Scalable quantum photonics using quantum dots

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Quantum photonic devices require methods to efficiently generate photonic qubits and to create strong photon-photon interactions. Quantum dots can provide both of these crucial functionalities. They are ideal single photon sources that exhibit both high efficiency and indistinguishability. Furthermore, coupling them to high Q cavities with small mode volumes enables the strong coupling regime where a nonlinearities can enter the single photon regime.

In this talk I will describe our effort to attain scalable quantum photonic devices using quantum dots. I will first describe a quantum transistor where a single photon can control a quantum dot spin and vice versa [1]. This switch realizes a transistor operating at the fundamental quantum limit, where in picoseconds timescales a single photon flips the orientation of a spin and the spin flips the polarization of the photon. This device provides the key mechanism to achieve photon-photon interactions and generate photonic entanglement [2], which is one of the two central requirements for photonic quantum information. I will discuss how this device can be used to achieve efficient optical readout of a quantum dot spin using a cavity QED system [3,4]. This approach utilizes the spin-dependent cavity reflectivity to determine the spin state, and is particularly important for qubits such as quantum dot spins that do not possess a good cycling transition for resonance fluorescence detection.

I will also describe our efforts to scale the quantum photonic circuits to larger number of devices. I will show a technique to achieve on-chip tuning of quantum dots in order to create indistinguishable emitters coupled to cavities and waveguides [5–7]. I will also describe new fabrication methods we are pursuing for hybrid integration of quantum dots with silicon photonics [6].

References:

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