Cavity-based Quantum Processor: Engineering Entanglement with Programmable Connectivity

Marvin Holten*[1], Stephan Roschinski[1], Johannes Schabbauer[1], Isabelle Safa[1], Sarah Waddington[1], Constantin Grave[1], Julian Leonard[1]

1. Atominstitut, TU Wien, Stadionallee 2, 1020 Vienna, Austria

Entanglement is the fundamental resource for applications like quantum computation and communication beyond the possibilities of classical machines. Many current devices are limited to local connectivity when system size is increased. Our goal is to establish an alternative platform for quantum simulation and information processing with full qubit connectivity. The idea is to trap an array of individually addressable atoms inside an optical cavity. The photon-mediated interactions of the atoms in the cavity will enable us to introduce non-local couplings and entangling operations between any two atoms or qbits in the system. We will implement a non-destructive readout scheme that relies on injecting a few-photon field into the cavity. Dissipation and non-destructive measurements open up exciting possibilities to generate highly entangled many-body ensembles, like large GHZ states, in our system. We want to use the quantum processor to address longstanding questions about thermalisation of quantum systems and information scrambling. With its scalability and fully programmable connectivity, our architecture has the potential to open up new pathways for a wide range of fields like quantum optimization, communication and simulation.

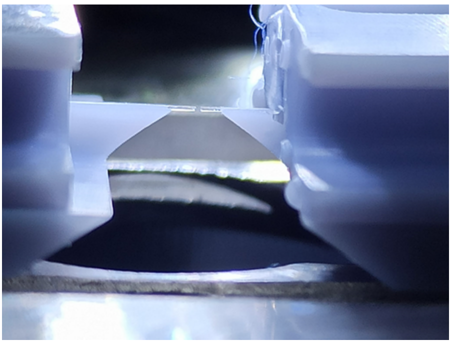

Fig. 1: Image of the fiber Fabry-Perot cavity in our experiment [1].

References

[1] Pfeifer, H., Ratschbacher, L., Gallego, J. et al. Achievements and perspectives of optical fiber Fabry–Perot cavities. Appl. Phys. B **128**, 29 (2022)

*marvin.holten@tuwien.ac.at