Thermal Markovian processes: from resource theories to molecular switches

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Quantum resource theory formulations of thermodynamics offer a versatile tool for the study of fundamental limitations to the efficiency of physical processes, independently of the microscopic details governing their dynamics. Despite the ubiquitous presence of non-Markovian dynamics in open quantum systems at the nanoscale, rigorous proofs of their beneficial effects on the efficiency of quantum dynamical processes are scarce. Here we combine the resource theory of athermality with concepts from the theory of divisibility classes for quantum channels, to prove that memory effects can increase the efficiency of photoisomerization to levels that are not achievable under a purely thermal Markovian (i.e. memoryless) evolution. This provides rigorous evidence that memory effects can provide a resource in ultrafast biological quantum dynamics, and, more generally, quantum thermodynamics at the nanoscale.