Controlling charge quantization with quantum fluctuations

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On a simple piece of metal, charge is quantized. Yet, in most of the electronic circuits, despite the granularity of charge transfer, no hints of charge quantization remain. To observe and exploit charge quantization effects, people have realized metallic nodes weakly connected to the circuit through tunnel contacts, as, for example, in a single electron transistor. Beyond tunnel junctions, quantized charging effects can arise in circuits made of coherent conductors and strongly modify the electrical transport. So, what governs the crossover from quantized to continuous charge on a metallic node?

In this talk, I will present our experimental investigation of charge quantization in a node, when the coupling of the node to the circuit evolves from tunnel regime to ballistic regime [1]. A single electron transistor was realized where the two tunnel junctions were replaced by quantum conductors with electronic quantum channels of arbitrary transmission probabilities. The charge quantization is revealed by a periodic modulation of the circuit zero-bias conductance when sweeping the voltage applied to a gate capacitively coupled to the island, and is characterized by the visibility of conductance variations.

Theory predicts that charge quantization in the island is reduced by quantum fluctuations as the transmission probabilities τ increase, and that it is completely destroyed as soon as one conduction channel is ballistic [2]. In our experiment, we can quantitatively check this prediction by avoiding spurious direct coherence effect. It closes a long standing debate as regard charging effects in open quantum dots [3,4,5]. Finally, our data provide a blueprint for charge quantization versus transmission probabilities at larger temperature when thermal fluctuations take the lead on quantum fluctuations.

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