Projected Lindblad dynamics via Hamiltonian symmetries for Quantum Error Mitigation

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Quantum error mitigation (QEM) techniques have shown extremely good promise in order to extract accurate expectation values of observables of interest by means of noisy quantum processors in the NISQ-era [1,2]. Some widely-accepted QEM methods have converged into to the so-called Probabilistic Error Amplification (PEA) based zero-noise extrapolation (ZNE) [2]. This method assumes that the ideal (target) expectation value of operators are functions of noisy values of those measured at different noise rates. It should be noted that the PEA+ZNE methods require precise characterization of the noise in the quantum device. Moreover, it is not generally easy to make assumptions of the decay tendencies of the observables, especially when non-Clifford circuits are targeted [2,3]. Some methods attempt to learn those by substituting most of the gates of a circuit by Clifford gates (Clifford Data Regression, CDR) [4] or by small-scale tractable circuits [5]. However, changing the circuit changes the noise and, thus, what is learnt might not be always accurate for the target circuit.

In this work, we propose a method based on projecting the ideal expectation values onto a linear span of noisy measurements. The method does not require to know the amplification ratios in the system. In order to train the coefficients for the linear span, we make use of observables whose expectation values are conserved over the dynamics (Hamiltonian symmetries). Specifically, we probe the noisy processor to obtain noisy expectation values (at different noise rates) of quantities that are conserved and, therefore, known, for obtaining the projection weights. The obtained model is then used to mitigate the noise of the target observables of interest. In this way, the circuits for which the training is made are exactly the same as for the actual experiment.

We numerically analyse the proposed method for studying the magnetization in the transverse field Ising and Heisenberg models. We will also discuss the potential of the method for discerning which is the function that defines the decays of the observable. We will also present the future research on the topic.

References

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