JOSEPHSON DIODE EFFECT IN ASYMMETRIC HIGHER-HARMONIC SQUID

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We theoretically investigate asymmetric two-junction SQUIDs with different current-phase relations in the two Josephson junctions, involving higher Josephson harmonics. Our main focus is on the "minimal model" with one junction in the SQUID loop possessing the sinusoidal current-phase relation and the other one featuring additional second harmonic. The current-voltage characteristic (CVC) turns out to be asymmetric, $I(-V) \neq -I(V)$. The asymmetry is due to the presence of the second harmonic and depends on the magnetic flux through the interferometer loop, vanishing only at special values of the flux such as integer or half-integer in the units of the flux quantum. The system thus demonstrates the flux-tunable Josephson diode effect (JDE), the simplest manifestations of which is the direction dependence of the critical current. We analyze asymmetry of the overall $I(V)$ shape both in the absence and in the presence of external ac irradiation. In the voltage-source case of external signal, the CVC demonstrates the Shapiro spikes. The integer spikes are asymmetric (manifestation of the JDE) while the half-integer spikes remain symmetric. In the current-source case, the CVC demonstrates the Shapiro steps. The JDE manifests itself in asymmetry of the overall CVC shape, including integer and half-integer steps.

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References

[1] Ya.V. Fominov and D.S. Mikhailov, Phys. Rev. B **106**, 134514 (2022).

[2] G.S. Seleznev and Ya.V. Fominov, in preparation.