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Plenary

# Quantum Computation and Quantum Simulation with Trapped $Ca^+$ Ions

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The state-of-the-art of the Innsbruck trapped-ion quantum computer is reviewed. First, we present an overview on the available quantum toolbox and discuss the scalability of the approach. Fidelities of quantum gate operations are evaluated and optimized by means of cycle-benchmarking [1] and we show the generation of a 16-qubit GHZ state. Entangled states of a fully controlled 20-ion string are investigated [2] and used for quantum simulations.

In the second part, we present both the digital quantum simulation and a hybrid quantum-classical simulation of the Lattice Schwinger model, a gauge theory of 1D quantum electrodynamics. Employing universal quantum computations, we investigate the dynamics of the pair-creation [3] and using a hybrid-classical ansatz, we determine steady-state properties of the Hamiltonian. Hybrid classical-quantum algorithms aim at solving optimization problems variationally, using a feedback loop between a classical computer and a quantum co-processor, while benefitting from quantum resources [4].

[1] A. Erhard et al., arXiv:1902.08543 (2019)
[2] N. Friis et al., Phys Rev X. 8 021012 (2018)
[3] E. A. Martinez et al., Nature 534, 516 (2016)
[4] C. Kokail et al., arXiv:1810.03421 (2018)