FNM 2016 Program Committee cordially invites people to submit abstracts for The International Workshop on Functional and Nanostructured Materials to be held in Tbilisi, Georgia 6th -10th September 2016.

Quantum devices with exciton-polaritons

O. Kyriienko[1] and T. C. H. Liew[2]
[1]*The Niels Bohr Institute, University of Copenhagen, Blegdamsvej 17, DK-2100 Copenhagen, Denmark*
[2]*Division of Physics and Applied Physics, Nanyang Technological University 637371, Singapore*

The system of exciton-polaritons – hybrid light-matter quasiparticles – offers an interesting platform for studying quantum optical phenomena. Most prominently, due to integer spin of polaritons, it allows to observe an analog of Bose-Einstein condensation for open systems. Up to date various nonlinear effects were demonstrated, including propagation of solitons, vortices, polarization patterns etc. However, due to the small value of an effective optical nonlinearity and short-lived nature of polaritons the observed physics is mostly restricted to mean-field effects. Considering the huge interest in quantum systems, the natural question to ask is: Can we build truly quantum devices with polaritons, despite small nonlinearity?

In the talk we will discuss possible solutions to this problem. First, the unconventional photon blockade (UPB) will be reviewed. It was theoretically predicted to occur in the coupled micropillars [1], where strong intercavity hopping is combined with Kerr nonlinearity being much smaller than decay rate. Serving as the first example of antibunching behavior for weakly nonlinear polaritonic modes, it originates from the quantum interference effects [2], and can potentially lead to single photon emission. Then we discuss the tunable realization for UCP based on the dipolaritonic structure [Fig. 1a]. It relies on the coherent light-matter coupling between direct excitonic (DX) and photonic modes (C), as well as tunneling coupling between direct and indirect exciton (IX) modes in a double quantum well [3]. As the antibunching region of UPB is very sensitive to detuning and coupling parameters, this largely simplifies the experimental accessibility of the effects.

Next, we show that polaritonic systems with three-mode parametric interaction, which naturally occurs due to exciton-exciton interactions, can exhibit strong photon antibunching for suitably chosen pumping conditions. In particular, considering three mode system (e.g. based on different momentum modes or dipolaritons) we found that strong drive of the lower mode [see sketch in Fig. 1b] can effectively enhance the weak 3-mode parametric nonlinearity, turning it to effective strong 2-mode parametric nonlinearity [4]. This can allow for creation of on-demand single photon emitter. Finally, we discuss the χ_2 nonlinear optical systems and show that antibunching with weak nonlinearity is possible when non-stationary regimes are considered [5].

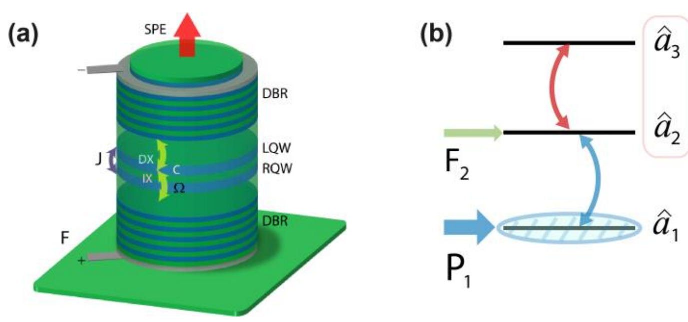

Figure 1. (a) Dipolaritonic system for an unconventional photon blockade observation. (b) Level scheme for three mode system with enhanced parametric interaction.

[1] T. C. H. Liew and V. Savona, Phys. Rev. Lett. 104, 183601 (2010)
[2] M. Bamba, A. Imamoğlu, I. Carusotto, and C. Ciuti, Phys. Rev. A 83, 021802(R) (2011)
[3] O. Kyriienko, I. A. Shelykh, and T. C. H. Liew, Phys. Rev. A 90, 033807 (2014)
[4] O. Kyriienko and T. C. H. Liew, Phys. Rev. A 90, 063805 (2014)
[5] O. Kyriienko and T. C. H. Liew, in preparation.

FNM 2016 aims to bring together physics, material science and engineering communities to present and discuss their work on fundamental physics and applications of functional nanoengineered materials.