Reconciliation of Quantum Local Master Equations with Thermodynamics

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The study of open quantum systems often relies on approximate master equations derived under the assumptions of weak coupling to the environment. However when the system is made of several interacting subsystems such a derivation is in many cases very hard. An alternative method, employed especially in the modelling of transport in mesoscopic systems, consists in using *local* master equations containing Lindblad operators acting locally only on the corresponding subsystem. It has been shown that this approach however generates inconsistencies with the laws of thermodynamics. In this contribution, we demonstrate that using a microscopic model of local master equations based on repeated collisions all thermodynamic inconsistencies can be resolved by correctly taking into account the breaking of global detailed balance related to the work cost of maintaining the collisions.[1] We provide examples based on a chain of quantum harmonic oscillators whose ends are connected to thermal reservoirs at different temperatures. We prove that this system behaves precisely as a quantum heat engine or refrigerator, with properties that are fully consistent with basic thermodynamics.

[1]G. De Chiara et al., New J. Phys. **20**, 113024 (2018).