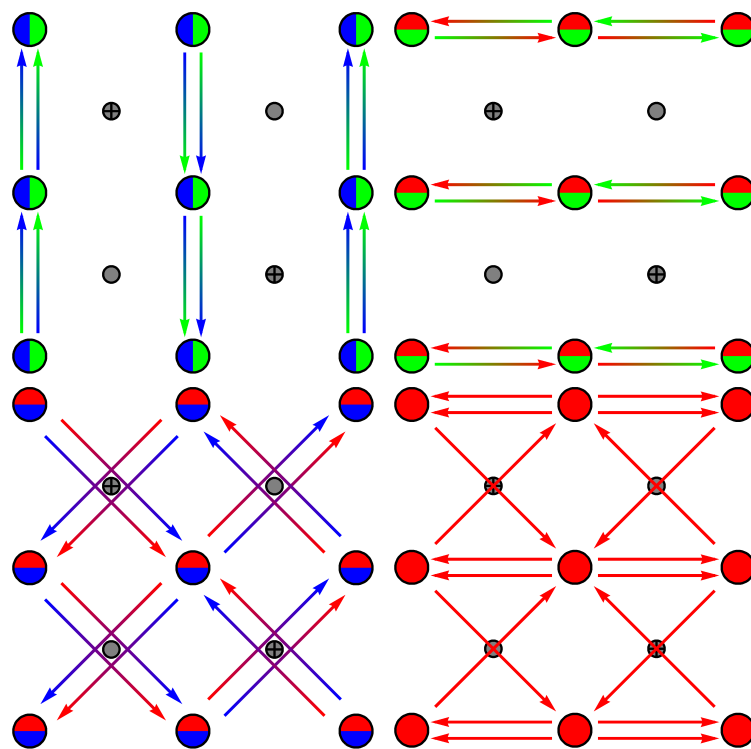


Another thesis on SNS junctions: numerical simulations and calculations



Master's Thesis

by

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Karlsruhe, den 24. Januar 2017

.....
(**Alexander Gawrilow**)

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Overview

1 Introduction

2 Analytical Model

2.1 Foundation of the quasiclassical model

In figure 2.1 a schematic SNS junction is depicted. The setup is two dimensional with width W and length L . The NS-interfaces are parallel to the y -axis and are placed at $x = \pm L/2$. Each of the superconducting leads has a phase χ_1 and χ_2 and the overall phase difference is $\chi = \chi_1 - \chi_2$. The superconducting gap parameter is only present in the superconducting leads and zero in the normal region and can be expressed as

$$\Delta(x) = |\Delta|e^{i\chi_1}\Theta(-L/2 - x) + |\Delta|e^{i\chi_2}\Theta(x - L/2) \quad (2.1)$$

The aim is to express the current through the junction using a quasiclassical approach. In this approach, the Andreev bound states are associated with straight trajectories connecting the superconducting leads. The superconducting current density is expressed in terms of these trajectories. We consider a ballistic sample with ballistic (BCS) coherence length $\zeta = \hbar v_F / \pi \Delta$. We assume that at this coherence length ζ is much larger than the Fermi velocity $\zeta \gg v_F$ (in order to induce superconductivity in the system?). The relation between the coherence length ζ and the sample length L determines, if the considered junction is a *short* or a *long* junction:

$$\begin{aligned} \zeta \ll L &\rightarrow \text{long junction} \rightarrow \text{many Andreev levels} \\ \zeta \gg L &\rightarrow \text{short junction} \rightarrow \text{one Andreev level} \end{aligned}$$

Needless to mention, the fermi wavelength λ_F has to be smaller than the sample length L . Now, check if this quasiclassical approach is valid. What are preliminary assumptions about the system? The presence of magnetic field will lead to a bending of the trajectories due to the Lorentz force. Depending on the strength of magnetic field B and the Fermi velocity the radius of this curve is

$$r_B = ??? \quad (2.2)$$

In order to justify the assumption of straight trajectories, either the magnetic field has to be weak enough or the Fermi wavelength has to be short enough. Then, the cyclotron radius r_B is simply much smaller than the sample length L . We consider the low temperature limit, where the thermal length scale of the system is smaller larger than the sample length:

$$L_T = \hbar v_F / k_B T \gg L \quad (2.3)$$

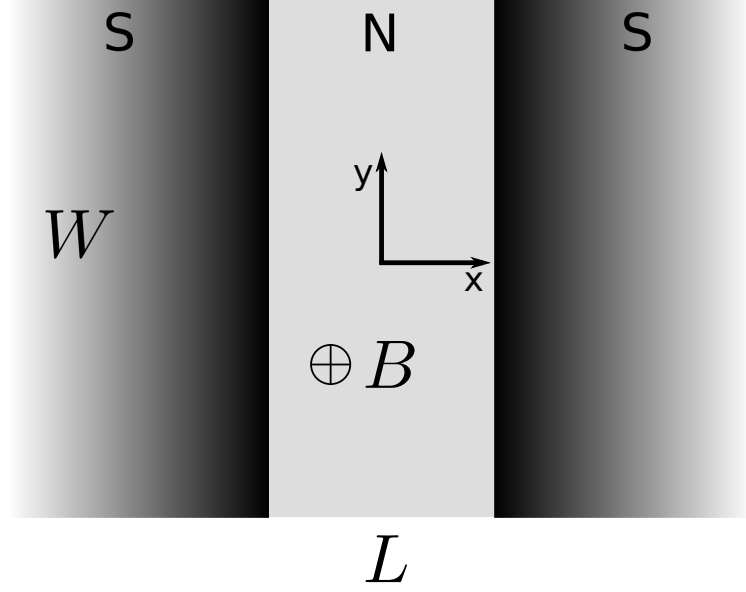


Figure 2.1: *Schematic representation of a short and wide SNS junction.*

2.2 Plane setup: calculation of current

To derive the current for the SNS setup depicted in figure 2.1, we start by writing down the Bogoliubov-de-Gennes-Hamiltonian for this system.

$$\begin{pmatrix} -\frac{1}{2m}\nabla^2 - \epsilon_F & \Delta(x) \\ \Delta^*(x) & \frac{1}{2m}\nabla^2 + \epsilon_F \end{pmatrix} \begin{pmatrix} \psi_e \\ \psi_h \end{pmatrix} = E \begin{pmatrix} \Psi_e \\ \Psi_h \end{pmatrix} \quad (2.4)$$

2.3 QPC setup: calculation of current

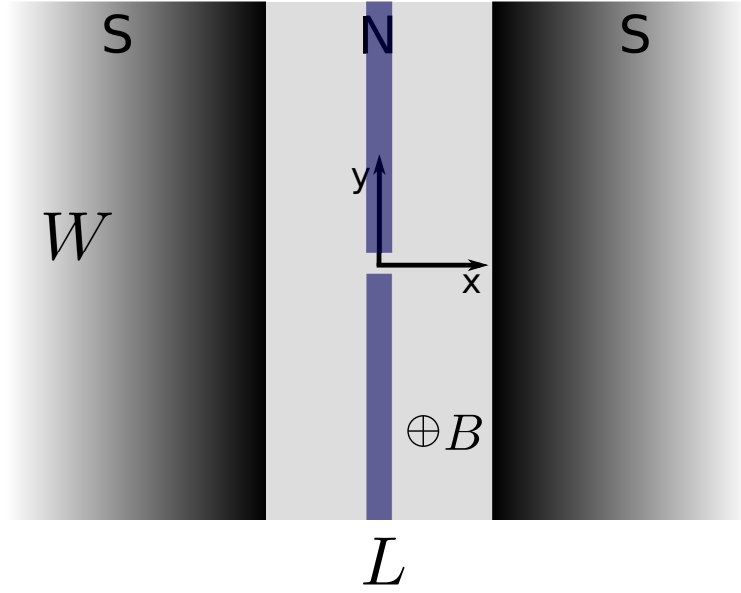


Figure 2.2: Schematic representation of a short and wide SNS junction with QPC setup.

3

Conclusion and Outlook

A

Appendix

