Point Contact Andreev method

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Point contact Andreev method (PCAR) is an experimental techniques used to measure the electronic spin-polarisation at the Fermi level in ferromagnets. The technique is based on the measurement of the conductance between the ferromagnetic materials and the superconducting tip. In such junctions, the so called Andreev reflection occurs, in which an electron from the metal/ferromagnet layer with energy below the superconducting gap is reflected from the interface as a hole with an opposite spin. It happens because an electron incident on the FM/SC interface pairs with an electron with an opposite spin in the SC region, creating a Cooper pair. The other electron comes from the normal metal/ferromagnet layer, so in that region a hole with the spin opposite to the spin of the incident electron appears.

The experimentally measured conductance can be described by two theoretical models:

1. The BTK model, in which we assume that the current through the junction is carried by two channels: the unpolarized channel and the fully polarized channel. The conductance is given by the weighted average of both:
$$G = (1 - P)G_{UP} + PG_P \tag{1}$$
where G_P and G_{UP} are the conductances of the polarized and unpolarized channels, respectively and P is the polarization.

2. The more general scattering matrix method in which we consider the FM/SC junction and determine all reflection probabilities for a given profile of polarization, scattering potential, and energy gap. The equation describing the NM/SC junctions is the Bogoliubov-de Gennes equation, which takes the form
$$\begin{pmatrix} -\frac{\hbar^2}{2m}\nabla^2 + V(x) - \mu - h(x) & \Delta(x) \\ \Delta(x) & -\left[-\frac{\hbar^2}{2m}\nabla^2 + V(x) - \mu + h(x)\right] \end{pmatrix} \begin{pmatrix} \psi_e^{\uparrow}(x,y) \\ \psi_h^{\downarrow}(x,y) \end{pmatrix} = E \begin{pmatrix} \psi_e^{\uparrow}(x,y) \\ \psi_h^{\downarrow}(x,y) \end{pmatrix}, \tag{2}$$
where $V(x)$ is the scattering potential at the NM/SC interface, m is the electron mass in metal, μ is the chemical potential, $h(x)$ is the exchange field in ferromegnet, $\Delta(x)$ is the superconducting energy gap in SC, and $\psi_e^{\uparrow}(x,y), \psi_h^{\downarrow}(x,y)$ is the electron and hole part of the wave function, respectively.

The main purpose of the project is to implement both the BTK and scattering matrix methods to fit the experimental data contained in the NbCu and NbFe folders, and to compare their applicability in extracting the spin polarization of electrons in different materials using the PCAR method.