

# Switchyard for single electrons

**German scientists achieved to transfer very small charge "packets", comprising a well-defined number of few electrons, between metallic electrodes precisely by using a single-electron pump. A single-electron transistor, being able to resolve charge variations of a single electron or less, served as a charge detector to monitor the charge movement. The successful experiment is an important milestone on the way to the setup of a new standard for capacitance, where a capacitor is charged by a well-known number of electrons.**

The corresponding voltage can be measured using a Josephson voltage standard. Tracing the capacitance to a resistance via the quantum-Hall effect finally allows the realisation of the so-called "Quantum Metrological Triangle", which establishes a link between all three electrical quantum effects. The precision aimed at in the experiment requires the demonstrated manipulation of charge on the scale of a single electron.

Task of this metrology project is the implementation of a new capacitance standard which is based on the quantization of electrical charge in units of the elementary charge  $e$ .

The basic idea of the experiment is to charge a capacitor with a well-known number of  $n$  electrons and to measure the resulting electrical voltage  $U$ . Thus, the capacitance  $C$  of the capacitor is determined by  $C = ne / U$ . Accurate "counting" of the electrons occurs with the help of a special Single-Electron Tunneling (SET) circuit, a so-called SET-pump. If the voltage  $U$  is measured by using a Josephson voltage standard ( $U = ifh / 2e$ ), the capacitance  $C$  can be expressed exclusively in terms of the fundamental constants  $e$  and  $h$ , the frequency  $f$  and integer numbers ( $n$  and  $i$ ). Thus, the experiment enables electrical capacitance metrology on quantum basis, as it is already usual for the electrical voltage  $U$  (using the Josephson effect) and the electrical resistance  $R$  (using the quantum Hall effect).

If the experiment is performed with a relative uncertainty of  $10^{-7}$  (0.1 ppm), it opens a way to realize the "quantum metrological triangle" which is a consistency test for the three electrical quantum effects involved. The results of this experiment will impact on a future system of units which will be based on fundamental constants.

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