Contribution ID: **58** Type: **Poster**

Constructing a modular microwave trapped ion quantum computer prototype

Trapped ions are a promising tool for building a large scale quantum computer. We present work towards a prototype demonstrating the key methods required to realise a scalable trapped-ion quantum computer architecture based on tileable, repeating modules [1].

To find practical applications, quantum computers need to scale significantly. A quantum computing architecture is best constructed in a modular way, where each future stand-alone unit incorporates a large number of zones for state preparation, entanglement and detection and is connected to other modules to execute quantum algorithms. Ion transport operations relying on the precise and synchronised delivery of voltages to DC electrodes is used to transfer the ion qubit between zones and connect arbitrarily many module.

At the centre of this scheme, high-fidelity single and two qubit-gates are realised via the interaction of our trapped ions with global microwaves and RF radiations combined with a local magnetic fields [2].

In our demonstrator device being constructed, embedded current-carrying wires within the substrate of a 2D surface-trap will generate a large local magnetic field gradient, which drives the entanglement between designated pairs of ions. We present the successful fabrication of current-carrying copper microstructures into a silicon substrate. We have successfully applied a current density >106 A/cm2 equating to a gradient exceeding 185 T/m. Ion traps can now be fabricated on top of such a structure for full integration.

To allow for the distribution and reconfiguration of our ion qubit ensemble within and in-between modules, we present the development and fabrication of a single X-junction surface ion trap module as well as a method for preparing well-defined module edges which paves the way towards coherent module-to-module shuttling of ion qubits. We measure alignment control capability between surface ion traps of <10 µm in the planar directions and 15 µm within the vertical direction using piezo actuators.

Finally, to reduce the ion motional heating rate and to efficiently dissipate heat away from the module, the system is best operated at 60K. We present the operation and characterisation of a scalable closed-loop circulating helium gas cryostat capable of independently cooling multiple ion trapping experiments [3].

[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,"Sci. Adv., vol. 3, no. 2, p. e1601540, Feb. 2017.

[2] S. Weidt, J. Randall, S. C. Webster, K. Lake, A. E. Webb, I. Cohen, T. Navickas, B. Lekitsch, A. Retzker, and W. K. Hensinger, "Trapped-Ion Quantum Logic with Global Radiation Fields,"Phys. Rev. Lett., vol. 117, no. 22, pp. 1–6, 2016.

[3] "Scalable helium circulation cryosystem for trapped-ion quantum technologies"–in preparation

Primary authors: Mr LEBRUN-GALLAGHER, Foni Raphaël (University of Sussex); Mr JOHNSON, Nicolas (University of Sussex); Mr ROMASZKO, Zak (University of Sussex); Mr SIEGELE, Martin (University of Sussex); Dr PUDDY, Reuben (University of Sussex); Dr HONG, Seokjun (University of Sussex); Dr BODART, Quentin (University of Sussex); Dr WEIDT, Sebastian (University of Sussex); Prof. HENSINGER, Winfried Karl (University of Sussex)

Presenter: Mr LEBRUN-GALLAGHER, Foni Raphaël (University of Sussex)

Session Classification: Poster Session

Track Classification: Quantum Information & Computing