A scalable, high-bandwidth warm atom quantum memory using hollow-core photonic crystal fibers

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The development of an optical quantum network will allow for the transmission and manipulation of quantum information over much greater distances and at much faster speeds than is currently possible. This will enable provably-secure communications via quantum key distribution, as well as optical quantum computing. Such networks will consist of nodes to localise and manipulate information-carrying photons, interconnected with channels to transmit the photons between nodes. Optical fibres are the obvious choice for providing links between nodes. Our work makes use of hollow-core photonic crystal fibres filled with warm rubidium atoms to create a system that is directly integrable with current optical fibre technology [1]. The tight transverse confinement (diameter of tens of microns) and extended interaction lengths (centimetres) of the fibres provide an extremely optically dense medium, ideal for efficient quantum information storage and manipulation.

Here we will present our latest work implementing the no noise, high-bandwidth Off-Resonant Cascaded Absorption (ORCA) quantum memory protocol [2, 3] within our hollow-core fibres down to the single-photon level (Fig. 1). We achieved similar memory efficiencies to previous work (30%, with 10 ns lifetime) but with a control power reduction of two orders of magnitude, demonstrating that waveguides such as hollow-core fibres present an opportunity to increase the scalability of optical quantum memories for future large-scale quantum information networks.

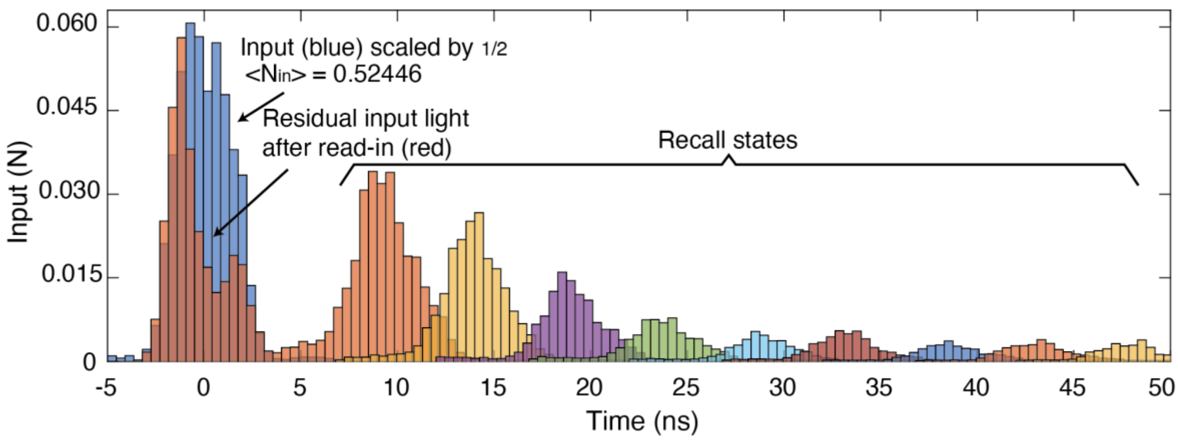

Figure 1: Single-photon level storage (blue), residual input light after read-in (red) and a sequence of recall states at different storage times using the ORCA protocol within a rubidium-filled hollow-core fibre.

[1] C. Perrella *et al.*, *Phys. Rev. Appl.* **9**, 044001 (2018).

[2] K. T. Kaczmarek et al., *Phys. Rev. A* **97**, 042316 (2018).

[3] R. Finkelstein et al., *Sci. Adv.* **4**, eaap8598 (2018)