Toward scalable photonic entanglement using quantum dots coupled to inverse-designed nanophotonic cavities

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Abstract:

Photons entangled in complex graph topologies can enable a variety of applications including measurement-based quantum computing, all-photonic quantum repeaters, and heterogeneous quantum interconnects. Since photons do not interact with each other, the deterministic generation of scalable photonic entanglement requires an intermediate interface achievable by coupling a matter qubit to a photonic cavity with high cooperativity. In this work, we experimentally demonstrate the coupling of a quantum dot incorporated in a charge-stabilizing p-i-n-i-n diode to a periodic ("bullseye") cavity of rings with a cooperativity as high as 8. By using a guided mode expansion-based inverse-design algorithm, we show that a further X8 cooperativity enhancement is achievable by utilizing a novel cavity with a unique asymmetric ring geometry. The resulting cooperativity could lead to the deterministic entanglement of polarization-encoded photons with fidelity of > 95%, enabling the entanglement of photons in complex topologies. We present our future directions of generating and characterizing such photonic entanglement over a real quantum network in the North Carolina Research Triangle.