"Engineering dynamical couplings for quantum thermodynamic tasks"

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The development of quantum technologies requires a deeper understanding of the energetics and thermodynamics of nonequilibrium quantum systems. Key problems for the construction of future quantum machines include optimization of the energetic cost of quantum protocols, efficient heat management, and the development of effective strategies for cooling. The common framework to deal with these problems is to consider open quantum systems weakly coupled to an infinitely large environment, so that any information which has been transferred to the environment is lost and cannot be retrieved by the system, thus excluding memory effects. On the other hand, when dealing with small, nanoscale quantum systems the above assumptions easily break down, and one should develop methods and tools to address regimes beyond that framework, taking into account memory effects and system-environment quantum correlations.

In this work, we address the above questions in systems where the system-environment couplings are periodically modulated in time, and suitably engineered to perform thermodynamic tasks. In particular, asymmetric couplings to two heat baths can be used to extract heat from the cold reservoir and to realize an ideal heat rectifier, where the heat current can be blocked either in the forward or in the reverse configuration by simply tuning the frequency of the couplings modulation. The developed formalism is ideally suited to apply optimal control and machine learning techniques to quantum thermal machines.

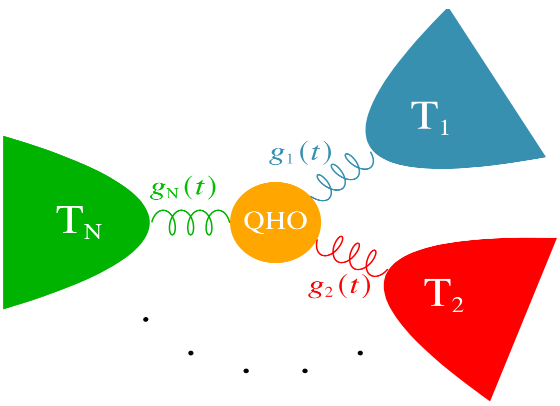

Fig. 1: Sketch of the proposed setup with modulated system/reservoir couplings.