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Improving robustness of laser-free entangling gates for a trapped-ion architecture

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The combination of the entangling Mølmer-Sørensen gate and single qubit rotations
is a well-established way to realise a universal set of quantum gates with trapped ions. Additionally, implementing this gate scheme using global microwave fields can further the scaling prospects of this quantum computing platform.
In previous work, the demonstration of a 98.5% fidelity Mølmer-Sørensen gate [1] using global microwave fields and a static magnetic field gradient was a milestone in demonstrating key elements needed for large scale quantum computation as outlined in Ref.[2]. Furthermore, this gate scheme can be particularly robust to magnetic field noise when realised using the dressed-state protocol [3]. However the gate fidelity in this demonstration was limited by the heating of the ions'motional state. Recent developments in the experimental set-up led to a substantial reduction of motional heating, which will enable future demonstrations of position-dependent logic.
Here we are discussing methods which will not merely increase the gate fidelity, but deliver improvements on the overall gate robustness. The methods considered are: dynamical decoupling techniques, which directly influence the gate mechanism [4], automated calibration techniques [5] and empirically motivated simulations, which use experimental results to improve theoretical predictions for gate parameters [6].

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[5] Julian Kelly et al. "Physical qubit calibration on a directed acyclic graph". In: arXiv preprint arXiv:1803.03226 (2018).
[6] Nicolas Wittler et al. "Machine-learning tools for rapid control, calibration and characterization of QPUs and other quantum devices". In: APS March Meeting Abstracts. Vol. 2021. 2021, pp. X32–015.

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