TOWARDS A COMPLETE THEORY OF QUANTUM THERMODYNAMICS

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Extending the formalism of thermodynamics to apply to small quantum systems away from thermal equilibrium is a program that has received much interest recently. However, we still have a very limited understanding of how quantum coherence between different energy levels evolves under thermodynamic processes. Quantum coherence is especially important in exotic and useful low-temperature phenomena such as superconductivity and magnetic resonance. In this talk we report an novel characterization of thermodynamic processes in the low-temperature regime. Calling the resulting mathematical model "cooling maps", we present necessary and sufficient conditions for the feasibility of state transitions under cooling maps, including the transformation of coherence. We also present an explicit construction of low-temperature thermodynamic processes that preserve coherence to the maximum extent possible. While other recent works have provided important insights into the workings of quantum coherence in thermodynamics, our treatment enables us to find elegant and succinct conditions in the low-temperature regime. Combining the spirit of our approach with that of other works could pave the way towards a more complete understanding of coherent thermodynamics at general temperatures.

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