Proximity effect, multiple Andreev reflections and conductance fluctuations in atomic-size contacts

Elke Scheer

Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany
elke.scheer@uni-konstanz.de

Modern nanofabrication techniques including modified scanning tunneling microscopes and mechanically controllable breakjunctions (MCBs) provide adjustable atomic-size contacts between two metallic banks. Since the Fermi wavelength in metals is of the order of the inter-atomic distance, these contacts are quantum point contacts (QPCs) e.g. they accommodate only a small number of conduction channels.

The number N and the individual transmission coefficients $0 < \tau_i \leq 1$ of these channels can be revealed when using superconducting metals. The current-voltage characteristics of superconducting contacts display the strong nonlinearities - called subgap structure - associated with multiple Andreev reflection (MAR) [1]. It has been shown that N of single-atom contacts is determined by the number of valence orbitals of the metal (in general $N > 1$) [2] according to a quantum chemical model by Cuevas *et al.* [3].

For determining the channel ensemble of a normal metal we have investigated here the electronic transport properties of gold QPCs with aluminum leads fabricated by the MCB technique [4]. The anomalies in the local density of states at the contact induced by the proximity effect are measured by tunnel spectroscopy and can be described assuming diffusive transport. The theory of multiple Andreev reflection of single channel quantum point contacts is extended to non-BCS superconductors for the determination of the number and transmission coefficients of the conduction channels in the contact regime.

We find that in single-atom contacts most often only one single channel contributes to the transport as predicted by Levy Yeyati *et al.* [5]. The transmission coefficient of this single channel depends on the exact configuration of the contact and can widely be varied between $0.1 \leq T \leq 0.98$. Gold single-atom contacts are therefore suitable model systems for studying transmission dependent transport.

Information about the local environment of the central-atom can be obtained by analyzing the conductance fluctuations of the nanobridge at high energies $E \approx 1\ eV$.

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