Robust Spin Polarization of the YSR States in Superconductor/Ferromagnetic Insulator Heterostrucures

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Yu-Shiba-Rusinov (YSR) states arise as sub-gap excitations of a magnetic impurity in a superconducting host.

Taking into account the quantum nature of the impurity spin in a single-site approximation, we study the spectral properties of the YSR excitations of a system of magnetic impurity in a spin-split superconductor, that is a superconductor in proximity to a ferromagnetic insulator at zero external magnetic field.
The YSR excitations of this system exhibit a robust spin-polarization that is protected from fluctuations and environmental noise by the exchange field of the ferromagnetic insulator, which can be as large as a few Tesla. We compare the results of this quantum approach to the classical approach, which conventionally predicts fully polarized YSR excitations even in the absence of exchange and external magnetic field. Turning on a small magnetic field, we show the latter splits the YSR excitations in the regime where the impurity is strongly coupled to the superconductor, whilst the classical approach predicts no such splitting.

The studied system can potentially be realized in a tunnel junction connected to a quantum dot in proximity to a spin-split superconductor.