Q 20: Quantum Optics III

Time: Monday 16:15–17:45 Location: K 0.016

Q 20.1 Mon 16:15 K 0.016

Coupling Single Mode Fibers to Single Quantum Emitters with Femtosecond 3D Printing Technology — •Ksenia Weber[1], Simon Thiele[2], Simon Ristok[1], Mario Hentschel[1], Alois Herkommer[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Institute for Applied Optics and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 9, 70569 Stuttgart, Germany

We propose a method to efficiently couple single photon quantum emitters to single optical mode fibers. Due to the undirected emission of single photon sources, such as quantum dots or defect centers in crystals, coupling into optical fibers which is essential for long range quantum communication is typically associated with high losses. To overcome this limitation, femtosecond two-photon lithography can be used to directly fabricate a combination of a microlens and an optical fiber chuck onto a quantum emitter. A single mode optical fiber is then integrated into the fiber holder. Due to the high precision of the femtosecond 3D printing process, the position of the fiber core can be adjusted with sub-micrometer accuracy to match the focal point of the microlens, as well as matching the high emission NA with the low input NA of the fiber. Light from the emitter which is focused by the microlens can therefore efficiently be coupled into the fiber.

Q 20.2 Mon 16:30 K 0.016

Emission properties and photon statistics of quantum-dot superluminescent diodes — •Franziska Friedrich and Reinhold Walser — Institut für Angewandte Physik, TU Darmstadt, Darmstadt, Germany

Broadband emitting quantum-dot superluminescent diodes (QD-SLDs) are indispensable semiconductor devices with many applications, e.g. in medical diagnostics (optical coherence tomography) or in fiber sensor technologies. Despite the widespread use, unusual behavior was observed regarding their photon statistics in a specific temperature regime [1]: the intensity correlation dropped down from 2 to 1.33 at $T = 190$K, which is relevant from a fundamental point of view.

Here, we present a microscopic theory of the amplified spontaneous emission (ASE) of a broadband QD-SLD with tilted end facets. This multimode quantum theory yields rate equations for the optical power densities, the level occupation of an inhomogeneous ensemble of quantum dots within the diode, as well as the emitted optical spectra. As a main result, we find the external power spectrum as a convolution of the intra-diode photon spectrum with a Lorentzian response, which agrees quantitatively with available experimental data [2]. In addition, we discuss photon statistics of QD-SLDs as a function of temperature.

[1] M. Blazek, W. Elsäßer, Phys. Rev. A **84**, 063840 (2011)
[2] F. Friedrich, R. Walser, to be published

Q 20.3 Mon 16:45 K 0.016

Temporal-mode selection with a quantum memory — •Benjamin Brecht[1], Sarah Thomas[1,2], Joseph Munns[1,2], Patrick Ledingham[1], Dylan Saunders[1], Joshua Nunn[3], and Ian Walmsley[1] — [1]Clarendon Laboratory, University of Oxford, Parks Road, Oxford, OX1 3PU, UK — [2]QOLS, Blackett Laboratory, Imperial College London, London SW7 2BW, UK — [3]Centre for Photonics and Photonic Materials, Department of Physics, University of Bath, North Road, Bath, BA2 7AY, UK

Photonic temporal modes (TMs) are appealing basis states for quantum information science. They are compatible with standard single-mode fibre, robust against linear dispersion, and span an infinite Hilbert space.

So far, TMs have been manipulated with dispersion-engineered frequency conversion processes, one example being the quantum pulse gate, where the selective conversion of one single TM to a different carrier frequency has been demonstrated.

Here we demonstrate TM selection with a quantum memory based on a two-photon Raman transition in warm atomic Caesium vapour. Contrary to frequency conversion, the memory does not necessarily change the carrier frequency of the selected mode, but rather separates TMs into different time bins. Also, the memory holds the potential to coherently re-shape the stored TM upon retrieval, making it a flexible tool for the manipulation of TMs at timescales that are not directly accessible with nonlinear optical processes.

Q 20.4 Mon 17:00 K 0.016

Non-classical states of light with smooth *P*-function — François Damanet[1,2], •Jonas Kübler[3], John Martin[2], and Daniel Braun[3] — [1]Department of Physics and SUPA, University of Strathclyde, Glasgow G4 0NG, United Kingdom — [2]Institut de Physique Nucléaire, Atomique et de Spectroscopie, CESAM, Université de Liège, Bâtiment B15, B - 4000 Liége, Belgium — [3]Institut für theoretische Physik, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

In quantum optics, the most fundamental criterion to judge the nonclassicality of a quantum state of light is in terms of the Glauber-Sudarshan P-function. If the P-function of a state is not a valid probability density, e.g. not a positive semi-definite function, the state is considered non-classical. However, most known non-classical states have a corresponding P-function which is highly irregular. This renders working with them difficult and direct experimental reconstruction impossible.

Here we introduce a new class of non-classical states with regular smooth P-functions by "puncturing" a classical P-function with narrow negative peaks. We analytically proof their existence and determine parameter ranges where the constructed states are physical, as well as the regimes yielding anti-bunching of light. To conclude, we present some possible experimental realizations of punctured states.

Q 20.5 Mon 17:15 K 0.016

Multimode photon-subtracted states of light — •Mattia Walschaers, Claude Fabre, Valentina Parigi, and Nicolas Treps — Laboratoire Kastler Brossel, UPMC-Sorbonne Université, ENS-PSL, Collège de France, CNRS, Paris, France

The deterministic generation of entanglement between large numbers of modes makes continuous variable quantum optics a promising platform for implementing quantum protocols. However, a genuine quantum advantage can only be achieved by introducing non-Gaussian features. Experimentally, this can be done through mode-tuneable photon subtraction.

In this contribution, we present a general theoretical framework to describe multimode photon subtracted states. With these theoretical tool we investigate a variety of non-Gaussian features in the state. In particular, we will focus on the newly introduced concept of inherent entanglement.

Q 20.6 Mon 17:30 K 0.016

Non-additivity of optical and Casimir-Polder potentials — •Sebastian Fuchs[1], Robert Bennett[1], Roman Krems[2], and Stefan Yoshi Buhmann[1] — [1]Albert-Ludwigs-Universität Freiburg, Freiburg, Germany — [2]University of British Columbia, Vancouver, Canada

An atom in presence of a surface experiences a usually attractive force caused by the fluctuations of the electromagnetic vacuum field, namely the Casimir-Polder (CP) force. On the other hand, an applied laser field causes an optical force on the atom. Using a perturbative approach, we report a new non-additive laser-induced CP potential stemming from the correlated coupling of the atom to both the laser field and the surface-assisted vacuum [1]. This term transforms the potential barrier of the two original potentials into a dip, that could serve as an atomic trap. Moreover, we outline an experimental setup to verify the occurence of this non-additive potential.

[1] Sebastian Fuchs, Robert Bennett, Roman V. Krems, and Stefan Yoshi Buhmann, arXiv:1711.10383 (2017)