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Electron tunneling through serially coupled double quantum dots: The coulomb blockade

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Abstract: In this paper we investigate the Coulomb blockade in the electron tunneling through a serially coupled double symmetric quantum dots. All the transport properties such that, the virtual energy levels of the two dots with the corresponding occupation numbers, the tunneling current and the differential conductance are calculate at the case where the interaction between the quantum dots and the leads is weak. From results we find numerically the shape of the coulomb blockade peaks in differential conductance as a function of bias voltage. Finally, we have focused our attention on the effect of the effective exchange interaction on the shape of the differential conductance in blockade regime. Our calculations that related to the Coulomb blockade make it sure that one can use the molecular quantum dots as an electronic switch.

Keywords: Molecular Quantum Dots; Coulomb Blockade; Effective Exchange Interaction.

1- Introduction

Quantum dot structures, where electrons are confined three-dimensionally in nanometer scale, show characteristics quite different from conventional bulk structures. In recent years, double-quantum-dot (DQD) systems have attracted much attention because of their importance in physics and device applications [1–3]. And one of these applications, which is for DQD is used in quantum computer technology [4,5]. It can also used as a noise detector [6]. Also, DQD system is exploited in optical spin manipulation [7]. On the one hand, DQD systems provide an ideal model system for studying the two-impurity effect, which has long been the highlight of condensed matter physics. On the other hand, a series-coupled DQD can cross over from the weak tunneling coupling regime to the strong tunneling coupling regime by varying the dot–dot coupling strength. Electron tunneling in a mesoscopic structure may be significantly affected by charging effects. The charging suppresses tunneling if the charge spreading is impeded by weak links or by a special geometry of the structure. Such a suppression of tunneling is commonly referred to as the Coulomb blockade. In a general definition, the Coulomb blockade (CB) is the increasing of resistance at small bias voltage of an electronic device. And because of the CB the resistance of the device has no constant value at low bias voltage, but it increases to infinity for a bias under a certain value current flow [8]. CB provides the back ground for the spin blockade (some times called Pauli's blockade) which includes quantum mechanics effects due to spin interactions between electrons. In any disposing of two conducting leads connected to a quantum dot in between not only has a resistance, but also has a finite capacitance (c), then the tunnel junction between leads behaves as a capacitor. As we know that the electronic charge is discrete then the current passed through the tunnel junction is a sequent of events in which one electron tunnels through the tunnel barrier. As the electron pass the tunnel junction the capacitor is charged with one electron causing a voltage buildup equal to e/c [9], if the capacitance is very small