Transport in Nanostructures

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The focus of this tutorial is on electronic transport in nanostructure systems. We start with a general overview of the important effects that are observable in small systems that retain a degree of phase coherence. These are also compared to the needs that one foresees in future small electron devices. This is followed by a general introduction to quantum confined systems, and the nature of quasi-two-, quasi-one- and quasi-zero-dimensional systems including their dielectric response and behavior in the presence of an external magnetic field, followed by an overview of semi-classical transport in quantum wells and quantum wires including the relevant scattering mechanisms in quantum confined systems. The concepts of quantum mechanical flux, reflection, and transmission are introduced and applied towards understanding of quantum wave guide systems, which introduces the tunneling/transmission connection upon which the Landauer formula is based. The concept of quantized conductance is introduced, and its connection to the experimentally observed conductance quantization in quantum point contacts. This is then followed by an elaboration of simulation techniques used for modeling wave guide structures and multi-terminal structures. Discussion will also focus on nonequilibrium transport in nanostructures, some of the experimental observations, and theoretical descriptions thereof. Finally, we focus on quantum dot structures beginning with their electronic structure, and then the experimental results and theoretical formalism related to single electron effects in such structures such as Coulomb Blockade. This is followed by discussion of more complicated systems of multiple quantum dots, and transport through such structures.

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