Supercurrent from the imaginary part of the Andreev levels in non-Hermitian Josephson junctions

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Abstract: Non-Hermitian Josephson junctions host complex Andreev spectra. Under suitable conditions, a supercurrent contribution emerges from the imaginary part of Andreev levels. We study this effect in quantum dot junctions coupled to ferromagnetic reservoirs.

We investigate the electronic transport properties of a superconductor–quantum dot–superconductor Josephson junction coupled to a ferromagnetic metal reservoir in the presence of an external magnetic field, Fig. 1 (a). The device is described by an effective non-Hermitian Hamiltonian, whose complex eigenvalues encode the energy (real part) and the broadening (imaginary part) of the Andreev quasi-bound states. When extending the Andreev current formula to the non-Hermitian case, a novel contribution arises that is proportional to the phase derivative of the levels broadening [1,2]. This term becomes particularly relevant in the presence of exceptional points (EPs) in the spectrum, but its experimental detection is not straightforward [3-5]. We identify optimal Andreev spectrum configurations where this novel current contribution can be clearly highlighted, and we outline an experimental protocol for its detection, Fig. 1 (b, c).

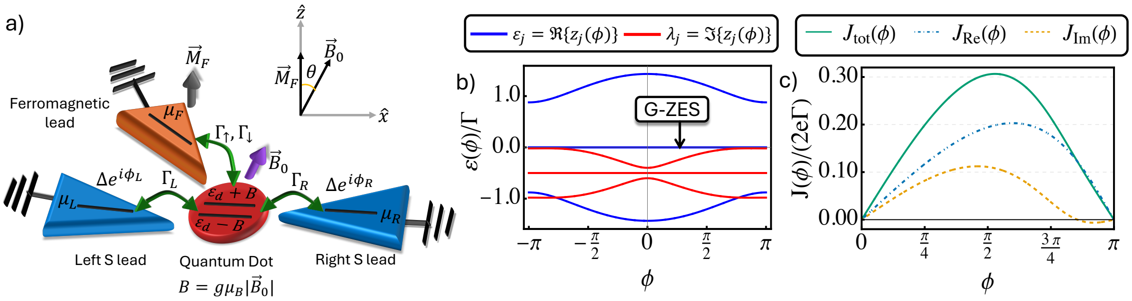

Fig. 1 In (a) the analyzed system made of a superconductor–quantum dot–superconductor Josephson junction coupled to a ferromagnetic metal reservoir in the presence of an external magnetic field. In (b,c) the Andreev levels spectrum and the current-phase relation corresponding to a system configuration where the supercurrent due to the imaginary part of the Andreev levels can be highlighted.

We point out that the phase dependence in the levels imaginary part originates from the breaking of a time-reversal-like symmetry. In particular, spectral configurations in the broken phase of the symmetry and without EPs can be obtained, where this novel contribution can be easily resolved [4]. The proposed protocol would allow to probe for the first time a fingerprint of non-Hermiticity in open junctions that is not strictly related to the presence of EPs.

Example References

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