Strong back-action of a linear environment on a single electronic quantum channel

F.D. Parmentier, A. Anthore, H. le Sueur, S. Jezouin, U. Gennser, A. Cavanna, D. Mailly, and F. Pierre

CNRS / Univ. Paris Diderot, Laboratoire de Photonique et de Nanostructures (LPN), route de Nozay, 91460 Marcoussis, France

Establishing the quantum laws of electricity in mesoscopic circuits is a formidable task in fundamental physics, which has also direct implications in the quantum engineering of nanoelectronic devices. A striking effect of these laws is the reduction of the conduction of a quantum coherent conductor when it is inserted in a circuit. This phenomenon, called environmental Coulomb blockade, results from the circuit back-action in response to the granularity of charge transfers across the coherent conductor. Although extensively studied for a tunnel junction in a linear circuit, it is only fully understood for arbitrary short coherent conductors in the limit of small circuit impedances and small conductance reduction.
We have investigated experimentally the strong back-action regime, with a conductance reduction of up to 90%, by embedding a quantum point contact, used as a model single quantum channel of tunable transmission, in an adjustable on-chip circuit of impedance comparable to the resistance quantum $R_K = h/e^2$ at microwave frequencies. Our experiment reveals important deviations from calculations performed in the weak back-action regime, and verifies more recent predictions. We propose a generalized expression for the conductance of an arbitrary quantum channel embedded in a linear environment.