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Long-lived Quantum Memories

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A memory based on hyperfine atomic coherences (spin waves) which can be read out optically at the single photon level, when classical noise sources have been eliminated, is a quantum memory. The spin waves are generally sensitive to ambient magnetic fields that limit their storage time to tens of microseconds. By optical pumping of the atoms and use of the clock coherence sensitivity to magnetic fields can be greatly reduced. Even in ultra-cold atomic samples motional dephasing becomes important on a scale of hundreds of microseconds. We present results of our work which circumvent both of these difficulties to achieve an atomic memory with a lifetime of several milliseconds. We will discuss various applications of the long-lived atomic memory, including deterministic single photon sources, matter qubit rotations, and matter-light entanglement.