Landau-Zener effect in a superconductor-quantum dot junction

When inserting a single quantum dot (QD - a molecule or a nanoparticle) between two superconducting (S) contacts, the resulting S-QD-S device has fascinating electronic conduction properties, which reflect the coupling of discrete quantum energy levels to superconductivity [1]. We have recently demonstrated the dynamical properties of such devices, which show up when driven at high frequencies [2]. In particular, the probability and direction of tunneling of every single electron can be very precisely tuned, thereby providing an on-demand single electron injector. This has applications in metrology (quantum current standard), quantum thermodynamics and quantum computation.

It was recently predicted that - at low drive frequencies - the tunneling properties of such devices could strongly differ from the usual Fermi golden rule picture of the tunneling processes [3]. We will investigate this prediction, which is analogous to the Landau-Zener effect in atomic physics [4], as a probe of the quantum coherence of bound states in superconductors, at energies below the superconducting gap. This is of particular relevance for the better understanding of the protection from decoherence of qubits based on subgap states in superconductors.

The experimental work involves nanofabrication of superconducting nano-junctions relying on a technique well mastered in the group, at Nanofab platform. Further, ultra-sensitive electronic transport measurements on S-QD-S will be conducted in a dilution refrigerator below 50 mK, both at low and high frequencies.


Possible collaboration and networking: This project is in close collaboration with theoreticians from LPMMC in Grenoble (D. Basko). We are also collaborating with Prof. J. Pekola (Helsinki) on this topic in the frame of his Chaire d’excellence in Grenoble.

Possible extension as a PhD: Yes

Required skills: M2 level in condensed matter or nanophysics. Prior experience with cryogenics, nanofabrication or quantum transport theory would be a plus, but is not a prerequisite.

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