Nonreciprocal phenomena in the asymmetric superconducting interferometer with external microwave irradiation

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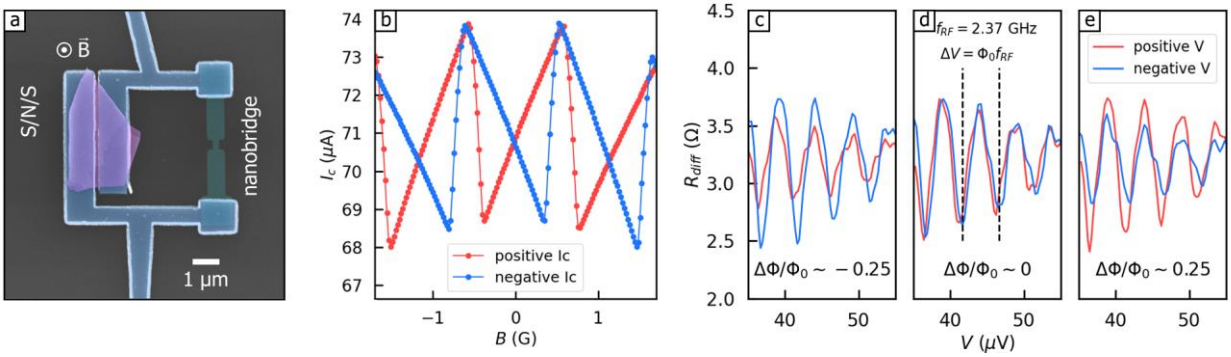
The superconducting diode effect has recently gained attention due to its relevance in fundamental research and potential in superconducting electronics [1]. Superconducting interferometers (SQUIDs) are often used to study this effect, as they allow for easy geometric asymmetry and time-reversal symmetry breaking via an external magnetic field.

Our study focuses on a SQUID intentionally fabricated from two qualitatively different types of Josephson junctions with sinusoidal and linear current-phase relation [2]. The main manifestation of the diode effect is the asymmetry of critical currents, which in our system amounted to 3%. However, in this work we go beyond conventional measurements of this phenomenon and highlight additional features of the current-voltage (I-V) characteristics — specifically, Shapiro steps that emerge under external microwave irradiation [3]. We find that in our system, the Shapiro steps display a significantly stronger asymmetry than the critical currents. Notably, this asymmetry oscillates with the SQUID's magnetic periodicity. Our experimental data enabled the development of a theoretical model that qualitatively reproduces these effects, offering deeper insight into nonreciprocal behavior in superconducting systems and potential applications across various devices and materials.



Pic.1 a) An image of the investigated SQUID; b) the diode effect in critical currents ;c–e) diode effect in Shapiro steps at different magnetic fluxes through the SQUID;

Bibliography

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