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Adiabatic Quantum Pumping of Coherent Electrons

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Abstract: We review recent theoretical calculations of charge transfer through mesoscopic devices in response to slowly-oscillating, spatially-confined, potentials. The discussion is restricted to non-interacting electrons, and emphasizes the role of quantum interference and resonant transmission in producing almost integer values (in units of the electronic charge e) of the charge transmitted per cycle, Q. The expression for the pumped charge is derived from a systematic expansion of the system scattering states in terms of the temporal derivatives of the instantaneous solutions. This yields the effect of the modulating potential on the Landauer formula for the conductance in response to a constant bias on one hand, and the corrections to the widely-used adiabatic-limit formula (in which the modulation frequency is smaller than any electronic relaxation rate) on the other hand. The expression for Q is used in connection with simple models to exemplify the intimate relationship between resonant transmission through the mesoscopic device and almost integral values of Q, and to analyze the charge pumped by a surface acoustic wave coupled to a quantum channel by the piezoelectric effect.

Key Words: interference in nanostructures, quantum pumping, surface acoustic waves, resonant transmission

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