Low-noise quantum memory for quasi-deterministic single photons generated by Rydberg collective atomic excitations

Jan Lowinski
Lukas Heller, Klara Theophilo, Auxiliadora Padron-Brito, Hugues de Riedmatten

ICFO - Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels, Spain

jan.lowinski@icfo.eu

Most of the demonstrations of quantum repeater links with ensemble-based quantum memories are based on probabilistic light-matter entanglement sources. These types of probabilistic sources lead to limitations due to a trade-off between excitation probability and fidelity of the generated state [1].
A quantum repeater architecture based on the use of deterministic single-photon sources and absorptive ensemble-based quantum memories was proposed to overcome this limitation [2].
In this work [3], we demonstrate storage and retrieval of an on-demand single photon generated by a collective Rydberg excitation [4] on a low-noise Raman quantum memory located in a different cold atomic ensemble [5]. We show that the single photons can be stored and retrieved with a signal-to-noise ratio (SNR) up to 26, preserving strong antibunching. We also evaluate the performance of the built-in temporal beam splitter offered by the Raman memory. In addition, we demonstrate that the Raman memory can be used to control the single photon waveshape.
Our results are an important step towards the implementation of efficient quantum-repeater links using single-photon sources.

References

[1] N. Sangouard et al., Reviews of Modern Physics 83 (2011) 33
[2] N. Sangouard et al, Physical Review A 76 (2007) 050301
[3] L.Heller et al., arXiv: 2111.08598
[4] Y. O. Dudin and A. Kuzmich, Science 336 (2012) 887
[5] K. F. Reim et al., Nature Photonics 4 (2010) 218

Figures

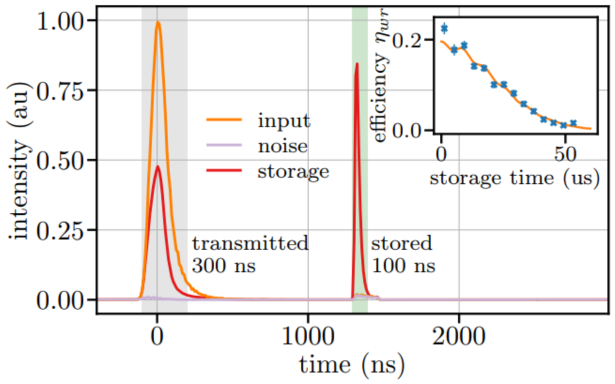

Figure 1: Photon histogram observed at the SNSPDs after the memory. The orange histogram is the input photon with no storage attempt. The red histogram presents a storage attempt and the lavender histogram is the noise. The inset shows the storage and retrieval efficiency as a function of storage time.

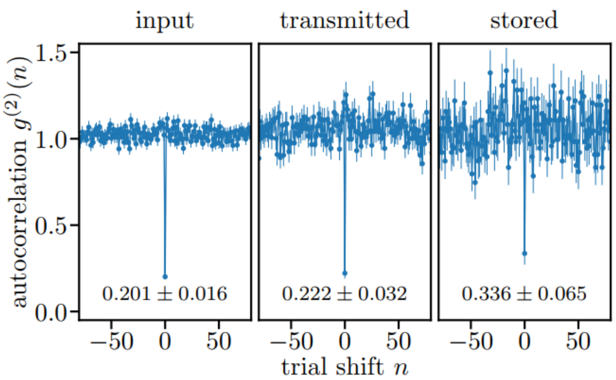

Figure 2: Autocorrelation $g^{(2)}$ as a function of shift between trials n for the input, transmitted and stored photons. For trials separated by a shift $|n| \geq 1$ the clicks are uncorrelated yielding $g^{(2)}(n) = 1$. Coincidences clicks in the same trial, $n = 0$, are much less frequent asserting the photons anti-bunching.