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Trapping quasiparticles between superconductors

physikalisches

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In Quantum mechanics, the energy of a particle in a box is quantized. This is realized for example in “quantum dots”, where a conductor is confined between two potential barriers. A similar effect occurs without any barrier, when a non-superconducting material bridges two superconductors. In such a “superconducting weak link”, the localized states are called Andreev Bound States. The energy of the Andreev states depends on this difference in the phases of the complex order parameters of the superconductors. As a result, weak links carry a supercurrent and have a phase-dependent inductance that depend on the occupation of the Andreev states.

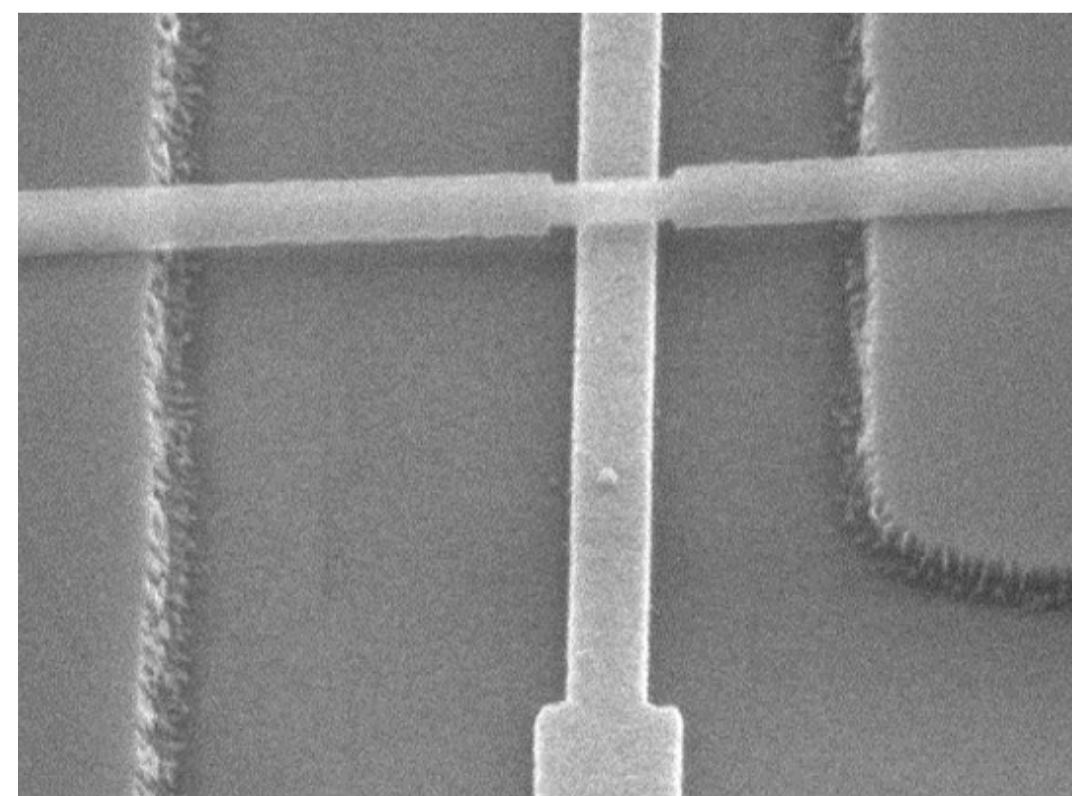
I will review a series of experiments performed on atomic-size contacts [1] and on semiconducting nanowire weak links [2,3] relying on the techniques of “circuit Quantum Electrodynamics”, which consist in probing a quantum circuit through a coupled resonator [4]. They reveal the rich physics of Andreev Bound States, from the basics to the effects of spin-orbit coupling and of Coulomb interactions.

[1] “Coherent manipulation of Andreev states in superconducting atomic contacts”, C. Janvier, L. Tosi, L. Bretheau, Ç. Ö. Girit, M. Stern, P. Bertet, P. Joyez, D. Vion, D. Esteve, M. F. Goffman, H. Pothier, and C. Urbina, *Science* 349, 1199 (2015).

[2] Spin-Orbit Splitting of Andreev States Revealed by Microwave Spectroscopy, L. Tosi, C. Metzger, M.F. Goffman, C. Urbina, H. Pothier, Sunghun Park, A. Levy Yeyati, J. Nygård, and P. Krogstrup, *Phys. Rev. X* 9, 011010 (2019).

[3] Circuit-QED with phase-biased Josephson weak links, C. Metzger, Sunghun Park, L. Tosi, C. Janvier, A. A. Reynoso, M. F. Goffman, C. Urbina, A. Levy Yeyati, and H. Pothier, *Phys. Rev. Research* 3, 013036 (2021)

[4] From Adiabatic to Dispersive Readout of Quantum Circuits, Sunghun Park, C. Metzger, L. Tosi, M.F. Goffman, C. Urbina, H. Pothier, and A. Levy Yeyati, *Phys. Rev. Lett.* 125, 077701 (2020)



InAs nanowire weak link