Charge Fluctuations and the Quantum Efficiency of Mesoscopic Detectors

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In mesoscopic physics arrangements in which the detector is also a mesoscopic structure and is directly integrated with the sample have become of increasing interest. We consider the case where a mesoscopic conductor is used as a detector to measure the relaxation and decoherence of a time-dependent superposition of states of a double-quantum dot. We develop a scattering theory of mesoscopic detectors [1]. We analyze the quantum efficiency of mesoscopic multichannel detectors. A detector is efficient if it permits to extract a maximum of information while at the same time introducing a minimum of decoherence into the measured system [1].
To maximize the efficiency all information on the system contained in the detector which is not actually measured has to be eliminated [2]. We have found a new condition for maximum efficiency which is important in multichannel detectors. Our theory provides an electrically self-consistent treatment of the detector [3] and expresses the relaxation rate and the dephasing rate in terms of (electro-chemical) capacitances and equilibrium and non-equilibrium charge relaxation resistances.

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