Contribution ID: **79** Type: **Talk 22min**

Towards Sideband Cooling and Thermometry on an X-Junction Surface Trap with Integrated Current Carrying Wires

Tuesday 9 July 2024 11:00 (22 minutes)

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].

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 [2]. By applying a stable, fast switching current source to these wires, we measure an accurate local magnetic gradient using Ytterbium 171 and demonstrate the current working operation of this chip. The local magnetic gradient is important to provide regions of the chip where entanglement is performed, and regions where qubits can be held in a memory zone, which do not utilise magnetic gradients.

Static magnetic gradients coupled with global microwave fields enable high spin-motion coupling parameters. 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. With this scheme, we are then able to perform sideband cooling to the motional ground state, which is required for certain gate schemes, and to perform diabatic transport.

[1] B. Lekitsch, S. Weidt, A. G. Fowler, K. Mølmer, S. J. Devitt, C. Wunderlich, and W. K.Hensinger, "Blueprint for a microwave trapped ion quantum computer", Science Advances 3 (2017).
[2] M.S.Brown et. Al. Fabrication of surface ion traps with integrated current carrying wires enabling high magnetic field gradients (2022) Quantum Sci. Technol. 7 034003

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Session Classification: Quantum Technologies

Track Classification: Quantum Technologies