Broadband quantum memories in hot alkali gases

O. Lazo-Arjona [1], S. Gao [1], P. M. Ledingham [1], B. Brecht [1], K. T. Kaczmarek [1], S. E. Thomas [12], G. S. Thekkadath [1], J. H. D. Munns [12], D. J. Saunders [1], J. Nunn, I. A. Walmsley[1]

[1] University of Oxford, UK
[2] Imperial College London, UK
[3] University of Bath, UK

A photonic quantum memory is a device capable of storing a quantum state of light and return it at a later time [1]. These devices have the capacity to synchronize stochastic production events in photon production, making them essential building blocks for long-distance quantum networks and quantum computing based in linear optics [2]. An important benchmark required for these applications is being able store and retrieve at frequencies comparable to modern electronic devices operating in the GHz range. We compare two broadband memory protocols mapping photons into hot alkali vapour excitations: the Raman quantum memory storing photons as coherences between two hyperfine ground levels [3], and the ORCA quantum memory [4], storing in coherences between a hyperfine ground level and a doubly excited orbital level. Applications into photonic temporal mode manipulation and frequency conversion using these protocols are discussed.

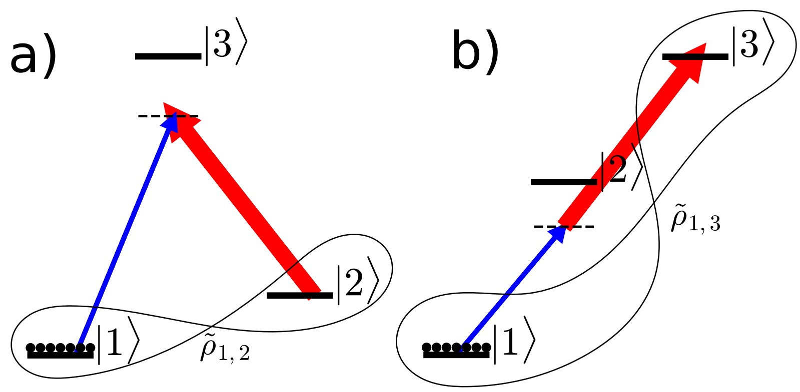

Figure 1. Level diagrams for photon storage a) for the Raman memory b) for the ORCA memory. Two-photon transitions are induced by an incoming single photon (blue) and a strong control laser pulse (red), mapping the photon into a coherence (black loops) for storage. To read out, a second control laser pulse reactivates the two-photon transition retrieving the stored photon.

[1] A. I. Lvovsky, Nature photonics, Vol. 3, no. 12, pp. 706714, 2009.
[2] J. Nunn, Physical Review Letters, Vol. 110, Iss. 13 29 March 2013
[3] J. Nunn, Physical Review A, Vol. 75, Iss. 1 - January 2007.
[4] K. T. Kaczmarek, Physical Review A, vol. 97, Iss. 4 - April 2018.