

Title: Work and heat at the mesoscale

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Abstract: Understanding the conversion between heat and work by heat engines led to the discoveries of entropy and to the formulation of the Second law of classical macroscopic thermodynamics. At the microscale and mesoscale, quantum coherences are a potential resource for various quantum processes. Quantum coherences can be used to enhance the performance of various devices beyond the limits demanded by classical physics. Recently many models have been established clarifying how coherences affect the speed and irreversibility of thermodynamic processes and raising the question of what experimentally relevant consequences various generalizations of the formalism of classical thermodynamics to the microscopic level may have. Here we study a few of these models in great detail. Specifically, we discuss fluctuations of coherence-enhanced heat currents, propose a model of a heat engine that does work while being in a steady state, and derive a condition on the rate of decoherence that specifies, when coherence-enhanced currents provide a significant advantage over the case without any coherence. Then we discuss coherence-inducing heat bath from the quantum thermodynamics point of view. We show, that coherences generated in this way provide an advantage in the extraction of work. We point out, that there is a need to modify the Second law of thermodynamics for this system. Our results provide new useful physical insights into the active research on the role of coherence in quantum thermodynamics and quantum optics.

Keywords: work, heat, quantum coherence, heat engine, two-level system, entropy production, quantum advantage, open systems, weak coupling, Lindblad master equation