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Quantum coherence, dissipation and charge quantization in mesoscopic circuits

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Real quantum systems never live in isolation but are embedded in surrounding media. An impressive example is cavity quantum electrodynamics (cQED) which deals with the interaction of atoms with light quanta or the electromagnetic vacuum in optical cavities. Its more recent realization is circuit-QED, where atoms are replaced by `artificial atoms', particularly designed (often superconducting) two-level systems, in microwave cavities.

The theory of quantum electrodynamics, however, has a much broader range and implies the interaction of fermionic with bosonic matter in general. In solid state physics, one of the most interesting processes is the transfer of charges due to external voltage sources. Particularly, in quantum electronics fascinating progress has been achieved in the last decades with accurate control down to the level of individual charge carriers.

Activities to combine these two previously basically distinct fields, circuit-QED and quantum electronics, have appeared only very recently, both in experiments and theory. This opens a new playground to study a wealth of phenomena close and far from thermal equilibrium including quantum-classical crossovers, Coulomb blockade, nonlinear resonances, squeezing and photon entanglement. In this talk I will first discuss experimental developments and theoretical challenges, and then focus on specific examples.