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Digital quantum simulation of a topological spin chain

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The quantum properties underlying a wide range of natural materials, such as topological matter or interesting molecules, have proven too complex to understand using classical physics and standard computation. The field of digital quantum simulation has been developed in order to study the behaviour of quantum systems by replicating the energy dynamics in a controlled, gate-based manner. The high fidelities and long coherence times of trapped ion systems make them an excellent candidate to demonstrate digital quantum simulation.

Here I will demonstrate the quantum simulation of a topological spin chain on a trapped-ion quantum processor. The digital simulation approach enables us to combine the tool-set of quantum information with high performance gate-based evolution to study not only condensed matter properties, but also quantum information properties of the system [1]. In particular, we study correlation and entanglement properties, as well as error-robust edge modes that arise due to topological symmetry in our material. In addition, I will discuss the integration of quantum control techniques to mitigate single- and two-qubit errors during quantum simulation [2, 3], a benefit of the gate-based approach of digital simulation.

[1] Müller, M. et al., "Simulating open quantum systems: from many-body interactions to stabilizer pumping ", New J. Phys. 13, 085007 (2011)
[2] Edmunds, C. L. et al., "Dynamically corrected gates suppressing spatiotemporal error correlations as measured by randomized benchmarking", Phys. Rev. Research 2, 013156 (2020)
[3] Milne, A. R. et al., "Phase-Modulated Entangling Gates Robust to Static and Time-Varying Errors", Phys. Rev. Applied 13, 024022 (2020)

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