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Integrated Current-Carrying Wires on a Planar Ion Trap to Produce a Magnetic Field Gradient.

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The combination of the entangling Mølmer–Sørensen gate and single qubit rotations
is a well-established method to realise a universal set of quantum gates using trapped ions. Implementing this gate scheme using global microwave fields can further the scaling prospects of this quantum computing platform, by reducing the complexity of the laser system required. [1]

Our approach uses current carrying wires embedded in the planar ion trap chip to generate the magnetic field gradient needed to achieve spin-motion coupling driven by long-wavelength radiation. [2] [3] This novel chip design has the potential to improve gate speed and fidelity, and simultaneously alleviate some of the limitations in scaling trapped-ion quantum computers. [4] Here we describe the design of the integrated gradient generating structure and discuss the use of frequency scans on the Zeeman states to characterise the geometry of the magnetic field. Additionally, time scans on the motional sidebands of these states are used as verification of these measurements. We also outline the dominant noise contributions in this system, and measure the coherence of a dressed hyperfine state qubit in such a gradient.

The techniques used for characterisation of the current carrying wires overlap with the ones we implement for coherent control in our systems. Dynamical decoupling techniques, automated calibrations and empirically motivated simulations based on Bayesian optimisation can further improve our results and lead to higher fidelity quantum gate operations.

References

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