Coherent pulse sequencing with gradient echo memory

M. Hosseini[1], B. M. Sparkes[1], G. Hétet[1], J. J. Longdell[2], P. K. Lam[1], and B. C. Buchler[1]
[1]Research School of Physics and Engineering, ACQAO, ANU
[2]Physics Department, University of Otago, Dunedin, New Zealand

One possible paradigm for optical quantum state storage is to write the optical field onto the polarisation of an atomic ensemble. Provided the atomic states are long-lived, this allows to freeze light in space. By mapping the atomic polarisation back to an optical field, the light can be released at a later time. Significant progress has recently been made in implementing atomic quantum memory using electromagnetically induced transparency (EIT), photon-echo, off-resonant Raman, and other atom-light interaction processes [1].

Our coherent memory system, known as "Gradient Echo Memory" (GEM), can be used with two- and three-level atomic systems and in principle it can be 100% efficient without adding any extra noise to the stored light [2, 3]. The key to two- or three-level GEM is the application of an atomic frequency gradient along the length of the storage medium. Depending on the atomic system, a linearly varying electric or magnetic field can be used to induce a Stark or Zeeman shift that varies in the z direction, as shown in Fig. 1a. In the most simple storage protocol, a probe field is absorbed by the frequency shifted ensemble of atoms. Due to the frequency gradient in the ensemble, the Fourier components of the probe field are distributed linearly along on the z-axis [4]. The light is released by inverting the gradient as shown in Fig. 1b.

We have experimentally demonstrated in warm Rb vapour [5] that three-level GEM can be used to stretch and compress pulses (Fig. 1c), recall pulses in any desired order (Fig. 1d) and split pulses over multiple recall events (Fig. 1e). Recall efficiency of over 40% was also observed.

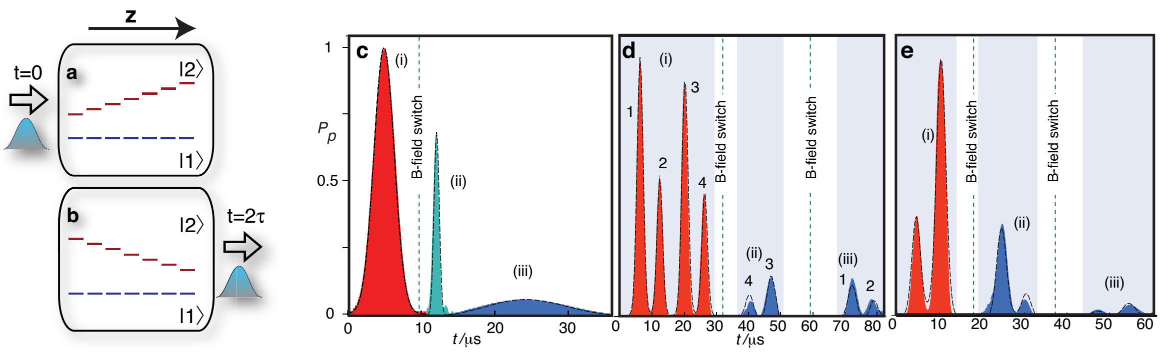

Fig. 1: (a) A pulse is absorbed in an ensemble. (b) Re-emission occurs after reversing the atomic frequency gradient. (c) Pulse compression (ii) and stretching (iii) of the input pulse (i). (d) Reordering of pulses. (e) Splitting of pulses. Pulse power (P_p) is in arbitrary units. The recalled pulses in (d) and (e) are magnified 10 times. The dashed lines show numerical models of the experiment. See [5] for details.

References

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