Quantum Thermodynamics from the Nonequilibrium Dynamics of Open Systems

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We take the perspective of open quantum systems and examine from their nonequilibrium dynamics the conditions when the physical quantities, their relations and the laws of thermodynamics become well defined and viable for quantum many body systems. We first describe how an open system nonequilibrium dynamics approach is different from the closed combined system+environment in a global thermal state setup.
Only after the open system equilibrates will it be amenable to conventional thermodynamics descriptions, thus quantum thermodynamics comes at the end rather than assumed in the beginning. We then study one broad class of open quantum systems where the full nonequilibrium dynamics can be solved exactly, that of the quantum Brownian motion of N strongly coupled harmonic oscillators, interacting strongly with a scalar field environment. In this talk we focus on the internal energy, heat capacity and the Third Law.