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An ion trap quantum processor with integrated ion-photon interface

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The aim of this project is to build a quantum computing processor with integrated ion-photon interface. It consists of an ion trap with zones for ion loading, QIP and a zone with an integrated optical cavity for enhanced communication. The electrode structure is designed for dual species operation, ion swapping and ion chain splitting. To achieve highly efficient high-fidelity quantum communication between processors, the system is equipped with an integrated cavity, strongly coupling to the trapped ion. To realize this, we designed a chip, which was manufactured using femtosecond laser induced selective etching (FLISE) from a fused silica substrate, and subsequently gold coated. Employing trenches between the electrodes the chip can be metalised without masks. The cavity is formed of fused silica rods instead of optical fibres as has been used previously [1] in order to improve the photon collection efficiency. In previous works, researchers have reported effective photonic entanglement by using high-numerical-aperture lens'to couple two ions'qubits into single-mode optical fibres to attain high rate and fidelity [2]. For our system, we expect significantly higher entanglement rates with high fidelity due to strong coupling operation.

[1] H. Takahashi et al., Phys. Rev. Lett., vol. 124, p. 013602, (2020).
[2] L. J. Stephenson et al., Phys. Rev. Lett., vol. 124, p. 110501, (2020).

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