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Coherent storage and processing of broadband light via the Autler-Townes effect in cold Rb atoms

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Techniques for coherently controlling light with matter open up the possibility for storing and manipulating optical signals, including those at the quantum level. These ideas were revolutionized by the realization of electromagnetically induced transparency (EIT), which relies upon quantum interference and leads to the well-known phenomenon of slow-light. In our laboratory, we have found that optical signals can be coherently controlled outside of the regime of EIT and quantum interference, which is described by the Autler-Townes effect and does not require slow light. We have developed a new Autler-Townes splitting (ATS) protocol that facilitates dynamically controlled coherent storage and manipulation of optical signals, and which can be implemented in almost any physical three-level system due to its robustness to decoherence. This technique, which relies on the absorption of the signal over a wide spectral region, is inherently broadband, well-suited to quantum memory applications, and reduces many of the technical constraints imposed by other memory techniques. We experimentally demonstrate the proof-of-principle of this technique for several applications in a laser-cooled sample of ^{87}Rb atoms: the storage of short (30 ns) optical signals; the temporal/spectral compression and stretching of optical pulses; coherent temporal and spectral beamsplitting operations; and wavelength conversion. Finally, we show that weak optical pulses with less than one average photon per pulse can be stored and retrieved with this method, demonstrating the low-noise operation of our approach for applications in quantum information processing.