Master project: Multi-cell quantum memory
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This project aims at realizing and testing a multi-cell quantum memory in which several optical pulses on the single photon level can be stored simultaneously. Such memories can be used in advanced experiments on neuro-inspired photonic computers [1], photonic quantum computation/simulation [2], quantum communication [3].

Optical memories convert optical pulses traveling at the speed of light into long-lived stationary excitations in an optical active medium, so called spin waves [4]. Ideally, this process is reversible and spin waves can be coherently back-converted into optical pulses. Various schemes for realizing optical memories have been introduced in the context of quantum communication. Most prominent are the schemes based on electromagnetically introduced transparency (EIT) or Raman transitions and photon echo schemes. Both can be implemented in a great variety of physical systems, where rare-earth doped crystals and warm or cold atomic vapors are most advanced. For applications alkaline vapor cells at room temperature are favorable, as they require lower experimental complexity compared to the other systems. See Fig. 1 for more details. Coherence times of 10 milliseconds up to one minute were observed in vapor cells with suitable anti-relaxation coatings. A recent experiment with a vapor cell memory reached a storage time of τ = 1 s. While quantum applications usually require memories with extreme low readout noise, the figures for this project are bandwidth and memory capacity. Furthermore, the capability of manipulating optical waveform shapes, in particular to perform a partial readout, where several optical pulses can be generated from a single stored spin wave is required. This has not yet been investigated experimentally in vapor cell memories.

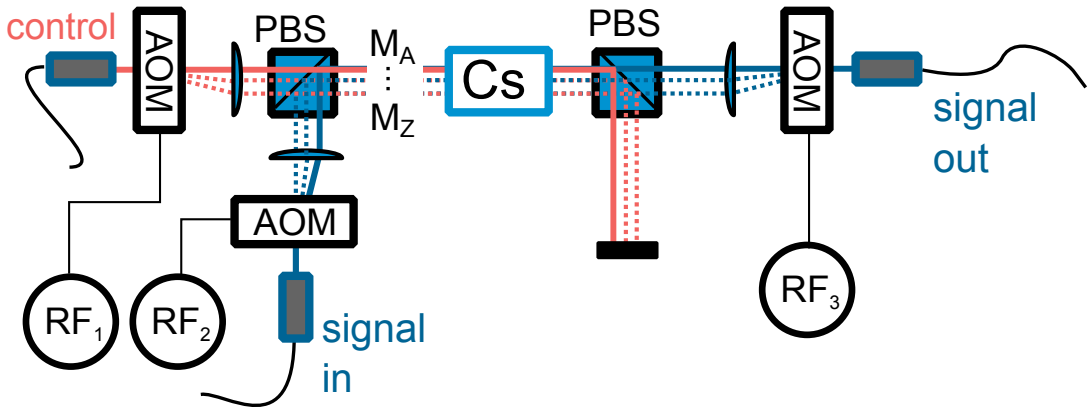

Fig. 1: Sketch of the experimental setup of a multi cell optical memory with storage in different spatial modes M_A...M_Z. AOM: acousto-optic modulator; Cs: Cesium vapor cell; PBS: polarizing beam splitter; RF: radio frequency source.

3 Bibliography

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[3] N. Sangouard et al., *Quantum repeaters based on atomic ensembles and linear optics,* Rev. Mod. Phys. **83,** 33 (2011).

[4] M. Fleischhauer, et al., *Dark-State Polaritons in Electromagnetically Induced Transparency,* Phys. Rev. Lett. **84**, 5094 (2000).