Q 12: Quanteninformation: Photonen und nichtklass. Licht

Time: Monday 14:00–15:45 Location: V7.02

Q 12.1 Mon 14:00 V7.02

Continuous-variable cluster state generation with cylindrical vector beams — •Stefan Berg-Johansen[1,2], Ioannes Rigas[1,2], Christian Gabriel[1,2], Andrea Aiello[1,2], Peter van Loock[1,2], Christoph Marquardt[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Germany

An intriguing property of cylindrically polarized beams of light is that their polarization and spatial degrees of freedom cannot be factorized even in a classical description. In the quantum treatment, this *structural inseparability* leads to spatial and polarization entanglement as well as entanglement between these two degrees of freedom when the beam is quadrature squeezed [1]. In this talk we present several schemes for the generation of four-node cluster states using such beams. A careful analysis of the properties of the resulting clusters reveals that cylindrically polarized modes are indeed well-suited for this purpose. We also report first steps towards the experimental realization of a cluster state. To this end, we generate amplitude squeezed radially and azimuthally polarized beams which form the backbone of our cluster state schemes. In a first implementation of one such scheme we have verified the predicted amplitude quantum correlations between the four resulting nodes.

[1] C. Gabriel et al., Phys. Rev. Lett. **106**, 060502 (2011)

Q 12.2 Mon 14:15 V7.02

Experimental Realization of Continuous Variable One-Way Steering — •Tobias Eberle[1,2], Vitus Händchen[1,2], Sebastian Steinlechner[1], Aiko Samblowski[1], and Roman Schnabel[1] — [1]Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) und Institut für Gravitationsphysik der Leibniz Universität Hannover, Callinstraße 38, 30167 Hannover, Germany — [2]Centre for Quantum Engineering and Space-Time Research - QUEST, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany

In 1935 E. Schrödinger introduced the term steering in order to describe Einstein-Podolsky-Rosen (EPR) entangled states for which a measurement on subsystem "A" may apparently allow for remote steering on the outcome of a measurement on subsystem "B" without the presence of a physical interaction between the subsystems. The EPR effect was already demonstrated by Ou et al. in 1992, however, in all experiments so far the steering effect was two-way, i.e. if Alice could steer Bob, Bob could also steer Alice. Here, we report for the first time on the realization of (continuous variable) one-way steering in which only Alice can steer Bob, but Bob cannot steer Alice, although they share the same entangled state.

Q 12.3 Mon 14:30 V7.02

Distinguishable and Indistinguishable Photons — •Falk Töppel[1,2], Andrea Aiello[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Institute for Optics, Information and Photonics, Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

Since the seminal work by Knill, Laflamme and Milburn [Nature 409, 46 (2001)], it is well known that linear optics combined with photon counting offers a promising route towards the realisation of an efficient scalable Quantum Computer. However, most of the proposed experimental schemes require indistinguishable photons. Since photons have many degrees of freedom (e. g. central frequency, spectral width, polarisation, etc.), the single photons produced in laboratories are very likely to become at least partially distinguishable, due to experimental imperfections.

We introduce in an operational manner a rate of distinguishability that quantifies the distinguishability of two photons with respect to a particular degree of freedom and to the particular state the photons are prepared in [arXiv:1108.5036]. Our measure relies on the Hong-Ou-Mandel experiment already widely used to test indistinguishability of photons experimentally. Our exemplary studies of Gaussian wave functions showed that in this instance the rate of distinguishability is universal for all degrees of freedom and that coupling between different degrees of freedoms critically affects the indistinguishability of photons.

Q 12.4 Mon 14:45 V7.02

Doubly resonant, narrowband photon pair source based on parametric down-conversion in a Ti:PPLN waveguide cavity — •Kai-Hong Luo, Harald Herrmann, Wolfgang Sohler, and Christine Silberhorn — Integrated Quantum Optics, Applied Physics, University of Paderborn, Warburger Straße 100, 33098 Paderborn, Germany

Narrowband photon pair sources have received considerable attention for future applications in quantum information, computing and communication. We present an integrated, resonantly enhanced, non-degenerated photon pair source based on spontaneous parametric down conversion (SPDC). The source consists of a Ti-indiffused periodically poled lithium niobate (PPLN) waveguide and two dielectric mirrors with high reflectivity deposited on the end-face of the waveguide. Theoretical studies were performed with the emphasis to design a narrowband source. Due to simultaneous resonance for both signal and idler photons, the parametric radiation is spectrally narrowed (in the ideal case down to single mode emission). We present details on the optimum design of such sources including a comparison between type I and type II-phase-matched processes. First experimental results towards the realization of such a source are discussed as well.

Q 12.5 Mon 15:00 V7.02

An Ultrafast Quantum Pulse Gate — •Benjamin Brecht, Andreas Eckstein, Andreas Christ, and Christine Silberhorn — Integrated Quantum Optics, Applied Physics, University of Paderborn, 33098 Paderborn, Germany

Ultrafast photonics quantum states feature a rich inherent structure, since they generally consist of a multitude of temporal, orthogonal pulses. Thus, they allow for novel, powerful information coding schemes, where those pulses play the role of information carrier. In earlier work, we have proposed a Quantum Pulse Gate (QPG) to single out and manipulate single pulses from such a manifold in a highly controlled and flexible way [1,2]. This is made possible by precise engineering of the gating process and by shaping the classical, bright pulses used to drive the process. Here, we give an update on the experimental progress of this work.

[1] A. Eckstein, B. Brecht, and C. Silberhorn, Optics Express 19, 13770-13778 (2011)
[2] B. Brecht, A. Eckstein, A. Christ, H. Suche, and C. Silberhorn, New J. Phys. 13, 065029 (2011)

Q 12.6 Mon 15:15 V7.02

Regularised tripartite continuous variable EPR states with CHSH violation — •Sol Jacobsen[1] and Peter Jarvis[2] — [1]Freiburg Institute for Advanced Studies, Freiburg Im Breisgau, Germany — [2]University of Tasmania, Hobart, Australia

Experiments making use of EPR correlations with continuous variables typically require infinite squeezing to maximize violation of the CHSH inequalities. The mathematical construction of such states is designed to have particular Wigner function behaviour, and to reach the appropriate EPR limit as the tunable squeezing parameter approaches infinity. In this talk we use a direct transcription of bipartite continuous variable EPR states with maximal violation for a finite value of a tunable parameter, and we provide a generalization to tripartite states. The results are compared with existing implementations from quantum optics, showing direct correspondence in the bipartite case, but with two regions of violation in the tripartite instance. The result is thus a rigorous and direct generalization of the EPR states, with a new structure suggesting alternative approaches to the experimental manipulation of such states are possible.

Q 12.7 Mon 15:30 V7.02

An efficient source of continuously tunable heralded single photons — •Michael Förtsch[1,2], Josef Fürst[1,2], Christoffer Wittmann[1,2], Dmitry Strekalov[1,3], Andrea Aiello[1,2], Christine Silberhorn[1], Christoph Marquardt[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institut für die Physik des Lichts — [2]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg — [3]Jet Propulsion Laboratory, California Institute of Technology, Pasadena

Single photon sources are a key-element in quantum information processing. To be compatible with different atomic transitions, ideally one requires a single photon source that is widely tunable, compact, stable and still efficient. We developed for the first time a narrow-band heralded single photon source, which is readily tunable in wavelength and bandwidth and efficient at once. This source is realized using a crystalline whispering gallery mode resonator with high quality factor operated far below the pump threshold of the comparable optical parametric oscillator (OPO). The variable evanescent resonator coupling in combination with the tunable phase matching conditions give us the freedom to adjust the bandwidth and the wavelength of the emitted photon pairs.