Q 61: Quantum Optics with Photons II

Time: Friday 11:00–13:00 Location: E001

Invited Talk Q 61.1 Fri 11:00 E001

Quantum Imaging With Nonlinear Interferometers — •Markus Gräfe — Institute of Applied Physics, Technical University of Darmstadt, Hochschulstraße 6, 64289 Darmstadt, Germany — Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Albert-Einstein-Str. 7, 07745 Jena, Germany

Exploiting nonclassical state of light allows new imaging and sensing approaches. In particular, nonlinear interferometers enable quantum imaging with undetected light. Here, based on the effect of induced coherence, samples can be probed with light that is not detected at all. Instead, it quantum correlated partner light is is recorded and yields the information of the sample although it never interacted with it. The talk will outline the fundamental concept, recent progress and limits as well as perspectives for biomedical application.

Q 61.2 Fri 11:30 E001

Unfolding the Hong-Ou-Mandel interference between narrowband heralded states — •Kaisa Laiho[1], Thomas Dirmeier[2,3], Golnoush Shafiee[2,3], and Christoph Marquardt[2,3] — [1]German Aerospace Center (DLR), Institute of Quantum Technologies, Wilhelm-Runge-Str. 10, 89081 Ulm — [2]Max Planck Institute for the Science of Light, Staudtstr. 2, 91058 Erlangen — [3]Friedrich-Alexander-Universität Erlangen-Nürnberg, Department of Physics, Staudtstr. 7/B2, 91058 Erlangen

The Hong-Ou-Mandel (HOM) interference is pivotal for many quantum information and communication applications. In order to drive such quantum optics hardware often spectrally narrowband photonic emitters are required. Lately, parametric down-conversion (PDC) that produces photons in pairs have become a versatile source of twin beams in order to reliably generate heralded states for these purposes.

At high count rates the PDC process produces multiphoton contributions, which are often disregarded in experiments leading to falsified interpretations. Here, we derive the temporal characteristics of the HOM interference between two independent narrowband heralded states emitted via PDC. We consider the effect of the PDC multiphoton contributions and other experimental imperfections such as optical losses and an unbalanced beam splitter ratio. We find out that the multiphoton background can significantly diminish the visibility of the HOM interference dip. Further, the signal-idler cross-correlation turns into a useful figure of merit for the calibration of the photon flux. Our results are important for reaching a high visibility in an experiment.

Q 61.3 Fri 11:45 E001

Interferometric measurement of the quadrature coherence scale using two replicas of a quantum optical state — •Célia Griffet[1], Matthieu Arnhem[1,2], Stephan De Bièvre[3], and Nicolas J. Cerf[1,4] — [1]Centre for Quantum Information and Communication, Ecole polytechnique de Bruxelles, CP 165, Université libre de Bruxelles, 1050 Brussels, Belgium — [2]Department of Optics, Palacký University, 17. listopadu 1192/12, 77146 Olomouc, Czech Republic — [3]Univ. Lille, CNRS, UMR 8524, INRIA - Laboratoire Paul Painlevé, F-59000 Lille, France — [4]James C. Wyant College of Optical Sciences, University of Arizona, Tucson, AZ 85721, USA

Assessing whether a quantum state is nonclassical (i.e., incompatible with a mixture of coherent states) is a ubiquitous question in quantum optics, yet a nontrivial experimental task because many nonclassicality witnesses are nonlinear in the state. In particular, if we want to witness or measure the nonclassicality of a state by evaluating its quadrature coherence scale, this a priori requires full state tomography. Here, we provide an experimentally friendly procedure for directly accessing this quantity with a simple linear interferometer involving two replicas (independent and identical copies) of the state supplemented with photon number measurements. This finding, that we interpret as an extension of the Hong-Ou-Mandel effect, illustrates the wide applicability of the multicopy interferometric technique in order to circumvent state tomography in quantum optics.

Q 61.4 Fri 12:00 E001

Photon counting with click detection — •Fabian Schlue[1], Michael Stefszky[1], Vladyslav Dyachuk[1], Suchitra Krishnaswamy[2], Jan Sperling[2], Benjamin Brecht[1], and Christine Silberhorn[1] — [1]Institute for Photonic Quantum Systems (PhoQS), Integrated Quantum Optics (IQO), Paderborn University, Warburger Str. 100, 33098 Paderborn, Germany — [2]Theoretical Quantum Science, Paderborn University, Warburger Str. 100, 33098 Paderborn, Germany

Gaining knowledge about the photon-number distribution (PND) of an arbitrary input state is important for improving quantum technologies like quantum simulation and quantum key distribution. However, current photon number resolved (PNR) detectors (e.g. transition edge sensors) have very low response time and operate at millikelvin, compared to click detectors (e.g. superconducting nanowire single photon detectors), which are cheaper, faster and can operate at several kelvin. However, pseudo PNR can be added in a resource-efficient way to click detectors by using time multiplexed detection (TMD).

Here we present a TMD device, based on cascaded beam splitters, that provides a variable amount of pseudo PNR by changing the number of multiplexed time bins. This can be easily done by adding or removing extension modules with fiber connections. Depending on the experimental needs a trade off between lower measurement time or higher PNR can be made. We implement several detectors tailored to different experimental boundary conditions and investigate methods to retrieve the PND from the measured click statistics. In particular, how different approximations impact the reconstruction.

Q 61.5 Fri 12:15 E001

Studying nonclassical states of light generated by conditional measurements using click detectors — •Ananga Mohan Datta[1], Konrad Tschernig[2], Armando Pérez-Leija[2], and Kurt Busch[1,3] — [1]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik & Photonik, 12489 Berlin, Germany — [2]CREOL, The College of Optics and Photonics, University of Central Florida, Florida 32816, USA — [3]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany

Conditional measurements are a promising way to generate nonclassical states of light [1-2]. Here we use the statistics produced by click detectors [3] to study the quantum states of light generated via conditional measurements on a detuned waveguide coupler. We investigate the states when one input port is excited by a coherent state while a single-photon Fock state is fed into the other port. We then analyze the projected states when several detectors click in one of the output ports. We present the results of the binomial Q_B parameter [4] of the projected state as a measure for the degree of nonclassicality induced by conditional click detection.

[1] M. Dakna et al., *Phys. Rev. A* **55**, 3184 (1997).
[2] T. J. Bartley et al., *Phys. Rev. A* **86**, 043820 (2012).
[3] J. Sperling et al., *Phys. Rev. A* **85**, 023820 (2012).
[4] J. Sperling et al., *Phys. Rev. Lett.* **109**, 093601 (2012).

Q 61.6 Fri 12:30 E001

Interference and Entanglement Generation using Multiport Beam Splitters — •Shreya Kumar[1], Daniel Bhatti[1], Alex E Jones[2], and Stefanie Barz[1] — [1]Institute for Functional Matter and Quantum Technologies and IQST, University of Stuttgart, 70569 Stuttgart, Germany — [2]Quantum Engineering Technology Labs, H. H. Wills Physics Laboratory and Department of Electrical and Electronic Engineering, University of Bristol, Bristol BS8 1FD, UK

Multi-photon entanglement is an integral part of optical quantum technologies. The generation of multi-photon entangled states typically employs the fusion of entangled pairs of photons from several sources. However, each type of state requires a different configuration of the experimental setup and thus, switching between different states can be cumbersome. Here, we demonstrate a simple and versatile scheme to generate different types of genuine tripartite entangled states with one experimental setup. We send three independent photons through a triport beam splitter, known as a tritter, to generate tripartite W, G and GHZ states. Varying the internal input states, for example, polarization, of the photons and post-selecting output combinations with a certain photon number distribution results in the generation of entangled states. We obtain fidelities of 87.33%, 83.42% and 78.84% for the W, G and GHZ states, respectively, confirming successful generation of genuine tripartite entanglement. Our scheme may also be used as a quantum network server, providing resource states to multiple parties to execute quantum protocols.

Q 61.7 Fri 12:45 E001

Twisted N00N states and the quantum Gouy phase — Markus Hiekkamäki, Rafael F. Barros, Marco Ornigotti, and •Robert Fickler — Photonics Laboratory, Tampere University, Tampere, Finland

Shaping the transverse structure of quantum light has attracted a lot of attention in quantum photonics ranging from fundamental studies to quantum information applications. A powerful way to describe any spatial structure in the paraxial limit are orthogonal transverse spatial modes e.g. Laguerre-Gauss modes. Amongst many other things, such spatial structures serve as a versatile testbed for novel complex quantum states.

I will present advanced schemes of spatial-mode modulation and how they can be used to generate spatial-mode N00N states. The latter describes states where N photons are in an extremal superposition between two orthogonal spatial modes. Our results show that such states when realized with twisted photons, i.e. photons carrying OAM, they can be used to achieve super resolving angle measurements. In addition, we studied spatial mode N00N states in connection to a fundamental wave phenomenon, the so-called Gouy phase. It describes the anomalous phase delay of transversely confined waves when propagating through a focus. When probing it in quantum domain, i.e. when probing the quantum Gouy phase we find that it behaves different from classical light waves in terms of phase evolution as well as spatial mode order.