Single-Photon Storage in a Ground-State Vapor Cell Quantum Memory

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Abstract We demonstrate storage and retrieval of SPDC generated photons in a ground-state Rb vapor cell memory, successfully maintaining the single-photon character of the retrieved light. Our platform of single-photon source and atomic memory is attractive for future room-temperature quantum networks operating at high bandwidth. ©2022 The Authors

Interfaced single-photon sources and quantum memories for photons together form a foundational component of quantum technology. Achieving compatibility between heterogeneous, stateof-the-art devices is a long-standing challenge. Hot vapor memories in particular are a promising platform due to the high acceptance bandwidths and technical simplicity. The latter point is technologically important as it promises reliable field-usability and miniaturization akin to what has been seen in the development of vapor cell based atomic clocks, once the memory performance justifies this kind of scaling. A long standing problem that has plagued both our own past implementation [1] and those of many others [2] is read-out noise ruining the retrieved photon quality as measured by number statistics. Furthermore, only a few hot vapor memories have been interfaced with actual single photon sources due to source compatibility issues. We address both of these problems by exploiting polarization selection rules to operate the memory with low noise in the longlived electronic ground state, and by building a tailored photon source, described in [3], designed to match the performance of our memory.

Here we report on successfully interfacing a heralded single-photon source based on cavity-enhanced spontaneous parametric downconversion in ppKTP and a matched memory based on electromagnetically induced transparency in warm ⁸⁷Rb vapor [4]. The bandwidth of the photons emitted by the source is 370 MHz, placing its speed in the technologically relevant regime while remaining well within the acceptance bandwidth of the memory. Simultaneously, the experimental complexity is kept low, with all components operating at or above room temperature. Read-out noise of the memory is considerably reduced by exploiting polarization selection rules in the hyperfine structure of spin-polarized atoms. For the first time, we demonstrate singlephoton storage and retrieval in a ground-state vapor cell memory, with $g_{c, \text{ret}} = 0.177(23)$ demonstrating the single-photon character of the retrieved light. Our platform of single-photon source and atomic memory is attractive for future experiments on room-temperature quantum networks operating at high bandwidth.

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