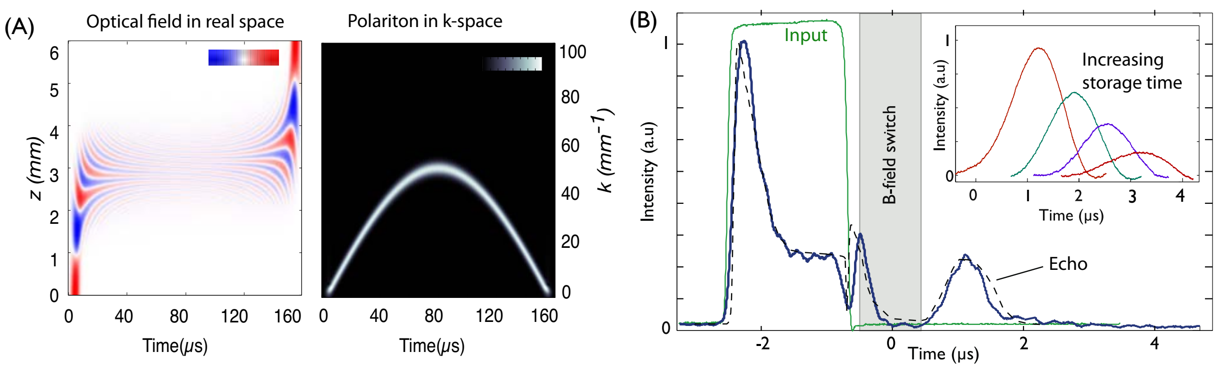
Memory for Light

G. Hétet[1], M. Hosseini[1], B. M. Sparkes[1], J.J. Longdell[2],M.J. Sellars[3],D. Oblak[4],
P. K. Lam[1], and B. C. Buchler[1]
[1] *ACQAO, College of Science, The Australian National University*
[2] *Department of Physics, University of Otago, Dunedin, New Zealand*
[3] *Laser Physics Centre, RSPhysSE, Australian National University, Canberra, ACT 0200, Australia*
[4] *QUANTOP, Niels Bohr Institute, University of Copenhagen, Denmark*

Atoms can be manipulated in different ways so that through interaction with light they can store optical quantum information in a controllable fashion. In order to store quantum information, decoherence processes must be controlled so as to avoid loss through coupling to the environment. High efficiency, fidelity and storage time are some requirements for building a “Quantum Memory”. We have developed a Gradient Echo Memory (GEM) technique that can be used to store quantum information carried by light in coherent ground states of atoms.

Theoretical modelling using two level atoms has shown how the combined atom-light excitation in the GEM system can be described as a normal mode in k-space [1]. The ’speed’ of the normal mode (Fig. A) in the k-t plane can be controlled using the slope of a linearly varying atomic detuning that is applied along the length of the storage medium. This can be done, for example, using a Stark or Zeeman shift. The model also shows that, in the limit of large optical depth, GEM is 100% efficient and preserves the quantum state of the light.

Our experimental implementation of the GEM system is based on a warm gas cell containing ^{87}Rb atoms and buffer gas. By applying a linearly varying magnetic field along the length the atomic ensemble and a strong Raman coupling beam, information can be stored in the ground states of the Rb atoms. By reversing the magnetic field gradient, we observed a photon echo, as shown in Fig. B [2]. So far, efficiency of 5 % has been achieved that is mainly limited by the optical depth of medium. The coherence time of the storage is of the order 1-2 μs. This appears to be mostly limited by Doppler broadening in the gas cells. We anticipate that cold atomic gases may yield great improvements in performance.



A: The optical field decays towards the detuning switching point at 80 μs and then re-grows symmetrically. The polaritonic mode propagates in k-space and reverses direction at the switching point. When the mode reaches the initial k value, light is remitted [1].
B: Storage in a warm rubidium vapour. The input pulse (green) is partially absorbed in the gas cell, the unabsorbed pulse is in blue on the left of the figure. After the magnetic field switch an echo is generated. As the magnetic field flip is delayed, the echo is also delayed, as shown in the inset [2].

References

[1] G. Hétet, J. J. Longdell, M. J. Sellars, P. K. Lam, and B. C. Buchler, Phys. Rev. Lett. **101**, 203601 (2008).
[2] G. Hétet, M. Hosseini, B. M. Sparkes, D. Oblak, P. K. Lam, and B. C. Buchler, Optics Lett. **33**, 20 (2008).