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Fachbereich Physik, Universität Stuttgart
Max-Planck-Institut für Festkörperforschung
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Cavity quantum electrodynamics with semiconductor quantum dots

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Abstract

Many quantum devices can be implemented by controlling the spontaneous emission of a semiconductor quantum dots in a microcavity: bright sources of quantum light, delayed photon entangler, optical quantum gates... In this talk, I will present recent results along this research line.
We use an in-situ lithography technique to deterministically control the coupling between a single quantum dot and a pillar microcavity. In the light-matter weak coupling regime, we obtain ultrabright sources of quantum light. We demonstrate sources of indistinguishable single photons with brightness as large as 79 % collected photon per pulse. With coupled pillar cavities, we fabricate the brightest sources of entangled photon pairs to date. The potential of these sources for quantum information processing is demonstrated by implementing an entangling controlled-NOT gate.
In the light matter strong coupling regime, we demonstrate giant optical non-linearities at the few photons scale. A near-unity input-coupling efficiency allows demonstrating a nonlinearity threshold for only 8 incident photons per pulse. Such a device can also be used to monitor in real time single quantum events: this is illustrated by monitoring the quantum jump of a single charge at the microsecond time scale.
Finally, we present a novel photonic structure and a technology allowing the electrical control of the devices, a critical step for the scalability of a quantum network based on semiconductor quantum dots.