A multiplexed light-matter interface for fibre-based quantum networks

E. Saglamyurek[1], M. Grimau Puigibert[1], Q. Zhou[1], L. Giner[1], F. Marsili[2], V.B. Verma[3], S.W. Nam[3], L. Oesterling[4], D. Nippa[4], D. Oblak[1], and W. Tittel[1]

[1] Institute for Quantum Science and Technology, and Department of Physics and Astronomy, University of Calgary, Canada

[2] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

[3] National Institute of Standards and Technology, Boulder, Colorado, USA

[4] Battelle Memorial Institute, Columbus, USA

Processing and distributing quantum information using photons through fiber-optic or free-space links is essential for building future quantum networks. The scalability needed for such a network can be achieved by employing quantum states that are multiplexed into time and/or frequency, and light-matter interfaces that are able to store and process such states with large time-bandwidth product, and large multimode storage and processing capacity. Despite important progress in developing such devices, the demonstration of these capabilities using non-classical light remains an open challenge. Here we report the quantum storage of heralded single photons at telecom (1532nm) wavelength with a time-bandwidth product approaching 1000 by implementing the atomic frequency comb quantum memory protocol in a cryogenically cooled erbium-doped optical fiber. Furthermore we demonstrate frequency-multimode storage. Our demonstrations rely on fully integrated quantum technologies operating at telecommunication wavelengths, i.e. a fiber-pigtailed nonlinear waveguide for the generation of heralded single photons by means of spontaneous parametric down-conversion, and an erbium-doped fiber for photon storage and manipulation. With improved storage efficiency, our light-matter interface may become a useful tool in future quantum networks.

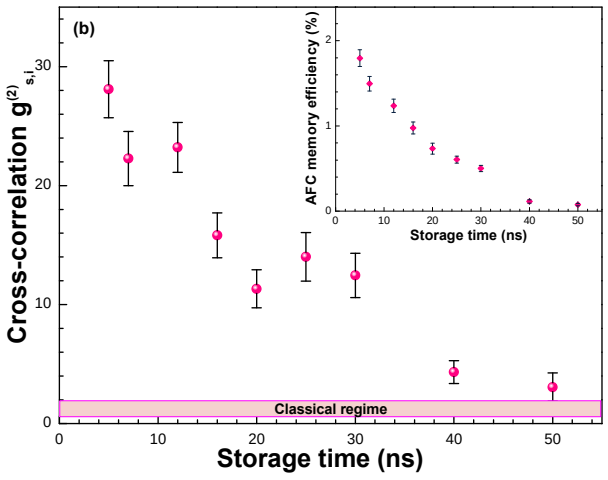

Fig. 1: Quantum storage with large time-bandwidth product. A cryogenically cooled erbium-doped fiber is programmed to store 16 GHz wide heralded single photons for 5 to 50 ns. The experimentally obtained cross-correlation function $g^{(2)}(0)$ exceeds the quantum-to-classical threshold of two for each storage time, demonstrating quantum storage with a time-bandwidth product of up to 800 (i.e. 16 GHz x 50 ns). The cross-correlation coefficient decreases with storage time due to a decreasing storage efficiency (see inset) paired with constant noise.