical and experimental researches. [10–17].

Furthermore, the transport properties of double quantum dots (DQDs) have newly attracted several interests between scientific communities [18]. Due to the behavior of such systems which mimics of the behavior actual molecules, DQDs can be considered the typical area to inspect diverse correlations within the nano-scale. When just one of the dots can directly connect to the leads, whilst the other dot can indirectly link via the first dot, the interference which happens for these different conduction pathways probably lead to produce the Fano effect [19]. Another interesting effect can happen in the presence of an external magnetic field. Data has indicated that the conductance via this system leads to fully spin-polarized, and it can be monitored the sign and degree of spin polarization by tuning the position of the DQD's levels [10]. A theoretical study to explore the spin transport is introduced for T-shaped double quantum dots embedded between two ferromagnetic leads, which still needs more investigations to verify the impact of the time-dependent external field. The ferromagnetic leads considered in our study are C-terminated ScC (1 1 1) surfaces [20]. The spin accumulation, total and spin currents and spin-polarization rate are calculated since the role of the time-dependent external field and the energy spacing to control spin transport are investigated.

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