Josephson diode effect in Andreev molecules

Jean-Damien Pillet*†[1], Samy Annabi[1], Hannes Riechert[1], Ambroise Peugeot[1], Everton Arrighi[1], Joël Griesmar[1], and Landry Bretheau[1]

[1]Laboratoire de physique de la matière condensée – Ecole Polytechnique, Centre National de la Recherche Scientifique, Centre National de la Recherche Scientifique : UMR7643 – Route de Saclay 91128 PALAISEAU CEDEX, France

Résumé

We propose a platform for observing the Josephson diode effect: the Andreev molecule (1). This nonlocal electronic state is hosted in circuits made of two closely spaced Josephson junctions, through the hybridization of the Andreev states. The Josephson diode effect occurs at the level of one individual junction while the other one generates the required time-reversal and spatial-inversion symmetry breaking. We present a microscopic description of this phenomenon based on fermionic Andreev states, focusing on single channels in the short limit, and we compute both supercurrent and energy spectra. We demonstrate that the diode efficiency can be tuned by magnetic flux and the junctions' transmissions and can reach 45%. Going further, by analyzing the Andreev spectra, we demonstrate the key role played by the continuum, which consists of leaky Andreev states and is largely responsible for the critical current asymmetry. On top of proposing an experimentally accessible platform, this work elucidates the microscopic origin of the Josephson diode effect at the level of the fermionic Andreev states.

The first part of this presentation will be dedicated to a general and pedagogical introduction to the Josephson diode effect, and in particular its link with symmetry breaking.

(1) J.-D. Pillet, S. Annabi, A. Peugeot, H. Riechert, E. Arrighi, J. Griesmar, and L. Bretheau, Phys. Rev. Research 5, 033199 (2023)

*Intervenant

†Auteur correspondant: jean-damien.pillet@polytechnique.edu