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# Adaptive variational low-rank dynamics for open quantum systems

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## Abstract

We introduce a novel, model-independent method for the efficient simulation of low-entropy systems, whose dynamics can be accurately described with a limited number of states. Our method leverages the time-dependent variational principle to efficiently integrate the Lindblad master equation, dynamically identifying and modifying the low-rank basis over which we decompose the system's evolution. By dynamically adapting the dimension of this basis, and thus the rank of the density matrix, our method maintains optimal representation of the system state, offering a substantial computational advantage over existing adaptive low-rank schemes in terms of both computational time and memory requirements. We demonstrate the efficacy of our method through extensive benchmarks on a variety of model systems, with a particular emphasis on multi-qubit bosonic codes, a promising candidate for fault-tolerant quantum hardware. Our results highlight the method's versatility and efficiency, making it applicable to a wide range of systems characterized by arbitrary degrees of entanglement and moderate entropy throughout their dynamics. We provide an implementation of the method as a Julia package, making it readily available to use.

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