Electronic properties of a quantum wire with magnetic impurities

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The conductance and density of states (DOS) of a quantum wire which is tunnel coupled to the underlying substrate are investigated theoretically using the retarded Green's function method. The wire is composed of periodically placed magnetic and non-magnetic impurities (see Fig. 1), and is modelled by a tight-binding Hamiltonian within the mean-field approximation.

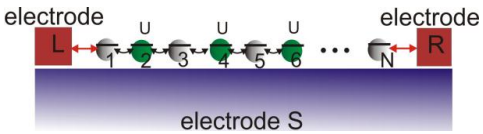

Fig. 1 Schematic view of a quantum wire consisting of N sites and coupled with the left (L), right (R) and surface (S) electron reservoirs. The wire is composed of interacting (magnetic) and noninteracting sites. In the above sketch the periodicity of impurities is m = 2.

It is shown that for a wire with periodically placed impurities a number of energy gaps in the DOS structure are observed. These gaps arise from the Coulomb correlations of the magnetic sites, U. For the case of non-periodic distributions of impurities or for vanishing U the DOS gaps of the system disappear.

Additionally, the quantum wire DOS as well as the conductance along the wire are studied for two different kinds of substrate: in one model the substrate's electronic wavefunctions are taken to be completely localized (an insulator surface) while in another model the substrate electronic wavefunctions are taken to be delocalized (a metal surface). It is interesting that for a substrate with localized electrons all energy gaps disappear with the wire-substrate coupling which is a signature of a metal-insulator transition. However, for the substrate with delocalized electrons the energy gaps survive and become somewhat wider. The conductance through the system also strongly depends on whether or not the substrate electrons are localized.