Waveguide Quantum Frequency Conversion of Heralded Single Photons emitted by Rubidium Quantum Memories to Telecom Wavelengths

Boris Albrecht, Pau Farrera\textsuperscript{1}, Xavier Fernandez\textsuperscript{1}, Matteo Cristiani\textsuperscript{1} and Hugues de Riedmatten\textsuperscript{1,2} 
\textsuperscript{1}ICFO-Institut de Ciencies Fotoniques, Av. Carl Friedrich Gauss 3, 08860 Castelldefels (Barcelona), Spain 
\textsuperscript{2}ICREA-Institució Catalana de Recerca i Estudis Avançats, 08015 Barcelona, Spain

In the context of long distance quantum communication, quantum repeater architecture \cite{1,2} have been proposed to overcome the exponential attenuation in optical fibers. Quantum repeaters rely on heralded entanglement between remote quantum memories. An important scheme to achieve this goal is based on the creation, storage and transfer to light of single collective spin excitations in cold atomic ensembles, following the scheme of Duan, Lukin Cirac and Zoller (DLCZ) \cite{1}. To achieve efficient entanglement, it is necessary that photonic quantum memories are connected to the optical fiber networks. However, most quantum memories operate in a wavelength range where the loss in optical fibers is significant. Hence a quantum interface allowing us to connect these quantum memories to the optical fiber network by converting the emitted photons to telecom wavelengths is needed for almost all applications in the context of quantum communication \cite{2}. This frequency conversion must be efficient, noise free and must maintain the quantum properties of the converted photon \cite{3}.

Frequency down conversion using difference frequency generation in non linear crystals (DFG) enables the conversion of visible or near infrared light to telecommunications wavelengths and is thus ideally suited for quantum repeater applications. DFG has been demonstrated with non-classical light from broadband down conversion sources \cite{4} and solid state emitters \cite{5,6}. However, so far DFG has not been demonstrated with long-lived quantum memories.

In this work, we present a solid state photonic quantum interface capable of connecting DLCZ quantum memories based on cold Rb ensembles to the telecommunication network. It is based on DFG in a non linear PPLN optical waveguide, in order to convert Rb resonant photons from 780 nm to 1550 nm \cite{7}. As proof of principle, we have successfully converted an heralded single photon emitted by the quantum memory. We showed that a significant amount of non classical correlations between the heralding and converted heralded photons is preserved during the frequency conversion process. These results show that integrated optical devices can be used as a practical and flexible interface capable of connecting quantum memories to the optical fiber network.

\begin{thebibliography}{9}
\bibitem{1} L.-M. Duan et al., Nature \textbf{414}, 413 (2001).
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