Quantum-mechanical derivation of Master equations for non-equilibrium transport

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We present microscopic quantum-mechanical derivation of Master equations for non-equilibrium electron transport in mesoscopic systems with time-dependent Hamiltonians. In the case of time-independent Hamiltonians, these equations become Markovian, but only in the strong non-equilibrium limit, or near the steady-state. Otherwise they are in general non-Markovian. The derivation is extended for open systems, where the environment is treated quantum-mechanically, as well. Since the resulting equations describe the system and the environment at once, they are very useful for study back-action of the system on the environment and its relation to quantum measurements. An example of qubit's measurements with a single-electron transistor (representing the measurement device) is presented. Our approach allows us to evaluate the qubit's decoherence rate as a function of the bias voltage and temperature.

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