Probing Magnetic and Triplet Correlations in Spin-Split Superconductors with Magnetic Impurities

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A superconductor (SC) in proximity to a ferromagnetic insulator (FMI) is predicted to exhibit mixed singlet and triplet pair correlations. The magnetic proximity effect of FMI spin-splits the energy of Bogoliubov excitations and leads to a spin polarization at the surface for superconducting films thinner than the superconducting coherence length.

In this work [1], we study manifestations of these phenomena in the properties of a magnetic impurity coupled via Kondo coupling to this FMI/SC system. Using the numerical renormalization group (NRG) method, we compute the properties of the ground state and low-lying excited states of a model that incorporates the Kondo interaction and a Ruderman-Kittel-Kasuya-Yosida (RKKY)-like interaction with the surface spin polarization. Our main finding is an energy splitting of the lowest even fermion-parity states caused by the proximity to the FMI. As the Kondo coupling increases, the splitting grows and saturates to a universal value equal to twice the exchange field of the FMI.

We introduce a two-site model that can be solved analytically and provides a qualitative understanding of this and other NRG results, not captured by the single-site model studied previously [2]. In addition, using perturbation theory we demonstrate that the mechanism behind the splitting involves the RKKY field and the triplet correlations of the spin-split superconductor. A scaling analysis combined with NRG shows that the splitting can be written as a single-parameter scaling function of the ratio of the Kondo temperature and the superconducting gap, which is also numerically obtained.

References

[1] C.H. Huang, A. Skurativska, F. S. Bergeret, M. A. Cazalilla **arXiv:2402.07184** (2024)
[2] A. Skurativska, J. Ortuzar, D. Bercioux, F. S. Bergeret. M. A. Cazalilla., PRB 107, 224507 (2023)