Current-phase relation in Fibonacci Josephson junctions

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Quasicrystals (QCs), lattices displaying long-range order without translational periodicity, have been shown to be topologically nontrivial [1]. They feature energy gaps linked to topological invariants, harbouring edge modes under specific conditions [2]. The Fibonacci quasicrystal (FQC), a prototypical example of a one-dimensional QC, comprises an aperiodic sequence of two alternating parameters.

We consider Josephson junctions where superconductors with a finite phase difference are subjected to chemical potentials arranged in a Fibonacci sequence. The FQC arrangement, which may be implemented using local gates, introduces gaps and edge modes above the superconducting energy gap (Fig. 1a). We show that these edge modes develop superconducting correlations, with an intriguing dependence on the superconducting phase difference (Fig. 1b). This effect gives rise to a finite Josephson current which can even dominate the contribution from common Andreev bound states (ABS), see Fig. 2.

The interplay between FQCs and the Josephson effect opens new avenues for exploring exotic phenomena with important consequences in topological superconductivity.

References

[1] Kraus et al., Phys. Rev. Lett. **109**, 2012
[2] Jagannathan, Rev. Mod. Phys. **93** 2021

Figures

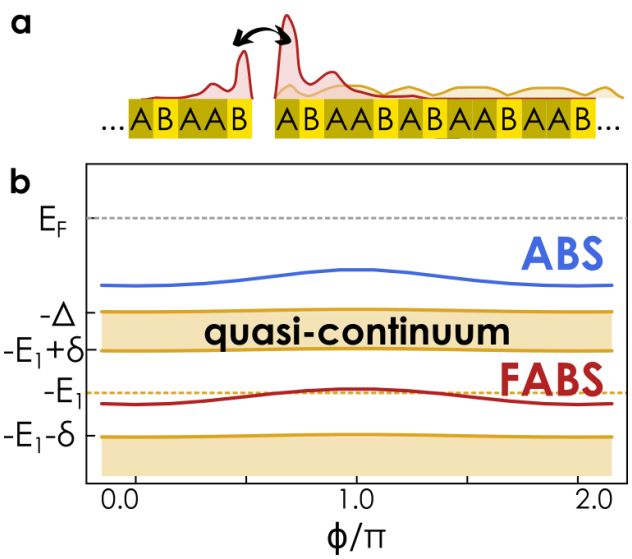

Figure 1: a Sketch of a one-dimensional FQC Josephson junction, showing a delocalized quasicrystal mode (yellow) and a localized Fibonacci-Andreev bound state (FABS) (red). **b** Energy levels as a function of the superconducting phase ϕ.

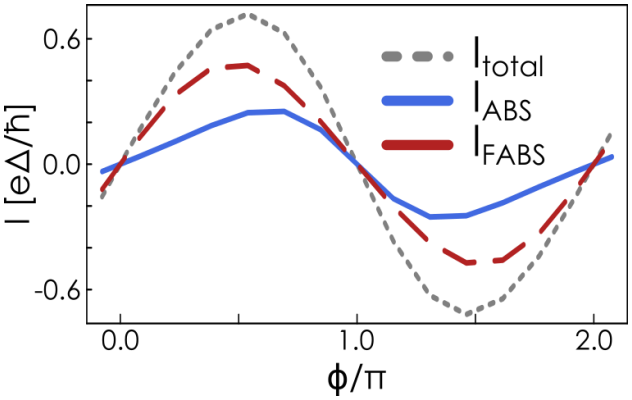

Figure 2: The FABS contribution to the supercurrent can dominate over the conventional ABS one.