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Authorized translation

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QUANTUM DECAY OF METASTABLE CURRENT STATES OF A SUPERCONDUCTING INTERFEROMETER

SQUIDs are widely used in metrology, for measuring power and attenuation, current and voltage, temperature, etc. [1]. Important issue in further advance of SQUID usage is the problem of enhancing their sensitivity which is limited, as commonly known, by quantum limitations.

The paper reports on studies of RF SQUIDs with high-impedance point contacts in hysteretic regime at temperature T=0.5 K. It was found [2] that the decay of metastable states of a superconductive interferometer is caused by macroscopic quantum tunneling (MQT). The comparison of the results with theory [3] shows essential disagreement in the decay probability distribution width and quantum transition temperature. This discrepancy can be eliminated in the theory of MQT for the direct conductivity contacts which are used in the experiment.

Along with MQT, we have found [4] an anomalous transparency at a certain "resonance" configuration of the interferometer potential energy.

Fig. 1 displays a set of the RF SQUID signal characteristics when the anomalous decays are observed. Note the doubling of peak-to-peak amplitude at low pumping as compared to the common peak-to-peak value at the stair. It is seen from the amplitude-frequency characteristics exploring that a periodic shift in resonance tank frequency occurs when changing the external magnetic field Φ_e like in non-hysteretic regime [5].

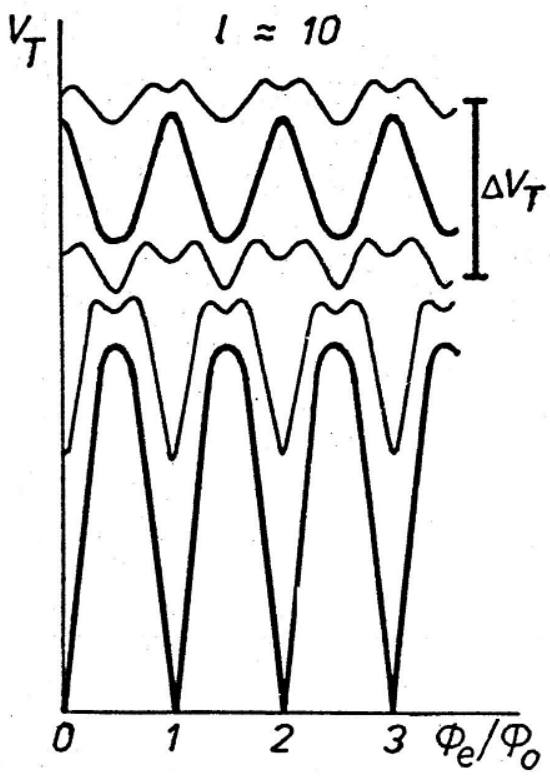

Fig. 1

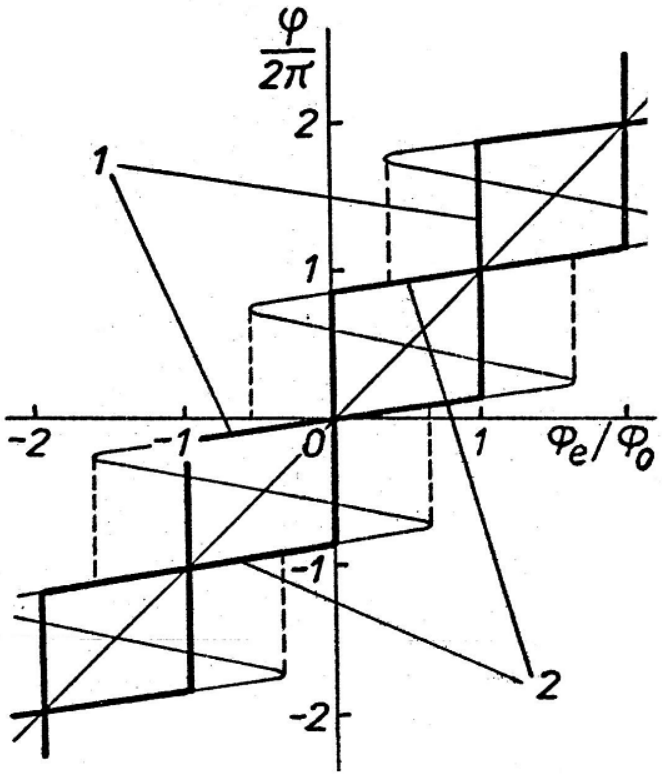

Fig. 2

The existence of the only anomalous transparency channel (reversible curve 1 in Fig. 2) would lead to the $2\Phi_0$ periodicity. In reality, there is a mutually-crossing branch (curve 2) with the same period shifted by Φ_0 relative to the first one while the branch-to-branch transitions occur in usual way. The observed characteristics can be interpreted as a superposition of the two signal characteristics shifted by Φ_0, with doubled peak-to-peak amplitudes and $2\Phi_0$ period. As the critical current rises, additional transparency channels emerge (at $\Phi_e=4\Phi_0$, $6\Phi_0$, ...) considerably complicating the experimental behavior.

Thus, a new phenomena in the interferometers is discovered, the emerging of the anomalous transparency channels that presumes the existence of macroscopic quantum coherent states separated by even number of flux quanta Φ_0. This regime enables a substantial increase in transformation coefficient and therefore in the device sensitivity.

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