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Theory of robust multi-qubit non-adiabatic gates for trapped-ions YOTAM SHAPIRA, RAVID SHANIV, TOM MANOVITZ, NITZAN AKERMAN, LEE PELEG, LIOR GAZIT, ROEE OZERI, Department of Physics of Complex Systems, Weizmann Institute of Science, ADY STERN, Department of Condensed Matter Physics, Weizmann Institute of Science — Trapped ion qubits are a leading platform for performing quantum computations and quantum simulations. These are achieved with entanglement gates acting on the ions, by coupling to the normalmodes of motion of the ion-chain. Typically, a single normal-mode is coupled and the remaining modes are decoupled by operating slowly. Analog quantum simulations are also performed in an adiabatic regime and allow only spin-spin interactions that scale as a power-law in the ion distance. We propose multi-qubit entanglement gates for trapped-ions [arXiv:1911.03073 (2019)]. Our gates utilize all the normalmodes of motion allowing for fast operation that was previously inaccessible, and require reasonable resources. Furthermore, we use our methods to generalize the coupling between the ions, and generate fast spin-Hamiltonian interactions, which are not limited to a power law. For example, a nearest-neighbor Ising model and the topological Su-Schriefer-Heeger Hamiltonian. Our gates use a multi-tone laser field, which couples uniformly to all ions, there is no need to individually address the ions. We endow our gate with robustness properties, making them resilient to various sources of system noise and imperfections. Our method is natural to common trapped-ion architectures.

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