Transport of interacting electrons through a double barrier

I.V. Gornyi and D.G. Polyakov

Institut für Nanotechnologie, Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany

We consider correlated electron liquid in quantum wires with impurities or artificially introduced inhomogeneities. Such systems include nanotubes, semiconductor quantum wires with small number of channels, or fractional quantum Hall edges. We concentrate on conductance through a *double barrier* (for recent experiments see, e.g. [1,2]) and study a rich variety of different transport regimes depending on the *strength* of the barrier and its *shape*, for arbitrary temperature T, down to $T \to 0$.

Focusing on the case of weakly interacting electrons, we develop a unified *fermionic* renormalization group (RG) approach to the double barrier problem, which enables us to treat on an equal footing both the resonant *tunneling* and the transmission through *weak* impurities. Our approach allows us to describe contributions to renormalized scattering amplitudes, which are absent in the case of a spatially structureless scatterer but are essential for the double barrier, also taking into account higher resonance levels.

For transport through *strong* barriers, both a sequential tunneling for high T and a resonant transmission for T smaller than the resonance width (which involves processes of *all* orders in the tunneling amplitude) are studied. For *weak* impurities, we show that two different regimes are possible. *Moderately weak* impurities may get strong due to a renormalization by interacting electrons, which in effect creates a quantum dot with tunneling barriers with a pronounced resonance peak structure. *Very weak* impurities, for which the renormalized *transmission* coefficient does not exhibit *any* peak, give a *sharp* peak in the *conductance* as a function of gate voltage, provided asymmetry is not too high. In contrast, the resonant structure is shown to be completely destroyed for a strongly asymmetric barrier.

All the regimes we study may be characterized by three different types of behavior of the conductance peak height G_p and the peak width w on T:

- for sequential tunneling, the results found earlier by a bosonic RG [3], $G_p \propto T^{\alpha-1}$ (where $\alpha > 0$ is the Luttinger interaction constant) and $w \propto T$, are confirmed within the fermionic RG approach.

For small T, the behavior of G_p and w depends on symmetry of the double barrier:

- for a symmetric barrier, $G_p = 1$ (per channel, in units of e^2/h), $w \propto T^{\alpha}$. The resonance is perfect and has zero width at $T \to 0$.
- for an asymmetric barrier, $G_p \propto T^{2\alpha}$ (i.e., the peak vanishes at $T \to 0$) and the width w saturates with decreasing T.

The approach may be extended to transport in many-impurity wires. Part of this work was presented in Ref. [4].

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