Switchyard for single electrons

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German scientists achieved to transfer very small charge "packets", comprising a well-defined number of few electrons, between metallic electrons 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 ofthe 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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