A low-noise atomic quantum memory in the Paschen-Back regime

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Quantum networks have been proposed to overcome current limitations in quantum communication and computing. A promising path to realize these networks are heterogeneous quantum nodes [1] consisting e.g. in a semiconductor single photon source and a bandwidth-matched atomic quantum memory. Recently we have demonstrated a quantum memory in warm Rb vapor with on-demand storage and retrieval compatible with photons emitted by quantum dots [2]. We are currently working to improve our memory by engineering the atomic energy levels with an applied tesla-order magnetic field. In doing so, we enter the Paschen-Back regime, where the hyperfine Hamiltonian is a perturbation to the magnetic field Hamiltonian, and the atomic electron and nuclear spins decouple. Separation of ground state hyperfine sublevels larger than the optical linewidth in the warm vapor allows us to optically address each individual sublevel, and we can form a near-ideal atomic three-level system without laser cooling. We should therefore avoid loss channels such as single photon absorption, and completely suppress four-wave mixing, which is a limiting noise source in conventional high-bandwidth atomic memories.

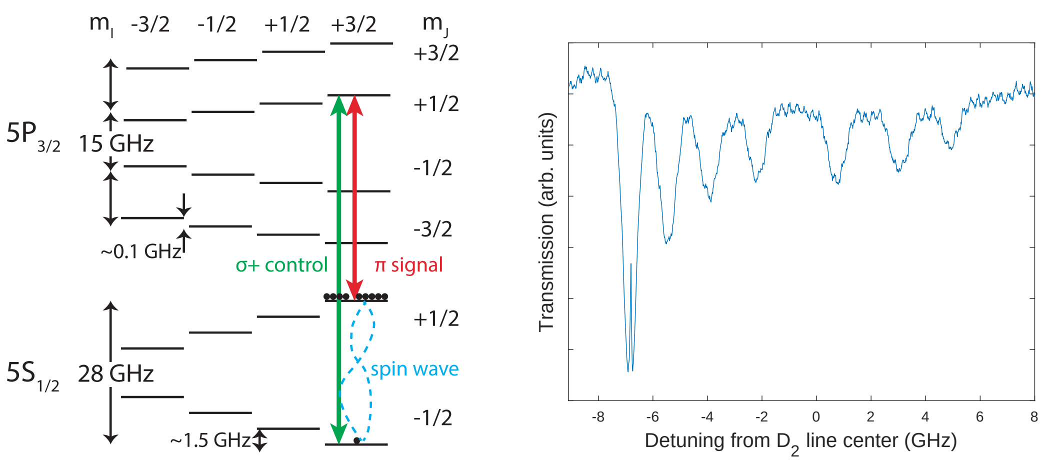

Figure 1. Energy levels of the Rb D2 line at 0.8T. In the Paschen-Back regime m_J and m_I are good quantum numbers. Optical transitions with $\Delta m_I \neq 0$ have low probabilities, since they would require a nuclear spin flip, thus creating four isolated manifolds. By applying a CW signal and control laser of suitable polarization to the indicated transitions (see figure) we observed EIT. This constitutes a first step towards a memory in the Paschen-Back regime.

[1] N. Sangouard et al., Long-distance entanglement distribution with single-photon sources, Phys. Rev. A **76**, 050301(R)(2007).

[2] J. Wolters et al., Simple atomic quantum memory suitable for semiconductor quantum dot single photons, Phys. Rev. Lett. **119**, 060502 (2017).