Supercurrent Reversal in Zeeman-Split Josephson Junctions

A.A. Golubov

Moscow Institute of Physics and Technology, Dolgoprudny, Moscow Region 141700, Russia

We theoretically study the current-phase relation in a Josephson junction comprising the Zeeman-split superconductors (ZSs) and a normal metal (N). We show that at low temperatures the Josephson current in the ZS/N/ZS junctions exhibits a supercurrent reversal at a certain phase difference $\phi_c \in (0, \pi)$. By calculating the spectral Josephson current, we demonstrate that the band splitting due to the Zeeman interaction causes the level crossing in the spectra of the Andreev bound states and the sign reversal of the Josephson current, similar to the known case of an SFIFS junction (F is a ferromagnet, I is an insulator). Additionally, we propose an alternative method to observe the supercurrent reversal. We have demonstrated that ϕ_c depends on the Rashba spin-orbit interaction in the normal segment. The spin precession of a quasiparticle due to the spin-orbit interaction modifies the energy spectra of the Andreev levels and ϕ_c. In experiments, the amplitude of the spin-orbit interaction is tunable by applying the gate voltage. Therefore, by measuring the CPR by tuning the spin-orbit coupling, one would be able to observe the anomalous current reversal.

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