A quantum electron pump operating at the Josephson frequency

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A macroscopic fluid pump works according to the law of Newtonian mechanics and transfers a large number of molecules per cycle (of the order of 10^{23}). By contrast, a nano-scale charge pump can be thought as the ultimate miniaturization of a pump, with its operation being subject to quantum mechanics and with only few electrons or even fractions of electrons transfered per cycle. It generates a direct current in the absence of an applied voltage exploiting the time-dependence of some properties of a nano-scale conductor. So far, nano-scale pumps have been realised only in system exhibiting strong Coulombic effects, whereas evidence for pumping in the absence of Coulomb-blockade has been elusive. Here we report the experimental detection of charge flow in an unbiased InAs nanowire embedded in a superconducting quantum interference device (SQUID). In this system, pumping may occur via the cyclic modulation of the phase of the order parameter of different superconducting electrodes. The symmetry of the current with respect to the enclosed magnetic flux and bias SQUID current is a discriminating signature of pumping. Currents exceeding 20 pA are measured at 250 mK, and exhibit symmetries compatible with a pumping mechanism in this setup which realizes a Josephson quantum electron pump.

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