Nonequilibrium Transport in Quantum Wires

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ABSTRACT

In this thesis, I present a theoretical study of the nonequilibrium transport properties of two different quantum wire structures. The quantum wires are described by the Luttinger liquid theory.

In the first part, I consider a quantum wire double barrier system with each wire segment described by a spinless Tomonaga-Luttinger model in which charge plasmons constitute the excitation spectrum. I investigate the steady-state distribution function for the central segment in the sequential tunneling regime when the system's dynamics can be described by a master equation, and show that it strongly influences the system's transport properties.

I show that the steady-state occupation probabilities at finite bias form a highly nonequilibrium distribution which depends on the electron-electron interaction strength. Especially, in the strongly interacting regime the probability distribution is a function of only the energies of the states and follows a universal form that depends on the source-drain voltage and the interaction strength. The non-equilibrium distribution of plasmons in the central wire segment leads to increased average current, enhanced shot noise, and full counting statistics corresponding to a super-Poissonian process. These effects are particularly pronounced in the strong interaction regime, while in the non-interacting limit I recover results obtained earlier using detailed balance arguments. The shot noise enhancement over the Poisson limit is explained by the emergence of several current-carrying processes, and the enhancement disappears if the channels effectively collapse to one due to, *e.g.*, fast plasmon relaxation processes.

In the second part, I study a quantum wire containing a finite scattering region formed by a confining constant potential, with the wire ends coupled to reservoirs by radiative boundary conditions. To investigate the nonequilibrium transport properties in this Luttinger liquid system, I evaluate the functional integral on a closed-time contour. This work is in progress.

Keywords: mesoscopic physics, quantum wire, Luttinger liquid, double barrier structure, shot noise, full counting statistics, strongly-correlated electrons.