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Digital Quantum Simulation and Symmetry Protection with Trapped Ions

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Our quantum computer consists of a chain of trapped 171Yb+ ions with individual Raman beam addressing and individual readout. This fully connected system can be configured to run any sequence of single- and two-qubit gates, making it in effect an arbitrarily programmable digital quantum computer. The high degree of control can be used for digital, but also for analog and hybrid quantum simulations.

Noisy operations influence all quantum computing applications and in the absence of fault-tolerant encoding, different mitigation strategies are being investigated. We recently simulated the real-time dynamics of a lattice gauge theory in 1+1 dimensions, i.e., the lattice Schwinger model, and report the comparison of different error mitigation strategies for this application [1].

The motional modes of trapped ions are a quantum computing resource that can be used for efficient operations. We present results on pairwise-parallel entangling gates applied using two sets of motional modes simultaneously, showing a significant error reduction in an example Ising-model simulation. We also describe progress towards an analog-digital hybrid quantum simulation of the Yukawa model, proposed in [3], that employs motional modes along multiple directions.

[1] N. H. Nguyen et al., PRX Quantum 3, 020324 (2022)
[2] D. Zhu et al., Science Advances 5, 10 (2019)
[3] Z. Davoudi et al., Phys. Rev. Research 3, 043072 (2021).

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