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Quantum Mesoscopic Physics of Electrons and Photons[1]

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We first review basic notions of coherent quantum transport at the mesoscopic scale for both electronic and photonic systems. We then show that successful descriptions developed for coherent electronic transport (e.g. weak localization and UCF) and thermodynamics (persistent currents), noise and full counting statistics can be extended and applied to the study of Quantum Electrodynamics of quantum conductors and of quantum optics based on photons emitted by such conductors. In this context, we discuss the two following specific problems : (1) Ramsey fringes and time domain interference for particle creation form a quantum vacuum with a specific application to dynamical Coulomb blockade. In that setup, the current noise of a coherent conductor is biased by two successive voltage pulses. An interference pattern between photon assisted processes is observed which is explained by the contribution of several processes to the probability to emit photons after each pulse. Recent experiments in this context will be discussed. (2) Quantum emitter coupled to a fractal environment. A new and unexpected type of oscillatory structures for the probability of spontaneous emission has been obtained which results from the fractal nature of the quantum vacuum. When applied to the case of a tunnel junction as a quantum emitter of photons, the same oscillatory structure arises for the conductance of the tunnel junction.

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