Thermodynamics of Quantum Coherence

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Quantum decoherence is seen as an undesired source of irreversibility that destroys quantum resources. Quantum coherences are a property that vanishes at thermodynamic equilibrium. Away from equilibrium, quantum coherences challenge the classical notions of a thermodynamic bath in a Carnot engines, affect the efficiency of quantum transport, lead to violations of Fourier's law, and can be used to dynamically control the temperature of a state. However, the role of quantum coherence in thermodynamics is not fully understood.

Here we show that the relative entropy of a state with quantum coherence with respect to its decohered state captures its deviation from thermodynamic equilibrium. As a result, changes in quantum coherence can lead to a heat flow with no associated temperature, and affect the entropy production rate. From this, we derive a quantum version of the Onsager reciprocal relations that shows that there is a reciprocal relation between thermodynamic forces from coherence and quantum transport. Quantum decoherence can be useful and offers new possibilities of thermodynamic control for quantum transport and to understand transport in photosynthetic complexes.