Counting statistics of single-electron capture by a dynamic quantum dot

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A renewed International System of Units (SI) strongly demands for a quantum-based current source relating the output current to the elementary charge e whose value will be fixed at redefinition [1]. A highly promising candidate for such a current source is the non-adiabatic single-electron pump [2, 3] exploiting a dynamic quantum dot forming out of a two-dimensional electron gas. Due to the dynamic tunnel barriers between the dot and the source/drain leads the dot can be driven by high frequencies since its population is not limited by tunneling constants. Recent measurements have qualified the pump accuracy to be better than 10^{-6} [4]. However, the exact initialization mechanism of these dynamic dots is still subject of current research.

Recently, a theoretical model of the probability of charge capture has been developed [5], including mainly three relevant energy scales for this process. These are the temperature (kT), the finite time scale for suppression of backtunneling (expressed by Γ_c) as well as the coupling of the rising source barrier to the energy levels of the quantum dot due to electrostatic cross talk (Δ_{ptb}). In the limit $\Gamma_c, \Delta_{ptb} \to 0$ the probability of charge capture follows a thermal distribution. In a second limit with $kT, \Gamma_c \to 0$, the previously predicted decay-cascade model [6] is reproduced.

To investigate these regimes and to identify the relevant processes in our samples, we combine such a dynamic quantum dot with highly-sensitive electrometers and perform counting measurements on the number of charges initialized on the dot and subsequently transferred to a measurement node. Using this architecture we are able to distinguish between these two limits and identify the decay-cascade regime as the dominating mechanism of charge capture in our sample [7]. Additionally, based on the relevant mechanism, we propose different strategies for further improvement.

Furthermore, an overview about the actual status of the self-referenced current source including an error-accounting scheme [8] will be given.

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