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Dimensional Crossover in Semiconductor Structures: From 3D Electron Transport to Ballistic Electrons in 1D

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Abstract: Modern semiconductor technologies have made possible special devices in which a gradual dimensional crossover may be induced by means of applied electric fields. Two specific examples are described. The first one is a special GaAs field effect transistor in which the thickness of the active electron gas layer may be varied by external voltages. With decreasing layer thickness transverse states become quantized and by depopulating the corresponding subbands a tunable dimensional crossover from 3D to 2D is achieved. The second example describes how a 2D to 1D crossover may be obtained in high-mobility split-gate GaAs/AlGaAs heterostructures. Effects of interactions in long wires, the nature of spontaneous magnetization and quantized conduction are discussed. Anomalous features in the conductance are modeled by means of the local spin density approximation for a realistic split-gate device. Advantages and disadvantages of this method are discussed.

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