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Collapse of the Josephson Emission in a Carbon Nanotube Junction in the Kondo Regime

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A carbon nanotube quantum dot connected to metallic reservoirs can be seen as a localized impurity coupled to a Fermi sea of electrons. That is why this system is often used to study the Kondo effect at the scale of a single impurity. By replacing the metallic electrodes by superconducting ones, as it can be conveniently done on carbon nanotubes, it allows as well to investigate the Kondo effect in competition with superconducting correlations. This issue has been widely addressed in the low frequency regime through the spectroscopy of Andreev Bound States and DC supercurrent measurements.

In this work [1], we aim at probing this competition at frequencies of the order of the Kondo temperature (T_K~1K, f~10GHz) by measuring the AC Josephson emission of a carbon nanotube-based Josephson junction and comparing it to its DC Josephson current. The AC emission is probed by coupling the carbon nanotube to an on-chip detector (a superconductor-insulator-superconductor junction), via a coplanar waveguide resonator (fig. 1.a). The measurement of the photoassisted current in the detector gives direct access to the signal emitted by the carbon nanotube. We focus on the gate regions that exhibit Kondo features in the normal state and demonstrate that when the DC supercurrent is enhanced by the Kondo effect, the AC Josephson effect is strongly reduced (fig. 1.b). This result is compared with expectations based on the Andreev Bound states estimated from numerical renormalization group theory. We attribute the collapse of the AC Josephson emission to transitions between the singlet ground state and the doublet excited state, enabled by the exchange of quasiparticles with the environment, that is favoured when the junction is driven out-of-equilibrium by a voltage bias.

[1] D. Watfa et al. Collapse of the Josephson Emission in a Carbon Nanotube Junction in the Kondo Regime. Phys. Rev. Lett. **126**, 126801 (2021). https://doi.org/10.1103/PhysRevLett.126.126801

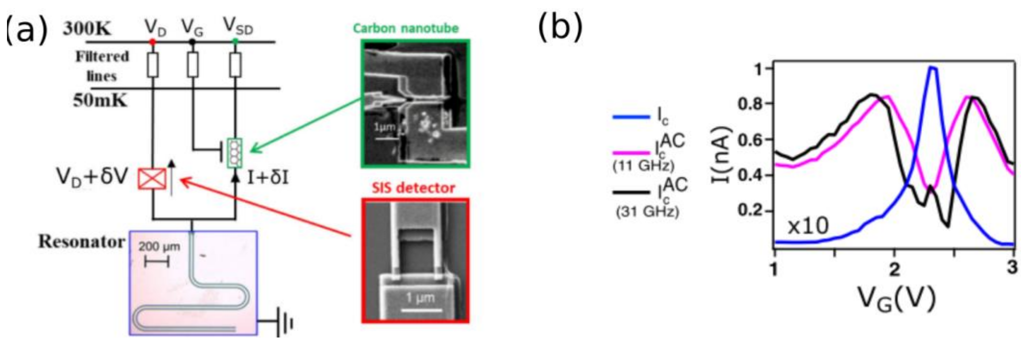

Figure 1 : (a) Experimental setup : the carbon nanotube is coupled to the superconducting tunnel junction detector through a microwave resonator of resonances frequencies 11 and 31 GHz. (b) The AC Josephson emission at these two frequencies is compared with the DC Josephson current in the Kondo regime.