NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2019-2020

Time-resolved detection of dissipative processes in quantum devices

Recent years have seen rapid developments in coherent quantum electronics based on nanoscale devices at low temperatures, with promising applications in quantum information technology. Yet, little is known about dissipation in these systems, although proper heat management is key for preserving quantum coherence. This is mainly due to the slowness of most currently available thermometry techniques, together with the difficulties in obtaining local information on temperature, in particular in nanoscale semiconductors.

Beyond applicative motivations, elementary dissipative processes pose fundamental physical questions in the growing field of quantum thermodynamics, related to the understanding of heat in the quantum world.

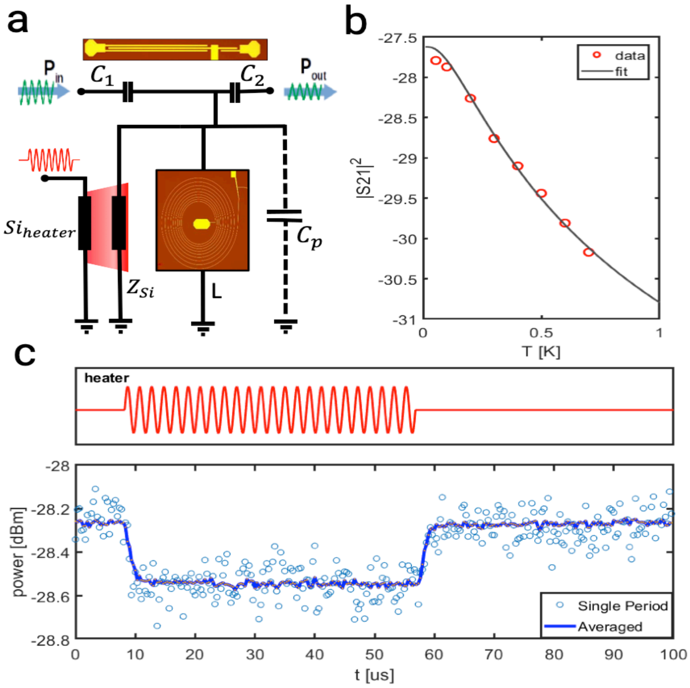

Figure 1: (a) Electric diagram of the RF thermometry scheme, involving a superconducting LC resonator in parallel with the temperature-dependent impedance Z_{Si}. A neighboring Si cell is used as a heater. (b) Temperature dependence of the resonator transmission and fit using the independently determined $Z_{Si}(T)$. (c) Real-time response of resonator transmission to a heating pulse, demonstrating µs-scale thermometry.

Our group has recently set up a time-resolved thermometry technique, suited to the study of quantum circuits. This work will couple driven quantum electronic devices with fast local electron thermometers. Local electron thermo-meters are provided by the temperature-dependent conductance properties of superconducting nano-junctions, which are coupled to a superconducting LC resonator (see proof of concept device in Fig. 1). The quantum devices involve semiconducting nanostructures such as quantum dot junctions in InAs nanowires.

The measurements will be performed at milliKelvin temperatures, using both ultra-low noise dc transport and radio frequency transmission measurements. All necessary instrumental tools are already available. To start, the main scientific work will consist in the design, nanofabrication and first tests of optimized devices.

Possible collaboration and networking:
The work bases on existing collaborations with partner teams in Helsinki, Lund and Pisa, on all aspects of the study: sample fabrication, low temperature measurements, analysis and theory.

Possible extension as a PhD: Yes

Required skills: MSc level in Physics or Applied Physics. Prior experience in low temperature physics, thermo-dynamics or nanoelectronics is a plus.

Starting date: early 2020

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