Nonequilibrium Transport Properties for a Three-site Quantum wire Model

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With advantage of fabrication techniques for nanometer scale structures, it becomes possible to create quantum wire with the diameter of the order of the Fermi wavelength, and to experimentally study the quantum transport properties through them.[1,2] We present theoretical and numerical results for nonequilibrium transport properties with a simplest model of three-site quantum wire making use of Keldysh formalism.[3-5] Some rigorous formulas in noninteracting case are provided for direct calculations. According to the numerical calculation results obtained from those formulas, we investigated the differential conductance, transport current, conductance and site electron charges of the wire in some special occasions. In the case of a uniform ingredient wire, we showed that, when the site-site couplings in wire are tougher than the wire-electrode couplings, the resonant tunneling transport takes place and the phenomenon of conductance quantization can be easily observed. Whereas when the wire-electrode couplings are tougher than the site-site couplings in wire, these quantum effects in transport will disappear gradually with the increase of the strength of the wire-electrode couplings. We also discussed the charge distributions in the three sites of the wire and the characteristics of the charge barrier (Schottky barrier) regardless of the Coulomb interaction. In the case of a wire containing impurities, the line shapes of the transport characteristics are changed because of the change of the system electronic states.

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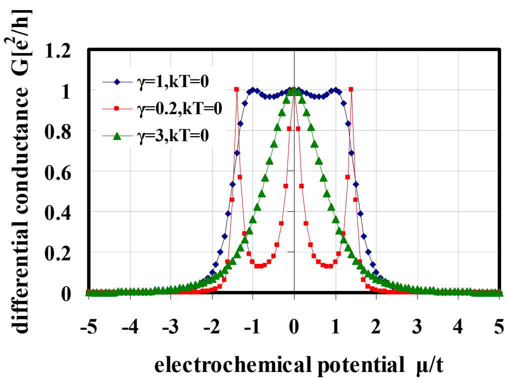

Fig.1. The differential conductance as a function of electrochemical potential μ for self energies γ= 1, 0.2 and 3, when T=0.

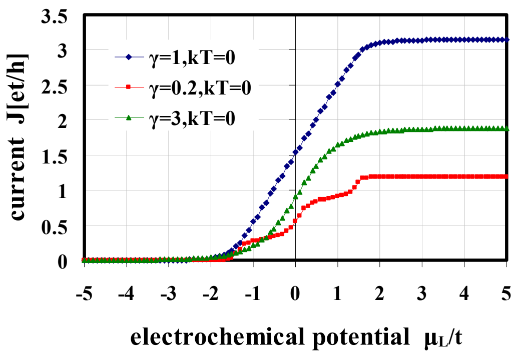

Fig.2. The transport current as a function of the electrochemical potential of the left electrode μ_L (μ_R=-5) for self energies γ= 1, 0.2 and 3, when T=0.

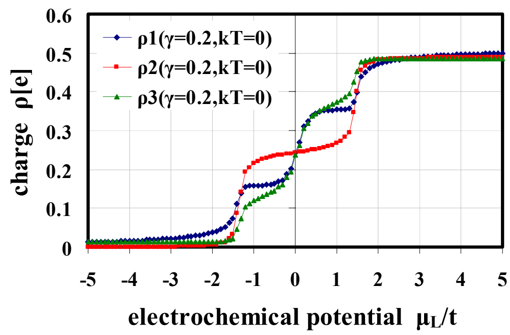

Fig.3. The charges in the three sites as a function of the electrochemical potential of the left electrode μ_L (μ_R=-5) for self energies γ= 0.2, when T=0.