Integrated Microring Resonators for Quantum Repeaters

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Quantum technologies are rapidly graduating from theoretical literature and laboratories into practical implementation. The most important applications, such as quantum cryptography and distributed quantum computing, generally require a reliable way of distributing entanglement for exchanging quantum information. More specifically, such long-distance quantum telecommunication networks need to overcome loss in fibre optics, which limits point-to-point transmission to a few hundred kilometres [1]. As classical signal repeaters cannot amplify and relay quantum information by the no-cloning theorem, we require the quantum analogue to such repeaters which can effectively establish entanglement across distant parties via a quantum protocol known as entanglement swapping [2].

This poster presents our recent work on performing entanglement swapping with a focus on working with experimental parameters that fall within the practical constraints of a functional quantum repeater link. Firstly, to achieve a reasonable rate of entanglement distribution, we demonstrate the use of integrated microring resonators (MRRs) as efficient sources of entangled photon pairs. Secondly, promising quantum repeater architectures typically require quantum memories that store and emit photons on-demand for timing synchronisation of the entanglement swapping protocol. As these memories have limited frequency bandwidths for efficient coupling, we specifically use Si_3N_4 MRRs producing narrow-bandwidth photons (~50MHz) that are compatible with state-of-the-art memory platforms such as $^{171}Yb^{3+}:Y_2SiO_5$ (~250MHz bandwidth) [3].

The poster will thus contain results from characterising the energy-time entanglement of two independent telecom wavelength MRR setups, the heralded HOM interference measurement between photons from each source, and finally the entanglement swapping protocol. We present our implementation of an asynchronous time-bin entanglement swapping protocol as well as the practical challenges associated with using narrowband/long coherence time (~6ns) photons. These include phase stabilising two highly imbalanced Franson fibre interferometers (~68ns delays) and locking the pump laser frequencies to a common stable reference across both sources.

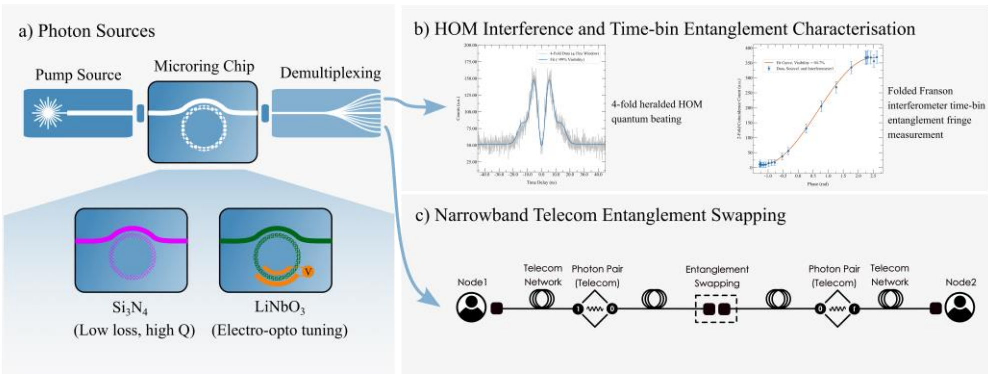

Fig. 1 Concept diagram depicting the key aspects of our quantum repeating work a) Using MRRs to produce photon pairs as a heralded single-photon source or for photon state preparation. Two candidate MRR materials are investigated. b) HOM interference between two independent telecom MRR photon sources, and time-bin entanglement characterisation of each source with Franson interferometers. We achieve a background-subtracted HOM visibility of >99%, and entanglement visibilities of 94.7% and 92%. c) Performing asynchronous time-bin entanglement swapping between the two MRR sources.

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References

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