Contribution ID: **107** Type: **Poster**

Design and development optimization of X junctions for three dimensional segmented ion traps

Tuesday 9 July 2024 17:48 (2 minutes)

In order to scale current hardware for trapped ion Quantum computers, it is imperative to go from the widely used one dimensional schemes (linear traps) to bi-dimensional schemes. A straightforward starting point is to implement arrays of linear traps, but they need to be efficiently connected between each other. Those interception points are called junctions, and can be X, Y or T junctions depending on the number and disposition of the incoming linear traps. In order to connect ions from different linear arrays, efficient and coherent transport across the junction is required. In this work, the design and development of X junctions via simulation is carried out using closed-loop optimization based on trap frequency and ion transport characterization.
With the aim of addressing subtle geometry variations that might lead to noticeable improvements in the junction performance, a closed-loop, feedback-driven simulation workflow is developed. Parameterized X junction designs are developed and iteratively tested by characterizing their performance for different geometric parameter sets.
The workflow was first implemented by characterizing trapping potential and ion transport through parameter sweeps. For each instance of the sweep, the optimal RF pseudo potential, which is responsible for the radial confinement within each linear trap segment, is firstly obtained. Then, the DC electrode voltages are set for each time step to maximize the transport performance across the junction is optimized.
In the following step we do not just blindly sweep through parameters, but use the transport performance results as feedback to change the set of geometric parameters towards further improvements. We also improve on the closed-loop optimization, by taking advantage of machine learning tools for reinforced learning to learn from the transport characterization results. In conclusion, our research focuses on the simulation and development of X junctions, which are crucial for the implementation of two dimensional scalable ion traps

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Session Classification: Poster session