Speeding up thermalization in quantum thermal engines

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We present a contribution to the ongoing discussion about the interplay between thermal engines and quantum physics. Does having a working fluid be quantum help or hinder the performance of a quantum engine? To contribute to this question, we consider a two-stroke ergotropy engine operating between two temperatures. The two heat baths are taken to be non-collinear spin baths at different temperatures. By non-collinear baths, we mean that the two spin baths are polarized along different directions. The working fluid is composed of a double quantum dot system. Such a working fluid undergoes two strokes, namely: (a) a thermalization stroke by coupling one qubit to the hot bath and the other qubit to the cold bath and (b) a work stroke composed of an optimal two-qubit unitary. The power of the engine per stroke is defined as the work extracted per cycle divided by the time for the stroke. Since the time to implement the optimal unitary operator is usually very fast, the power per stroke of such engines typically is dominated by the thermalization times. We show that this power can be improved by using quantum control techniques in order to speed up thermalization. We prove uniform convergence of a generalized Krotov algorithm for open quantum systems in Liouville space and use it to improve the thermalization time. Such a control protocol injects work and heat into the engine and is expected to reduce the efficiency, in keeping with similar engines operating at finite time. We calculate the work, the power and the commensurate loss in efficiency of the engine. We propose an experimental implementation of the engine using a quantum dot spin valve setup.