Performance of a quantum heat engine at strong reservoir coupling

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We study a quantum heat engine at strong coupling between the system and the thermal reservoirs [1]. Exploiting a collective coordinate mapping [2], we incorporate system-reservoir correlations into a consistent thermodynamic analysis, thus circumventing the usual restriction to weak coupling and vanishing correlations. We apply our formalism to the example of a quantum Otto cycle, demonstrating that the performance of the engine is diminished in the strong coupling regime with respect to its weakly coupled counterpart, producing a reduced net work output and operating at a lower energy conversion efficiency. We identify costs imposed by sudden decoupling of the system and reservoirs around the cycle as being primarily responsible for the diminished performance, and define an alternative operational procedure which can partially recover the work output and efficiency. More generally, the collective coordinate mapping holds considerable promise for wider studies of thermodynamic systems beyond weak reservoir coupling, and we shall also discuss the potential for strong reservoir coupling effects to enhance power output in finite time engine cycles.

[1] D. Newman, F. Mintert, and A. Nazir, Phys. Rev. E 95, 032139 (2017)
[2] J. Iles-Smith, N. Lambert, and A. Nazir, Phys. Rev. A 90, 032114 (2014)