Simple atomic quantum memory suitable for semiconductor quantum dot single photons

Gianni Buser[1], Janik Wolters[1], Roberto Mottola[1], Andrew Horsley[1], Lucas Béguin[1], Andreas Jöckel[1], Jan-Philipp Jahn[1], Richard J. Warburton[1], and Philipp Treutlein[1]

[1] University of Basel, Departement of Physics, Klingelbergstrasse 82, 4056 Basel, Switzerland

Quantum memories matched to single photon sources will form an important cornerstone of future quantum network technology. We have demonstrated such a memory in warm Rb vapor, based on electromagnetically induced transparency [1]. With an acceptance bandwidth of $\delta f = 0.66\,\mathrm{GHz}$, the memory is suitable for single photons emitted by semiconductor quantum dots. Wavelength-matched sources with lifetime-limited linewidth are available [2], and recently control has been established over the temporal profiles and the bandwidth of the emitted single photons [3]. With the bandwidth gap closed, we present the latest progress on the memory side and discuss the prospect of bringing together such a memory and source in a combined experiment.

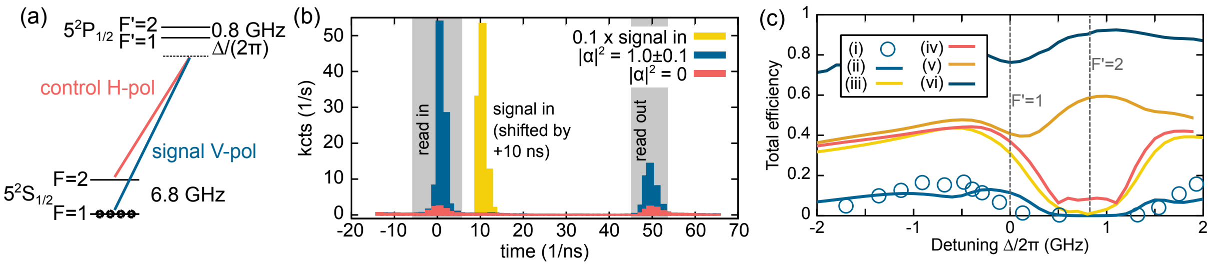

Figure 1. Main results from [1]. (a) Energy levels of the Rb D_1 line and the transitions involved in the EIT based storage process. (b) Arrival time histogram of photons detected in a 50 ns storage and retrieval experiment for a coherent input state with $|\alpha|^2 = 1.0$ and for a blocked input (characterizing the noise). The measured end-to-end efficiency accounting for noise and including all losses and filtering is $\eta_{\mathrm{e2e}}^{50\,\mathrm{ns}} = 3.4(3)\,\%$. The signal-to-noise ratio for single-photon-level input is SNR $= 3.7(6)$. (c) Total efficiency of the memory as a function of detuning for, (i) our experimental data, and simulations of the level-scheme with, (ii) all parameters as in experiment, (iii) as (ii) but Gaussian control pulses have optimal power, (iv) as (ii) but control pulses are fully optimized in power and shape, (v) as (iii) but suppressing parasitic single photon transitions as is possible with our newest level-scheme, (vi) as (v) but increasing OD from the experimentally used value of 5 to 35.

[1] J. Wolters, G. Buser, A. Horsley *et al.*, "Simple atomic quantum memory suitable for semiconductor quantum dot single photons," Phys. Rev. Lett. **119**, 060502 (2017).
[2] J.-P. Jahn, M. Munsch, L Béguin *et al.*, "An artificial Rb atom in a semiconductor with lifetime-limited linewidth," Phys. Rev. B **92**, 245439 (2015).
[3] L. Béguin, J.-P. Jahn, J. Wolters *et al.*, "On-demand semiconductor source of 780 nm single photons with controlled temporal wave packets," arXiv:1710.02490 (2017).