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Towards Fast Coherent Transport and Reconfiguration Operations on Microfabricated X-Junction Ion Traps with Integrated Current Carrying Wires

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Trapped ions have proved to be a promising way of realising a large-scale quantum computer. They allow for simple reproducibility and modular architectures which is crucial for a scalable, universal quantum computer. Our blueprint for a trapped-ion based quantum computer outlines operating with global microwave (MW) fields to dress the ground-state hyperfine manifold of 171Yb+ ions [1]. By applying individually controlled static (DC) voltages, ions can be effectively shuttled around and between modules, while modulated radio-frequency (RF) signals are utilised to facilitate quantum logic gate operations [2].

Borrowing knowledge from the semiconductor industry, we have produced microfabricated ion traps with embedded current-carrying wires (CCWs) which provide a controllable, high magnetic field gradient [3]. This allows spin-motion coupling which allows more accurate energy measurements to be performed on the motional sidebands and track the heating rate of the ion which is very important for measurements of gate infidelities and characterizing transport and reconfiguration protocols.

Our approach towards scalability and quantum algorithm implementation involves physically transporting ions across the surface trap. The shuttling operations need to be as fast as possible to speed up quantum computation, as well as adiabatic, to preserve the ions' motional state. By simulating trapping potentials and ion dynamics, we investigate various candidate transport and reconfiguration protocols on our X-junction trap. We examine and compare different tools for simulating the potentials, including BEM and FEM based methods, and test them against experimental observations, with the aim of achieving precise and accurate control potentials..

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