Nano-scale Quantum Optics

Mini-colloquium 30

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Quantum optics and nanophotonics have both seen remarkable progress in the last decade. The former lead to an unprecedented understanding and control of the interaction of photons with matter, in particular atoms and cold gases, whereas the latter taught us how to design, to realize and to measure electromagnetic fields localized on a nano-scale, i.e., well below the respective vacuum wave length. In particular, enormous field-enhancement factors and long storage times for photons have been achieved using, e.g., nano-antennae.

The mini-colloquium highlights very recent developments at the interface of quantum optics and nanophotonics: *Active* manipulation of the electromagnetic energy flow in nanophotonic systems necessarily involves the (non-linear) interaction with matter. Ideally, an individual quantum emitter, e.g., a single dye molecule or a single quantum dot or defect center, suffices as ‘active non-linear matter’. Thus, research in active nanophotonic systems leads directly to issues typically studied in quantum optics, such as entanglement. As a consequence, progress in nano-scale quantum optics has direct bearings on other fields of quantum science and technology, such as quantum information & computation, quantum metrology and energy transfer in light-harvesting complexes.

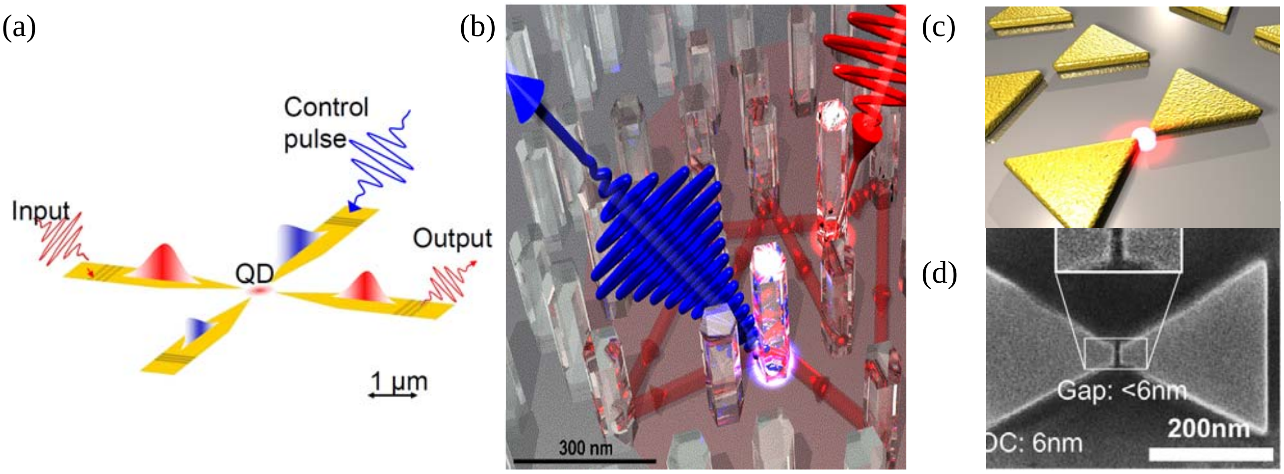

Figure 1: *(a) A possible application of nano-scale quantum optics is the switching of light by light as illustrated here for a quantum dot (QD) interacting with plasmons launched/detected via grids engraved into gold structures. (b) An important ingredient is a strong local non-linear response, presented here as second-harmonic generation of nano-needles, cf. [M. Mascheck et al., Nature Photon., 6, 293 (2012)]. (c,d) Artificial structures such as bow-tie antennae shaped by a Helium-ion milling can be used to strongly enhance the electromagnetic fields, cf. [H. Kollmann et al., Nano Lett., 14, 4778 (2014)].*

The mini-colloquium is open to all contributions related to the light-matter interaction on a nano-scale where the quantum nature of matter matters. Particular emphasis lies on the following themes:

- Generation, detection and storage of quantum states of light at the nanoscale
  (incl. single-photon detectors based, e.g., on superconducting nanostructures)
- Nonlinearities and ultrafast processes in nanostructured media
  (incl. metamaterials and electrons in optical near-fields)
- Quantum plasmonics
- Quantum coherence and quantum entanglement (incl. quantum memories)
- Cooperative effects, correlations, and many-body physics in strongly confined fields.

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