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Magnetoconductance through a small nonlinear one-dimensional system

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Abstract

We study the effect of Coulomb correlation on the transmission properties of a one-dimensional chain connected to two perfect leads in the presence of a static magnetic field. Due to the presence of a strong on-site nonlinear interaction between two opposite spins within the chain, the zero-voltage conductance exhibits strong correlations between parallel and antiparallel spin conduction channels which results in a substantial spin polarization for small chain sizes.

1. Introduction

Spin-polarized electron tunnelling has become a very active area of research due to its potential in the manufacture of magnetic field sensors and digital storage devices [1]. Usually these applications deal with nanostructure devices and consequently the mutual Coulomb interaction between electrons due to their strong confinement plays an important role. This gives rise to a nonlinear interaction which will certainly affect the transport properties of the system. Nonlinear effects have been the subject of intensive research in condensed matter physics, both from the theoretical and experimental points of view [2]. This is due, in part, to the wide range of potential applications in the design of new optical and electronic devices for computing and communications. For instance, it has been shown that nonlinearity gives rise to multistability and noise, and might originate a chaotic behaviour in certain systems. Transport properties of nonlinear chains of atoms and double-barrier structures under applied electric fields have been recently examined by Cota *et al* [3]. Their work shows that resonances shift in the presence of nonlinearity and that their width decreases as the nonlinearity becomes stronger. Nonlinearity is also relevant to transport problems in nanoscale devices [4]: it is known that the electron–electron interaction is important in any serious study of the transport properties of small systems such as quantum dots and few-impurity models [5]. Generally speaking, the Coulomb interaction gives rise to a nonlinear term in the Schrödinger equation. In this case the Coulomb interaction is modelled by a cubic, nonlocal term in the equation of motion of the corresponding fermionic field operators. To proceed further, a Hartree–Fock

