Quantum Phase Slip Phenomena in Superconducting Nanostructures

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The topic of quantum fluctuations in quasi-1D superconductors, also called quantum phase slips (QPS), has attracted a significant attention [1]. The phenomenon is capable to suppress the zero resistivity of ultra-narrow superconducting nanowires at low temperatures T«Tc [2, 3] and quench persistent currents in tiny nanorings [4]. A superconducting nanowire in the regime of QPS is dual to a Josephson junction [5]. Here we experimentally demonstrate that, being imbedded in a high-impedance environment, the I-V characteristic of such a wire demonstrates Coulomb blockade and Bloch oscillations. The latter phenomenon is dual to the well-known Shapiro effect: the voltage steps for a Josephson junction are substituted by the current steps for a QPS wire. The position of the n-th step follows the relation $I_n = n \times (2e) \times f$, where f is the frequency of external RF radiation and 2e is the charge of a Cooper pair. The effect leads to the important metrological application - the quantum standard of electric current.

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