Abstract

,,Interference and Electron Correlations in Quantum Dots Coupled to Superconductors”

Jan Barański

The main purpose of this dissertation was a description of rich physical phenomena that occur on quantum dots coupled between the metallic and superconducting leads. In particular, we studied the proximity induced superconducting order on quantum dots and its interplay with correlation effects such as the Coulomb blockade or Kondo physics. We also analyzed an interference of the subgap quasiparticles and studied their stability on a decoherence driven by the fermionic and/or bosonic environment.

The first part of Ph.D. thesis investigates the heterojunction consisting of a single level quantum dot coupled with metallic and superconducting lead. The physics in such system is affected by proximity induced pairing and by correlations effects. In the case of strong hybridization to superconducting electrode the wave function of Cooper pairs ,,leak” into the quantum dot region converting it to, so-called, superconducting grain. We pointed out that in consequence of this pairing the quasiparticle states are represented by coherent superposition of the empty and doubly occupied states. Strong correlations, in turn, disfavor any double occupancy therefore the Coulomb repulsion strongly suppresses the superconducting order. We investigated the antagonism of these two competing effects.

Next, we analyzed the interference that appears when the main transport channel via continuum of states is combined with the additional path through some discrete levels. In such systems we observe the asymmetric Fano lineshapes. In the case with superconducting lead the quasiparticles induced on quantum dots are involved in such interference. We have shown

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Jan Barański

how such quantum interference manifests itself in the density of states and the differential conductivity (measurable experimentally).

In this dissertation we also analyzed a stability of the above mentioned effects on a decoherence caused by the external fermionic degrees of freedom. It was shown that due to phase randomization the interference effects are strongly suppressed. Quantitative results of this phenomenon may be helpful to specify the conditions under which one can observe the interference of quasiparticles.

In the last chapter of the Ph.D. thesis we investigated an influence of the external boson reservoir on charge transport through the N-QD-S heterojunction. We have shown that bosonic modes give rise to the multiple quasiparticle states. As a consequence one may expect these multiple in-gap states could enhance the anomalous Andreev conductance.

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