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Generalized quantum subspace expansion for quantum error mitigation

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Abstract

One of the major challenges for erroneous quantum computers is undoubtedly the control over the effect of noise. Considering the rapid growth of available quantum resources that are not fully fault tolerant, it is crucial to develop practical hardware-friendly quantum error mitigation (QEM) techniques to suppress unwanted errors. Here, we propose a novel generalized quantum subspace expansion method which can handle stochastic, coherent, and algorithmic errors in quantum computers. By fully exploiting the substantially extended subspace, we can efficiently mitigate the noise present in the spectra of a given Hamiltonian, without relying on any information of noise. The performance of our method is discussed under two highly practical setups: the quantum subspaces are mainly spanned by powers of the noisy state and a set of error-boosted states, respectively. We also propose the resource-efficient implementation of generalized quantum subspace expansion by using the dual-state purification method, and show that it can even allow for the simulation of the twice the system size with the moderate sampling overhead.