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Indistinguishability, coherence and entanglement of atom-like systems in nanophotonic devices[1]

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Atom-like systems strongly interacting with single photons form the basis for quantum networks and enable optical nonlinearities at the single-photon level. Realizing such systems in solid-state materials is attractive for scalability and high-bandwidth operation, but is complicated by environmental dynamics that degrade optical coherence. In this talk, I will describe a platform for addressing this challenge using silicon-vacancy (SiV) color centers in diamond nanophotonic devices. The inversion symmetry of the SiV center leads to a first-order insensitivity of its optical transitions to dominant environmental dephasing mechanisms. This property results in narrow optical transitions and enables high-cooperativity atom-photon interactions for a single SiV coupled to a nanocavity. Using this platform, we demonstrate quantum nonlinear cavity transmission controlled by a single color center. Detuning the cavity from a pair of SiV centers leads to photon-mediated interactions and spectrally resolved superradiant and subradiant states. Finally, we show that the detection of an indistinguishable photon from a pair of spatially separated SiV centers in a waveguide leads to superradiant emission of two entangled SiV centers. These results open up new opportunities for realizing quantum optical experiments in new regimes using nanoscale devices.

[1]This work was performed at Harvard University under the supervision of Prof. Mikhail D. Lukin.