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Deterministic cavity quantum dot coupling and fabrication of an ultrabright source of entangled photon pairs

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Quantum dots present discreet quantum states and appear as artificial atoms in the solid state. Like an atom, a quantum dot can emit single photons, or polarization entangled photon pairs. Numerous potential applications rely on the control of the spontaneous emission of single quantum dots embedded in optical microcavities. For example, the regime of spontaneous emission enhancement (Purcell effect) allows efficient extraction of single photons emitted by the dot and to fabricate very bright sources for the field of quantum information. The strong coupling regime between the quantum dot and a cavity mode gives rise to mixed states of light and matter which can be used to entangle distant qubits. However, the actual coupling of a cavity mode and quantum dot is a significant challenge because the standard growth techniques of these emitters do not allow to control in a deterministic way their spatial and spectral characteristics.

The first result I will present is a technique which allows for the deterministic coupling of a single quantum dot to a cavity mode. This technique has been used to demonstrate the control of spontaneous emission in the weak coupling regime as well as in the strong coupling regime.

The second result pertains to the design, fabrication and characterization of an original microcavity which allows for the efficient extraction of polarization entangled photon pairs. By deterministically coupling a quantum dot to the modes of a photonic molecule, we have fabricated a source of polarization entangled photon pairs one order of magnitude brighter than any other existing source.

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