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ORIGINAL PAPER

Magnetic field effect on the electron transport through a spherical quantum dot

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Abstract: The influence of magnetic field on the electron transport through a quantum dot embedded between two normal (non-magnetic) leads has been studied. The energy levels of the quantum dot, the occupation numbers, the broadening, the correlation energy and linear conductance have been calculated as a function of gate voltage. The related functions which are spin-dependent have been solved self-consistently. The transport through a quantum dot for weak and strong coupling regimes has been investigated. The calculations have been performed with and without a constant bias voltage, which was applied to the right lead.

Keywords: Anderson model; Quantum dot; Magnetic field

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1. Introduction

In recent years, quantum dots have attracted the attention of many experimental and theoretical research groups. Theoretically, quantum dots represent ideal systems to study electron dynamics and correlation. Technological advances in the manufacture of nanostructures made it possible to confine electrons in all three spatial dimensions of semiconductor quantum dots. In such small structures, the electrons are at completely separate energy levels. In quantum dots, the number of electrons can be changed experimentally and thus quantum dots are used to study a large variety of many-body effects.

Many researchers [1–7] considered the quantum dot connected to two leads similar to magnetic impurity in a metal. The impurity Anderson model and several theoretical methods have been used to analyze the phenomena in quantum dots [8–17].

In this paper, theoretical study for the magnetic field effect on the electron transport through a spherical quantum dot has been performed.

2. Theoretical treatment

2.1. Preface: the system under consideration

This section represents a model calculation which is based on a single-impurity Anderson model due to its ability to determine the charge and spin on the impurity. Single impurity has been modeled as single-level quantum dot to study the electron tunneling process through it. Its occupation numbers and the conductance are formulated as a function of all important "chemisorptions" functions and parameters (leads temperatures, bias and gate voltages) related to the tunneling process. Quantum dot properties and environment properties, which determine the strength of the couplings with the quantum dot, have been taken into consideration.

2.2. The system Hamiltonian

The single-impurity Anderson model (SIAM) is a paradigm of a strongly correlated electron system [18]. This seemingly simple model gives rise to dynamical screening of the local spin by the electrons in the Fermi sea, leading to a crossover from a weak coupling system at high temperatures to a strongly coupled one at low temperatures, with the relevant temperature scale given by Kondo temperature T_K. While the high-temperature behavior of the SIAM can

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