Coherent DC transport in biased Josephson bijunctions

Denis Feinberg[1], Régis Mélin[1], Thibaut Jonckheere[2], Jérome Rech[2], Thierry Martin[2], Benoît Douçot[3], Andreas Pfeffer[4], François Lefloch[4], and Hervé Courtois[1]

[1]*Institut NEEL, CNRS and Université Joseph Fourier, Grenoble, France*

[2]*CPT, CNRS and Aix-Marseille University, Marseille, France*

[3]*LPTHE, CNRS and Université Paris 6,7, Paris*

[4]*SPSMS/LaTEQS, CEA-INAC and Université Joseph Fourier, Grenoble*

The Josephson effect couples two superconductors by a weak link. At equilibrium (zero bias), DC phase-coherent Cooper pair transport is controlled by the junction phase. With a voltage bias, the AC Josephson effect appears together with DC subgap quasiparticle transport. The present work considers novel devices (Bijunctions) where three superconductors are coupled by a common weak link. Then new DC Josephson transport channels appear. Biasing independently two contacts, commensurate combinations of voltage lead to multipair resonances, like two pairs (a nonlocal quartet) simultaneously crossing to different leads while conserving the energy [1]. At lowest order, quartets coexist as a phase-coherent DC channel, together with dissipative DC quasiparticle channels. Therefore, phase and voltage are independent control parameters for a DC quartet current. In addition, phase-sensitive DC quasiparticle currents are possible.

I will present theoretical results for bijunctions made of: i) tunneling contacts with arbitrary transparency; ii) quantum dots where a dramatic enhancement of the multipair resonances can be obtained by tuning the dot energies [2]; iii) metallic contacts. I will also present the first experimental results for long diffusive Aluminium-Copper bijunction [3]. Strong resonances in the bijunction conductance when one contact is a zero voltage, and the others at V and -V, manifest for V well above the Thouless energy. This rules out a possible synchronization of otherwise AC currents and points towards the quartet channel as a phase-coherent coupling of all three superconductors. I will briefly mention the high potential of multipair processes in bijunctions, in terms of electronic entanglement and microwave photon quantum correlations.

[1] A. Freyn, B. Douçot, D. Feinberg, and R. Mélin, Phys. Rev. Lett. 106, 257005 (2011)

[2] T. Jonckheere, J. Rech, T. Martin, B. Douçot, D. Feinberg, and R. Mélin, to appear (Physical Review B)

[3] A. H. Pfeffer, J. E. Duvauchelle, H. Courtois, R. Mélin, D. Feinberg, and F. Lefloch, submitted