Quantum dot single photon sources: Prospects for applications in linear optics quantum information processing

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abstract An optical source that produces single photon pulses on demand has potential applications in linear optics quantum computation, provided that stringent requirements on indistinguishability and collection efficiency of the generated photons are met. We show that these are conflicting requirements for anharmonic emitters that are incoherently pumped via reservoirs. As a model for a coherently pumped single photon source, we consider cavity-assisted spin-flip Raman transitions in a single charged quantum dot embedded in a microcavity. We demonstrate that using such a source, arbitrarily high collection efficiency and indistinguishability of the generated photons can be obtained simultaneously with increased cavity coupling. We analyze the role of errors that arise from distinguishability of the single photon pulses in linear optics quantum gates by relating the gate fidelity to the strength of the two-photon interference dip in photon cross-correlation measurements. We find that performing controlled phase operations with error $< 1\%$ requires nano-cavities with Purcell factors $F_P \geq 40$ in the absence of dephasing, without necessitating the strong coupling limit.