Tailoring arbitrary energy-phase relationships using Josephson tunnel junctions

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Abstract

Josephson tunnel junctions exhibit a simple current-phase relation, characterized by single harmonics. Conversely, high-transparency Josephson junctions feature multiple harmonics, with the specific harmonics depend on microscopic details of the junction, presenting a challenge for precise control.

In this talk, I will illustrate that two Josephson tunnel junctions are connected in series, their energy-phase relationship is identical to a high-transparency Josephson junction (see Fig.1 (a)).
Based on this, I will demonstrate that by connecting multiple arms in parallel and introducing a magnetic flux (see Fig.1(b)), we can systematically engineer specific current-phase relationships.

As an example, I will showcase a superconducting diode implementation with a high efficiency, a two-terminal device that controls supercurrent flow in one direction differently from the other.
The resulting superconducting diode efficiency is robust against the imperfections in the design parameters, making it practical for real-world implementations.
Beyond superconducting diodes, I will also showcase various other energy-phase relationships to demonstrate the versatility of the approach.

This technique can be useful for engineering sophisticated energy-phase landscapes for advanced quantum computing systems.

References

[1] A. Mert Bozkurt, Jasper Brookman, Valla Fatemi, Anton R. Akhmerov, SciPost Phys. 15, 204 (2023).

Figures

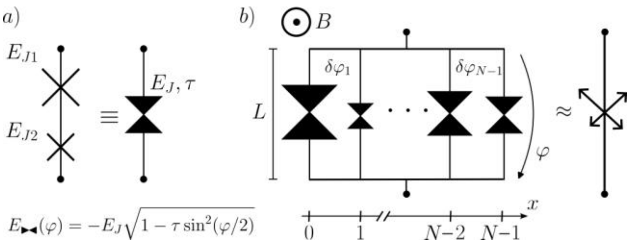

Figure 1: a) Two Josephson tunnel junctions in series is equivalent to a high transparency Josephson junction. (b) The layout of the Josephson junction array with N arms connected in parallel. Magnetic field B points out of the plane of the Josephson junction array, giving rise to phase difference between arms. We denote the resulting EPR of the Josephson junction array as a two-terminal circuit element.