Q 37: Quantum Optics (Miscellaneous) V

Time: Wednesday 14:00–16:00 Location: Q-H14

Invited Talk Q 37.1 Wed 14:00 Q-H14

Nanophotonic structure-mediated free-electron acceleration and manipulation in the classical and quantum regimes — •Roy Shiloh — Chair of Laser Physics, Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Staudtstrasse 1, 91058 Erlangen, Germany

Dielectric laser accelerators (DLA) are, fundamentally, photons interacting with free electrons, with a nanostructure mediating energy and momentum conservation. The potential of accelerating electrons to high energies using this method recently propelled DLA skywards; fabricated using standard (silicon) clean-room technology, their size advantage over conventional RF accelerator schemes promise table-top compact sources of high-energy electrons for tunable radiation generation and medical treatments. To reach this goal, we have already demonstrated electron beam transport on a nanophotonic chip, using the alternating phase focusing technique [1,2]. However, using the same setup we can also demonstrate quantum photon-electron interaction such as photon-induced electron-microscopy (PINEM). Observable as a spectral comb in the free electron wavepacket's energy spectrum, where the peaks are photon-energy separated, we measured this in a scanning electron microscope for the first time [3].

[1] Shiloh, Illmer, Chlouba, Yousefi, N. Schönenberger, Niedermayer, Mittelbach, and Hommelhoff, Nature 592, 498 (2021); [2] Shiloh, Chlouba, and Hommelhoff, J. Vac. Sci. Technol. B (2022); [3] Shiloh, Chlouba, and Hommelhoff, arxiv.org/abs/2110.00764 (2021)

Q 37.2 Wed 14:30 Q-H14

Fabrication of quantum light emitting diodes based on qiant shell quantum dots (GSQLED) — •Ekaterina Salikhova, Hendrik Schlicke, Jan-Steffen Niehaus, and Horst Weller — Fraunhofer CAN, Grindelallee 117, 20146 Hamburg, Germany

Colloidal semiconductor nanoparticles, so-called quantum dots (QDs), have several unique properties such as a narrow emission bandwidth and a high photoluminescence quantum yield. While QDs are used for photoluminescence-based color-conversion in TVs, there are still no commercial devices employing QLED (quantum light emitting diode) technology, where the QDs are driven by direct electronic charge injection. Quasi-type II quantum dots with a 'giant' shells (GSQDs) show a good stability and near-unity photoluminescence quantum yields. When using these particles as emitter layer in QLEDs, high electroluminescence intensities and an improved device stability are expected. However, QLEDs based on such particles are rarely described in the literature. The hindered charge carrier injection when using GSQDs in QLEDs, especially green-emitting particles, is still a current challenge.

In this talk, the production of 1x1 cm^2 GSQLEDs based on red (CdSe/CdS, 11 nm diameter) and green ($CdSe/Cd_{0.5}Zn_{0.5}S$, 14 nm diameter) emitting GSQDs with a stack sequence ITO/PEDOT:PSS/HTL/QDs/ZnO NP/Al is presented. The polymers PVC or TFB were used as hole transport layers (HTL). Through the use of the PVC, as well as a ligand exchange of the QDs' native ligands with aminoethanol during an optimized layer production as part of the developed layer-by-layer process, the QLED properties were significantly improved.

Q 37.3 Wed 14:45 Q-H14

Two-photon absorption spectroscopy in nonlinear interferometers — •Shahram Panahiyan[1,2], Carlos Sanchez Munoz[3], Maria V. Chekhova[4], and Frank Schlawin[1,2] — [1]Max Planck Institute for the Structure and Dynamics of Matter, Center for Free Electron Laser Science, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Departamento de Fisica Teorica de la Materia Condensada and Condensed Matter Physics Center (IFIMAC), Universidad Autonoma de Madrid, Madrid, Spain — [4]Max-Planck Institute for the Science of Light, Staudtstr. 2, 91058 Erlangen, Germany

We study two-photon absorption in a nonlinear SU(1,1)-interferometer [1], where a sample is placed between two optical parametric amplifiers which are used to squeeze and (re-)un-squeeze an input state of light. The advantages of nonlinear spectroscopy with two-photon absorption and squeezed light have to compete with photon losses that can happen due to imperfect detectors or scattering originating from interaction with the sample. To address this challenge, we study the influence of photons losses. We quantify their influence by investigating the sensitivity of measurement of the expectation value of operators [2]. Furthermore, we calculate quantum and classical Fisher information and use Cramer-Rao bounds to assess the achievable sensitivity.

[1] M. V. Chekhova and Z. Y. Ou, Adv. Opt. Photon. 8, 104 (2016).

[2] C. S. Munoz, G. Frascella, and F. Schlawin, Phys. Rev. Research 3, 033250 (2021).

Q 37.4 Wed 15:00 Q-H14

Higher-order photon statistics as a new tool to reveal hidden excited states in a plasmonic cavity — •Philipp Stegmann[1], Satyendra Nath Gupta[2], Gilad Haran[2], and Jianshu Cao[1] — [1]Department of Chemistry, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA — [2]Department of Chemical and Biological Physics, Weizmann Institute of Science, Rehovot 761001, Israel

Among the best known quantities obtainable from photon correlation measurements are the $g^{(m)}$ correlation functions. Here, we introduce a new procedure to evaluate these correlation functions based on higher-order factorial cumulants $C_{\mathrm{F},m}$ which integrate over the time dependence of the correlation functions, i.e., summarize the available information at different time spans [1]. In a systematic manner, the information content of higher-order correlation functions as well as the distribution of photon waiting times is taken into account. Our procedure greatly enhances the sensitivity for probing correlations and, moreover, is robust against a limited counting efficiency and time resolution in experiment. It can be applied even in case $g^{(m)}$ is not accessible at short time spans. We use the new evaluation scheme to analyze the photon emission of a plasmonic cavity coupled to a quantum dot. We derive criteria which must hold if the system can be described by a generic Jaynes-Cummings model. A violation of the criteria is explained by the presence of an additional excited quantum dot state.

[1] P. Stegmann, S. N. Gupta, G. Haran, and J. Cao, arXiv:2112.02201 (2021).

Q 37.5 Wed 15:15 Q-H14

First detection time statistics of many partially distinguishable particles — •Niklas Neubrand[1], Christoph Dittel[1,2], and Andreas Buchleitner[1,2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]EUCOR Centre for Quantum Science and Quantum Computing, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany

We show how partial distinguishability between many identical bosons or fermions impacts the first detection time statistics after the particles' coherent evolution on a finite lattice. To this end, we generalize the formalism of stroboscopic projective measurements from the single-particle to the many-particle domain, and present numerical results for two non-interacting particles evolving on a one-dimensional lattice. We observe clear signatures of the particles' indistinguishability in the total detection probability and the first detection time. For particular evolution times between consecutive measurements, we find a discontinuous behavior of these quantities, which can be understood through degeneracies of the corresponding many-particle unitary evolution operator.

Q 37.6 Wed 15:30 Q-H14

Atomic spin-controlled non-reciprocal Raman amplification of fibre-guided light — •Christian Liedl, Sebastian Pucher, Shuwei Jin, Arno Rauschenbeutel, and Philipp Schneeweiss — Department of Physics, Humboldt-Universität zu Berlin, 10099 Berlin, Germany

In a non-reciprocal optical amplifier, gain depends on whether the light propagates forwards or backwards through the device. Typically, one requires either the magneto-optical effect, a temporal modulation, or an optical nonlinearity to break reciprocity. By contrast, here, we demonstrate non-reciprocal amplification of fibre-guided light using Raman gain provided by spin-polarized atoms that are coupled to the nanofibre waist of a tapered fibre section. The non-reciprocal response originates from the propagation direction-dependent local polarization of the nanofibre-guided mode in conjunction with polarization-dependent atom-light coupling. We show that this novel mechanism can also be implemented without an external magnetic field and that it allows us to fully control the direction of amplification via the atomic spin state. Our results may simplify the construction of complex optical networks. Moreover, using other suitable quantum emitters, our scheme could be implemented in photonic integrated circuits and in circuit quantum electrodynamics.

Q 37.7 Wed 15:45 Q-H14

First detection times of tunneling events — •Robin L. Grether, Christoph Dittel, Andreas Buchleitner, and Felix Thiel — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Deutschland

We provide an in-depth analysis of the stroboscopically detected first arrival time of a quantum walker, with the dynamics generated by a Hamiltonian with a spectrum which may contain both, an absolutely continuous part and discrete eigenstates. Specifically, we address the first arrival time upon tunneling across an energy barrier, for a tight-binding quantum walker on a one-dimensional lattice.