Seed Phase



# Ion Trap and Cavity Developments for networked large-scale quantum computing

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## What is the problem?

A key challenge facing quantum computing is scalability. A possible solution inspired by classical distributed computing is to form a network of quantum processors, each containing a few qubits. For trapped-ion architectures, like the type EQuIP works on, this would involve linking separate ion traps using single photons. In other words, the ability to generate and capture photons in this system determines the efficiency of the connection. One of the promising solutions to increase the collection efficiency is by placing an optical cavity around the ions. The market problem is that there are no reliable commercial suppliers of the apparatus (ion traps and cavities). Therefore, many researchers resort to designing and building their own system, investing more than a year to design and develop their ion traps, taking up time and resources: a significant amount of time is spent away from core research by students and postdocs

## What is your solution?

We employ a novel fabrication method known as selective laser-induced etching (SLE). SLE is a subtractive 3D printing process which lifts the complexities in producing and assembling ion traps and cavities. EQuIP has already manufactured our own ion traps (Fig. 1) and miniature optical cavities in-house. The ion trap is currently operational and able to confine a chain of ions (Fig. 2) each of which could serve as qubits in a quantum processor. In the next steps, we will integrate the optical cavities into a second-generation ion trap for creating an efficient photonic link between two such ion traps, taking the first significant step towards establishing a scalable quantum processor. To this end, we plan to use state-of-the-art equipment available at OIST to create waveguides and spot size converters to interlink these cavities using fiber optics.

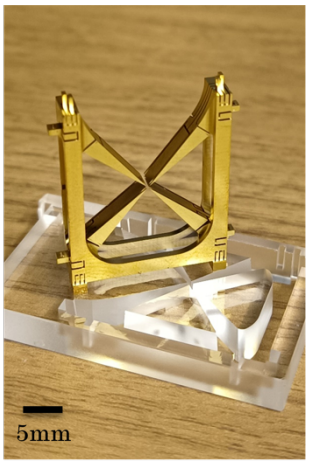


Figure 1. A gold-plated 3D printed ion trap on top of the glass substrate it was machined out of.

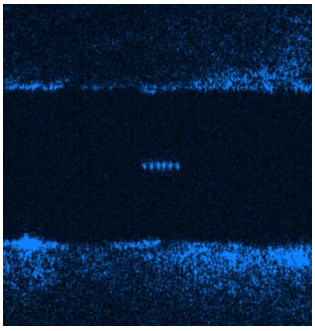

Figure 2. 6 laser cooled single Calcium ions between the electrodes of the ion trap above

### Other resources

- Unit publication list
- Unit website

**Keywords:** Quantum Computing, Quantum networking, Quantum Internet, Ion trap, Cavity Quantum Electrodynamics

### Contribution to SDGs


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