Unitary and Non-Unitary Few-Mode Heat Machines

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The enormous number of hot and cold bath modes involved in standard heat machines (HM) justifies their thermodynamic description. Anomalous, non-thermal/coherent bath effects can strongly boost HM performance [1-3], but these HM, as their standard counterpart, are still treated as dissipative, open systems. Recently, we have changed the accepted paradigm by considering HM involving only few hot and cold "bath" modes at the same frequency. This allows their exact quantum analysis, without resorting to open-system approaches. Within the new paradigm, we have introduced [4] the concept of non-unitary work extraction from single-mode thermal noise by homodyne measurements followed by unitary manipulation of the post-measured state. For thermal noise with more than 1 quantum on average, optimized measurements can yield heat to work conversion with efficiency that approaches unity when the mean number of quanta is well above 1. This protocol is substantially superior to existing concepts of information and heat engines. Alternatively, we propose a fully coherent or unitary principle of operating HM by mixing few hot and cold modes in Kerr-nonlinear interferometers. Such devices enable heat to work conversion (or vice versa) in a selected mode at the expense of other modes. They are autonomous and require no information input. By breaking the dissipative HM paradigm, we can track the transition from coherent dynamics to thermodynamics as the number of "bath" modes grows. This may pave the way to new technologies of energy conversion.

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