Room temperature atomic frequency comb memory for light

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Quantum memories for light provide a crucial capability - enabling the deterministic synchronisation of probabilistic processes associated with quantum constituents within a large-scale network. For this there are strict requirements on the properties of the quantum memory, such as storage time, retrieval efficiency, bandwidth, and scalability. Off-resonant ladder protocols in warm alkali vapour platforms are promising [1,2], combining efficient high-bandwidth operation with low-noise on-demand retrieval. However, the storage time is limited by motion-induced dephasing associated with the broad velocity distribution of atoms comprising the vapour. We solve this issue by velocity selective pumping of a room temperature caesium vapour and perform the atomic frequency comb (AFC) memory protocol [3, 4].

We prepare multiple velocity classes in the F= 4 hyperfine ground state of caesium using velocity selective optical pumping facilitated via narrowband lasers on the D1 and D2 lines. The frequency spacing of the classes is chosen to coincide with the $F' = 4$ to $F' = 5$ hyperfine splitting of the $6P_{3/2}$ excited state resulting in a broadband GHz periodic absorbing structure. Weak coherent state pulses of duration 2ns are stored and retrieved with pre-programmed recall times of 8 ns and 12 ns with an efficiency of around 9 % and 3 % respectively. We demonstrate the multimode nature of the AFC quantum memory by storing 2 temporal modes with no detriment to the total efficiency.

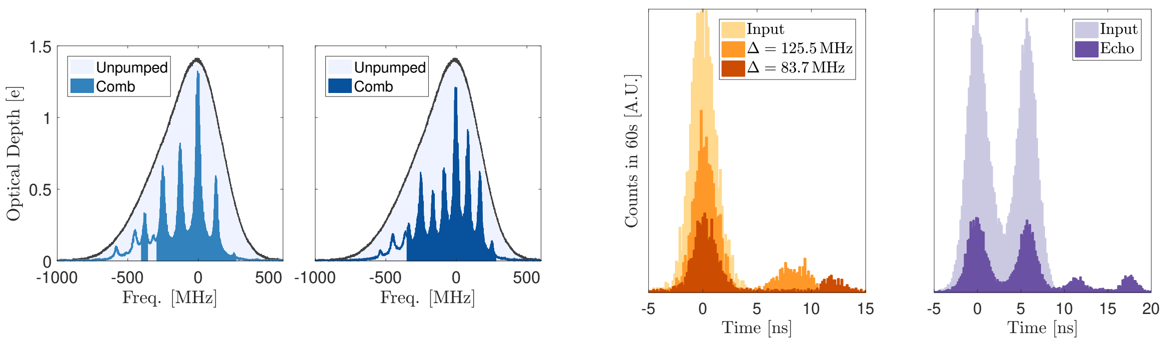

Figure 1: Atomic frequency comb memory in warm vapour via velocity selective optical pumping. 1st/2nd panel: Spectra ($\Delta = 125.5$ MHz and $\Delta = 83.7$ MHz, respectively). 3rd panel: AFC storage and retrieval; 4th Panel: Multimode storage.

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