Non-Equilibrium Thermodynamics of Quantum Processes

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Thermodynamics is an inherently macroscopic theory that describes energy-exchange processes between a system and its environment, and the extraction of work from a driven system. Its traditional formulation requires processes that are quasi-static: at every instant of time, the system should be close to its thermodynamic equilibrium, so that macroscopic thermodynamic quantities (such as pressure, volume, and temperature) could be meaningfully defined.
Yet, the current management of microscopic systems evolving according to the theory of quantum mechanics extends up to the viability of observations of individual trajectories. This opens up the possibility to study non-equilibrium processes that are strongly affected by non-classical (i.e. non-thermal) fluctuations. Which are the implications for thermodynamics? Is it still possible to define and study thermodynamic quantities when we address non-equilibrium processes at the quantum level?
In this talk I will introduce the field of stochastic thermodynamics of quantum processes, illustrating recent theoretical developments, inspired by an information-theoretic approach, and the experimental progresses that have resulted from them. I will address both theoretical proposals (aimed, for instance, at sharpening the fundamental Landauer principle), and experimental endeavours in NMR, linear optics, optomechanics, and intra-cavity ultra-cold atoms.