Can the conductance step of a single-mode adiabatic ballistic constriction be lower than 2e^2/h?

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Using electron beam lithography, it is possible to pattern the surface of a GaAs/AlGaAs heterostructure with a pair of "split-gate." By negatively biasing the surface split-gate, one can electrostatically define a one-dimensional (1D) constriction within a two-dimensional electron gas (2DEG). If the elastic scattering length is longer than the 1D constriction, transport through the 1D channel is ballistic and one observes conductance plateaux quantised in units of $2e^2/h$. Deviation from exact conductance quantization was observed earlier in long weakly disordered quantum wires and in the structures with nonadiabatic coupling between 2DEG and 1D wire (T-shaped cleaved-edge-overgrowth and V-groove quantum wires). In this report we show that decrease of the first conductance step is possible even if a short clean constriction is adiabatically connected to the 2DEG reservoirs.

Experimentally in the two-terminal conductance measurement of a 1D constriction within a 2DEG one has to consider a series resistance R_s which occurs as a result of ohmic voltage drop in the reservoirs. Deviation of the plateaux from exact integer multiples of $2e^2/h$ demands that the influence of the series resistance be minimised in a more precise measurement. In light of this, we perform four-terminal measurements of a 1D ballistic constriction with three overlaying finger gates. In our system, a 1D ballistic constriction can be formed by applying a negative voltage on the split-gate. By changing the finger gate voltage, we are able to modulate the potential profile within the 1D constriction. In this paper we show that the conductance steps of a 1D ballistic constriction show a gradual decrease from $2e^2/h$ to $(0.97 \times 2e^2/h)$ with increasing negative finger gate voltage as shown in figure 1. We ascribe this striking effect to the interplay between reflection in the first mode and tunneling via the second mode. We have found that the tops of the first and second subbands move with different velocities in response to the change of the split-gate voltage. This leads to a slower decrease of the reflection as compared to simultaneous increase in the tunneling, and therefore onset of the next conductance step occurs at a lower value than G=$2e^2/h$. When the negative voltage on the centre finger gate approaches zero the plateaux become more pronounced and the effect vanishes. Both simple analytical estimate and realistic modeling of the device give the same magnitude (3%) of the decrease as observed in our experiments.

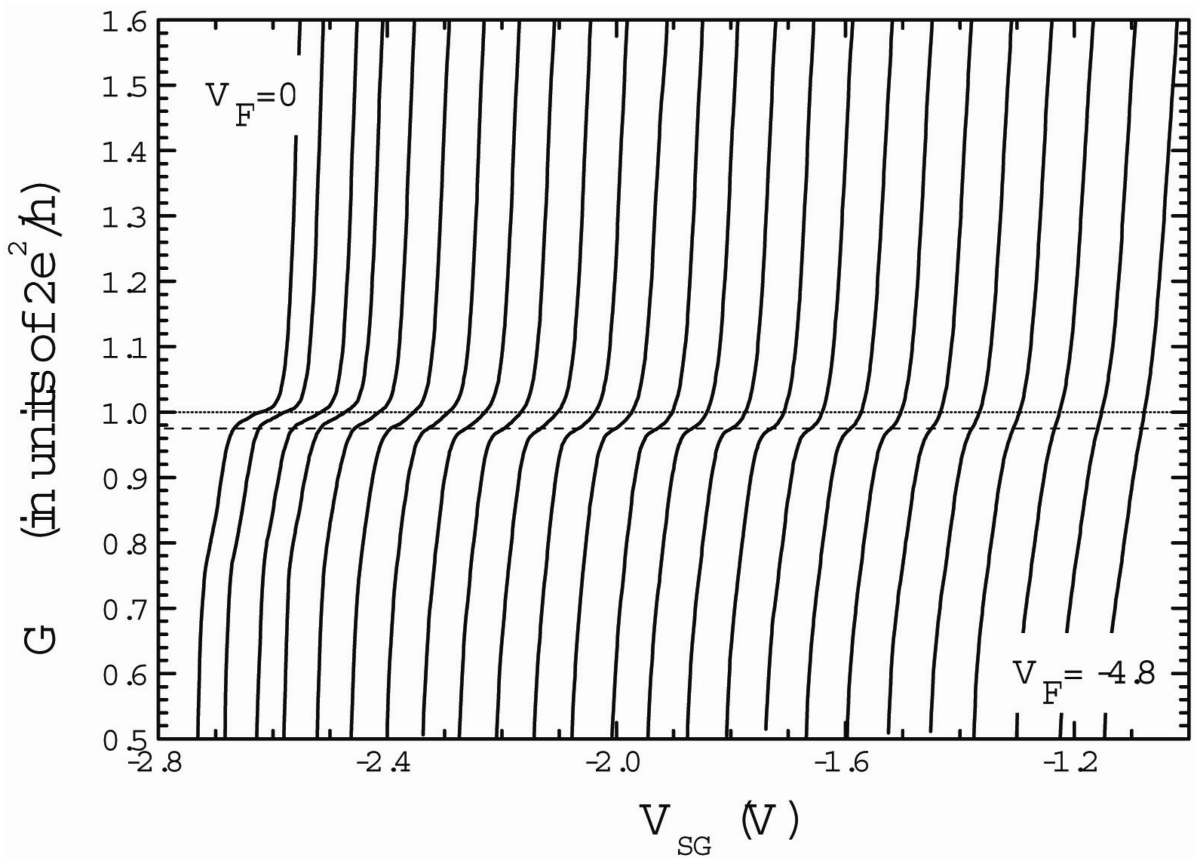

Figure 1: Conductance measurements *G* as a function of split-gate voltage (V_{SG}) at various finger gate voltages. The first conductance step shows a gradual decrease with increasing negative finger gate voltage.