Realization of a time-controlled single electron source

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We have realized the electron analog of the single photon source in a two dimensional electron gas [1]. Time controlled coherent emission of single electrons is achieved on sub-nanosecond time scales providing an important missing brick for manipulating quantum information in ballistic quantum conductors [2]. As a by-product, periodic operation of the single electron source, gives a quantized ac-current in the few 100Mhz range suitable for metrology. The single electron injection is obtained using a quantum dot connected to the conductor via a tunnel barrier of variable transmission D (quantum point contact). A magnetic field $B \approx 1.3T$ is applied to the sample so as to work in the quantum Hall regime with no spin degeneracy. Only the last edge state ($\nu = 1$) is transmitted. To trigger electron emission, a potential step is suddenly applied to a top gate to compensate the dot charging energy Δ. The electron of the topmost occupied energy level is then injected from the dot to the lead formed by the edge state running along the wide 2DEG region. The injection energy above the lead Fermi energy can be controlled by the potential step height and the electron emission time τ by the QPC barrier transparency, $\tau = h/(D\Delta)$. The single electron emission time is in the range of 0.1 to 10 nanoseconds suitable for further experiments aimed at manipulating coherent single electrons. When the potential returns to its initial value, a single electron is absorbed (or equivalently a hole is emitted in the lead Fermi sea). Periodic repetition, at frequency f, of sequences of single electron emission followed by single electron absorption leads to a quantized ac current whose first harmonic is I=2ef. These experimental results are in excellent agreement with a theoretical description that will be also presented. As the dot charging energy and the QPC transmission can be obtained from independent linear measurements [3,4], no free parameter is used.

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