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Theoretical Investigation in Coherent Manipulation throughout the Calculation of the Local Density of States in FM-DQD-FM Device

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Abstract. In this work, theoretical investigation in coherent manipulation throughout local density of states calculation for serially coupled double quantum dots embedded between ferromagnetic leads (FM-DQD-FM) by using the non-equilibrium Green's function approach. Since the local density of states are formulated incorporating the spin polarization and the type of spin configuration on the leads. Our model incorporates the inter-dot hopping, the intra-dot Coulomb correlation, the spin exchange energy and the coupling interactions between the quantum dots and leads. The results concerned to the parallel configuration at strong inter-dot coupling regime show that the spin down electrons in the quantum dots may be more coupled coherently if the regime is tuned. The local density of states of the two dots for spin up electrons shows decoherent state. In the weak interdot coupling regime, it is obvious that the spin dependent density of states on the quantum dots show that the resonances are not well splitted. For the antiparallel configuration in the strong coupling regime, the spin dependent density of states of the double quantum dots show four peaks but with broad and overlapping.

Introduction

Magnificent developments in nanotechnology have opened up a wide field of studies that based on the electronic structure of semiconductor quantum dots. In semiconductor quantum dots, the conduction band electrons are confined at the semiconductor interface to zero dimensional systems [1-3]. In few electrons quantum dots, the electrons form shells of electronic density, like in atoms. For this reason the quantum dots (QDs) are often called “artificial atoms” [4].

Because of their interesting properties and their applications in nanotechnology, attention has been focused in last years on properties of the coupled quantum dot systems, where the small size and low power dissipation have stimulated a number of proposals for their use in spintronic devices and as qubits for future quantum computers [5-7]. The type of coupling between the QD’s determines the character of the electronic states and the transport properties of the artificial molecule [8]. In the tunneling regime, the electronic states are extended across the entire system and form coherent states based on the bonding or antibonding levels of the QDs. In the presence of an interdot coupling, coherent electron states can extend over the whole double quantum dot (DQD) system, like the formation of chemical bonds in molecules [9]. Depending on the strength of the interdot coupling, the two dots could be ionic like (weak tunnel coupling) or covalent like bonds (strong tunnel coupling). In the case of ionic bonding the electrons are localized on the individual dots. The binding occurs, because a static redistribution of electrons leads to an attractive Coulomb interaction. Electrostatically coupled quantum dots with weak interdot tunnel conductance are covered by ordinary Coulomb blockade theory [10]. Two electron states are quantum mechanically coupled in the case of covalent bonding. The key prerequisite for covalent binding is that an electron should tunnel in a phase-coherent manner several times between the two dots. The electron should not be considered here as a particle residing in a single dot, but it must be thought of as a coherent wave that is delocalized over the two dots. The bonding state of a strongly coupled