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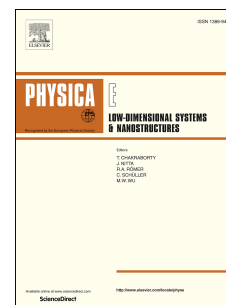
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A T-shaped double quantum dot system as a Fano interferometer: interplay of coherence and correlation upon spin currents

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Abstract

Based on Keldysh non-equilibrium Green function method, we have investigated spin current production in a hybrid T-shaped device, consisting of a central quantum dot connected to the leads and a side dot which only couples to the central dot. The topology of this structure allows for quantum interference of the different paths that go across the device, yielding Fano resonances in the spin dependent transport properties. Correlation effects are taken into account at the central dot and handled within a mean field approximation. Its interplay with the Fano effect is analyzed in the strong coupling regime. Non-vanishing spin currents are only obtained when the leads are ferromagnetic, the current being strongly dependent on the relative orientation of the lead polarizations. We calculate the conductance (spin and charge) by numerically differentiating the current, and a rich structure is obtained as a manifestation of quantum coherence and correlation effects. Increase of the Coulomb interaction produces localization of states at the side dot, largely suppressing Fano resonances. The interaction is also responsible for the negative values of the spin conductance in some regions of the voltage near resonances, effect which is the spin analog of the Esaki tunnel diode. We also analyze control of the currents via gate voltages applied to the dots, possibility which is interesting for practical operations.

Keywords: Double quantum dot device, Fano resonance, Correlations, Negative spin conductance

1. Introduction

During the last decade, abundant research has been conducted, both theoretically and experimentally, on spin dependent transport properties in hybrid nanosystems with quantum dots (QDs) in their structure. A sample of representative papers is given in [1, 2, 3, 4], and references therein. The growing interest is twofold, basic research and potential applications in new spintronic devices [5, 6]. QDs with a few number of electrons simulate artificial atoms, and as such, they display charge energy effects when extra electrons are added to the dot, promoting some electrons to higher level states. They are excellent prototypes to study electron-electron (e-e) correlations in confined systems, and one can probe fundamental many-body effects when QDs are coupled to charge reservoirs (leads). By applying gate voltages to the dots, one

can tune the dot barrier height. For very high barriers (weak coupling), the transport is dominated by electron-electron interactions in the so called Coulomb-blockade regime, where the transport is suppressed unless energy is provided to overcome the Coulomb repulsion when adding an extra electron to the dot. At intermediate coupling between the QD and the leads, one decreases the confinement of the barriers, and tunneling effects and spin interactions dominate over the Coulomb interactions. The transmission through the dot broadens, leading to Kondo resonance peaks. The effect has been observed when the dot develops a net spin due to odd-electron occupancy [7, 8]. The signature of the effect is the unitary limit of the conductance at low temperatures and zero bias, *i.e.* $G = G_0$, with G_0 being the quantum of conductance. This Kondo resonance would be strongly modified when quantum interference is allowed in the nano-structure. This is the case in systems, whose topology allows the interference of a ballistic channel with the

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