Weak-measurement protection in quantum simulations of lattice gauge theories

Matteo Michele Wauters
Edoardo Ballini, Philipp Hauke

Pitaevskii BEC center, University of Trento, via sommarive 5, 38123 Trento, Italy

matteo.wauters@unitn.it

Abstract

Lattice gauge theories (LGT) are promising yet challenging candidates for quantum simulation protocols, because of their highly constrained dynamics and complex interactions. A fundamental issue in any experimental proposal is the mitigation of errors breaking the local gauge symmetries, thus leading to unphysical results. However, weak continuous measurements of the symmetry generators drive a transition to a regime where the quantum Zeno effect protects gauge invariance [1]. We extend this approach in the context of digital quantum simulations by measuring ancillary qubits coupled to the system [2] and show that it can be applied also to nonabelian LGTs implemented on qudit platforms [3-5]. Our findings provide valuable tools for error-mitigation and error-correction schemes in quantum simulations of strongly interacting and highly constrained quantum systems.

References

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[3] E. Zohar, M. Burrello, Phys. Rev. D, 91 (2015) 054506
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Figures

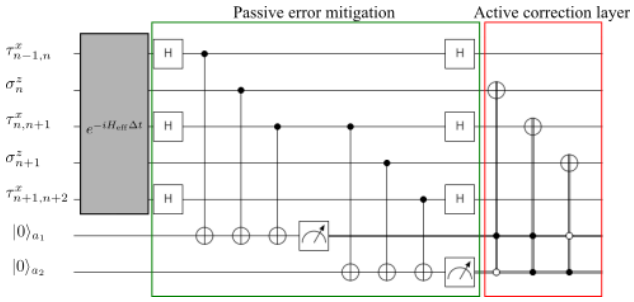

Figure 1: Measurement of two neighboring local symmetry operators by coupling to ancillary qubits. A feedback correction layer can be added to correct incoherent spin-flip errors.

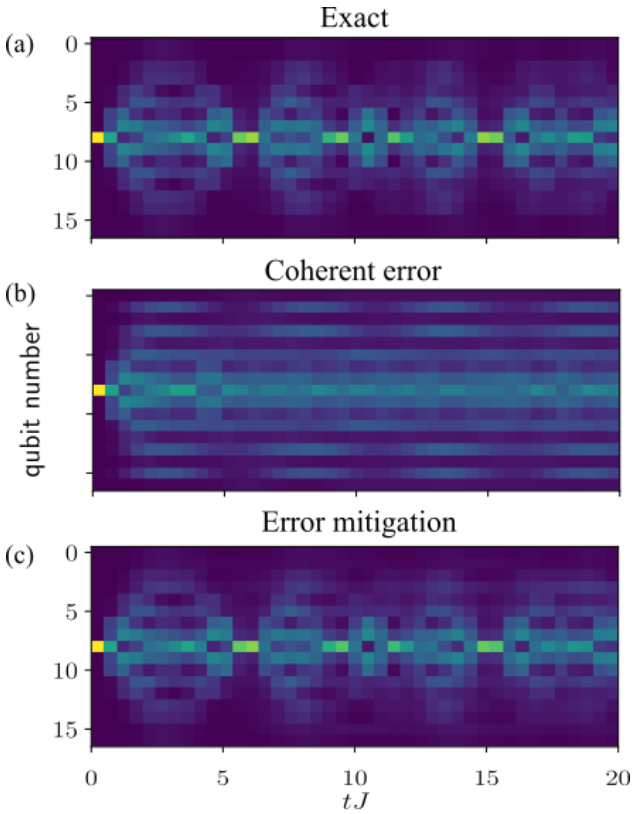

Figure 2: comparison between the exact dynamics (a), with coherent errors (b), and measurement-induced error mitigation (c).