

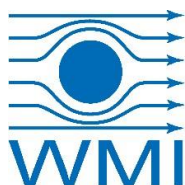
# MQC-meeting Fall 2017

Date: 13<sup>th</sup> of October, 2017

Location: Technische Universität München  
Zentrum für Nanotechnologie und Nanomaterialien (ZNN)  
Am Coulombwall 4a  
85748 Garching  
Groundfloor seminar room

## Time schedule:

- 1:30 pm Come-together with coffee & tea
- 2:00 pm Tatjana Wilk:  
Quantum nonlinear optics with a single atom strongly coupled to a cavity
- 2:30 pm Kai Müller:  
Achievements and surprises in quantum nanophotonics
- 3:00 pm Coffee & tea refreshment



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# Quantum nonlinear optics with a single atom strongly coupled to a cavity

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Single atom cavity quantum electrodynamics (CQED) in the strong coupling regime provides an ideal platform for the observation of nonlinear optical effects on the level of individual photons. A prominent example is single-photon blockade, where the absorption of one photon blocks the absorption of further photons, and which has been observed using a two-level atom [1]. Recently, the concept of photon blockade has been extended to multi-photons and a two-photon blockade, where two photons block the absorption of further photons, has been demonstrated [2]. More quantum nonlinear effects can be observed if, instead of a two-level atom, one with three or four levels is used. For example, a three-level atom showing cavity electromagnetically induced transparency [3] allows for an all optical control of the photon statistics of the transmitted light field [4] and for four-wave-mixing on the single-photon level. Furthermore, a four-level atom with strong coupling to two different cavity modes gives the possibility to implement controlled coupling between the two light fields in the cavity, resulting in, e.g., mutual switching [5] or conjunct tunneling of photons. First experimental results of quantum nonlinear effects with multi-level atoms will be presented.

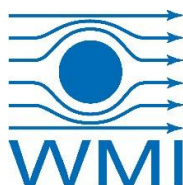
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[2] C. Hamsen, K. N. Tolazzi, T. Wilk, G. Rempe, Phys. Rev. Lett. 118, 133604 (2017).

[3] M. Mücke et al., Nature 465, 755 (2010).

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Optically active semiconductor nanostructures are promising candidates for building blocks in future photonic quantum technologies, including quantum information processing, quantum communication, quantum sensing and quantum metrology. Embedding a single quantum emitter or optically-active spin qubit, such as self-assembled InAs quantum dots (QDs) or color centers, into a tailored nanophotonic environment allows to control its interaction with the outside world or to efficiently couple it to integrated nanophotonic circuits.

First, I will review the potential of resonantly excited two-level systems for the on-demand generation of single photons. I will discuss fundamental limitations and demonstrate that resonantly driven two-level systems are surprisingly also capable of generating two-photon pulses [1]. By making use of nanophotonic resonators which strongly localize the optical field, it is possible to achieve a very strong light-matter interaction. Embedding self-assembled QDs into photonic crystal cavities with ultra-small mode volume allows to reach the strong coupling regime where the formation of hybridized light-matter states results in effective photon-photon interactions and enables the on-chip generation of nonclassical light [2-3]. Exploiting interference effects which are intrinsic to the photonic crystal platform [4] allows to significantly improve the signal to noise ratio and enables the on-chip generation of indistinguishable photons with state-of-the-art metrics [5].

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