Theory of supercurrent in microwave-irradiated quantum point contacts

Sebastian BERGERET (bergeret@uam.es)
Université de San Sebastian

In recent years, the dc Josephson effect has been observed in a great variety of weak links such as those based on atomic contacts, carbon nanotubes, semiconductor nanowires and graphene. In spite of their intrinsic differences, the dc Josephson effect in these systems can be described in a unified manner.
It has been shown that for constrictions shorter than the superconducting coherent length, the Josephson current is carried exclusively by a single pair of Andreev bound states (ABSs). This unified microscopic picture has been recently confirmed experimentally in the context of atomic contacts [1], where the current-phase relationship has been directly measured. These experiments mainly probed the ground Andreev state and it would be of great interest to probe also the excited state, for instance, through microwave spectroscopy.

In my talk, I will present a microscopic theory of the effect of a microwave field on the supercurrent through a quantum point contact of arbitrary transmission [2]. Our theory predicts the following novel effects: (i) at low temperatures, the super current can be strongly suppressed at certain values of the phase due to resonant microwave-induced transitions between the two ABSs. (ii) As the radiation power increases, the supercurrent-phase relation is strongly modified and it can even reverse its sign. (iii) At finite temperatures, the radiation can induce the transition of quasiparticles from the continuum to the lower ABS leading to an enhancement of the critical current as compared to the case in the absence of microwaves. Apart from their fundamental interest for a variety of weak links, our findings are also important for the description of experiments that aim at the manipulation of the quantum state of atomic point contacts.

[1] M.L. Della Rocca, M. Chauvin, B. Huard, H. Pothier, D. Esteve, and C. Urbina, Phys. Rev. Lett. 99, 127005 (2007).
[2] F. S. Bergeret, P. Virtanen, T. T. Heikkilä, and J. C. Cuevas, Phys. Rev. Lett. 105, 117001 (2010).