Quantum thermodynamics: heat transport and thermalization in quantum nanostructures

Energy is a central concept in physics: fundamentally it is the Hamiltonian that governs the system under study. From the practical point of view, energy loss (relaxation) is a basic mechanism in decoherence of qubits. On the other hand, heat, the “waste” form of energy, limits the packing density of components in microchips.

In these lectures I focus on energy exchange by photons, electrons and phonons in quantum circuits and mesoscopic structures and devices at low temperatures. I discuss ways of measuring thermal transport. Then I present devices, such as ultrasensitive detectors and refrigerators, based on superconducting and hybrid quantum nanostructures. At the end I discuss some of our recent interests such as the relaxation of qubits when coupled to two-level systems, the concept of a heat bath, and thermalization of isolated quantum systems.

1. Basics of heat transport mechanisms in quantum nanostructures. Thermometry and refrigeration.
2. Applications in superconducting qubit-based circuits.
3. Calorimetry. Thermal noise. Fundamental limitations in thermal sensing.
4. Prospects: Open quantum systems. Heat baths. Thermalization in open and isolated quantum systems.

General references:

Rev. Mod. Phys. **78**, 217 (2006)
Rev. Mod. Phys. **93**, 041001 (2021)