CROSSED ANDREEV REFLECTION IN MULTITERMINAL SUPERCONDUCTING HYBRID STRUCTURES

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We develop a quantitative theory of electron transport in three terminal normal-superconducting-normal (NSN) structures. Subgap electrons entering S-electrode from one N-metal may form Cooper pairs with their counterparts penetrating from another N-metal. This phenomenon of crossed Andreev reflection (CAR) and normal scattering at SN interfaces are two mechanisms of the charge transfer in considered structure.

In diffusive limit local and non-local conductances were evaluated non-perturbatively at arbitrary interface transmissions. At low temperature non-local resistance becomes universal and doesn't depend on barriers resistances and parameters of the normal terminals. For instance, in quasi one-dimensional geometry nonlocal resistance takes the following form

$$R_{12} = \frac{r_\xi}{2} e^{-d/\xi},$$

where ξ is zero temperature superconducting coherence length, d is the distance between NS contacts, and r_ξ is Drude (normal state) resistance of the segment of S-metal with lengths ξ. It is well known that interplay of the Andreev reflection and disorder induced scattering leads to zero bias anomaly in conductance of NS junctions. We show that similar anomaly appears in non-local conductance.

Local and nonlocal transport in hybrid superconducting structures is very sensitive to the presence of ferromagnetism in the normal terminals. In particular, in ferromagnet-superconductor-ferromagnet structure nonlocal resistance is no longer universal and depends on mutual polarization of the ferromagnets and zero bias anomaly is strongly suppressed by exchange field both in local and nonlocal conductances.

Our predictions are in a good agreement with recent experimental observations.

References

[1] D.S. Golubev, M.S. Kalenkov, A.D. Zaikin, Phys. Rev. Lett. 103, 067006 (2009).