Q 56: Quanteninformation (Photonen und nichtklassisches Licht I)

Zeit: Freitag 11:00–13:00 Raum: 1A

Q 56.1 Fr 11:00 1A

Two-mode single-atom laser as a source of entangled light — •Martin Kiffner[1], M. Suhail Zubairy[1,2], Jörg Evers[1], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Institute for Quantum Studies and Department of Physics, Texas A&M University, College Station, Texas 77843, USA and Texas A&M University at Qatar, Education City, P. O. Box 23874, Doha, Qatar

Continuous variable entanglement is a key resource in many applications of quantum information and quantum computation theory. We theoretically investigate a single atom trapped inside a doubly resonant cavity as a source of entanglement in macroscopic light. The four-level gain medium atom interacts with two (nondegenerate) cavity modes on separate transitions, while the two other transitions are driven by control laser fields. Spontaneous decay of the atomic levels as well as cavity losses are included in our model. We employ an inequality [1] based on the correlation of the field operators as a sufficient criterion for the entanglement of the cavity field. It is shown that the considered two-mode single-atom laser gives rise to an entangled state of the cavity modes with a macroscopic number of photons over a wide range of control parameters and initial states of the cavity field [2].

[1] L.-M. Duan, G. Giedke, J. I. Cirac, and P. Zoller, Phys. Rev. Lett. **84**, 2722 (2000).

[2] M. Kiffner, M. S. Zubairy, J. Evers, and C. H. Keitel, Phys. Rev. A **75**, 033816 (2007).

Q 56.2 Fr 11:15 1A

Aperture imaging beyond the classical resolution limit by using incoherent photons — •Christoph Thiel[1], Thierry Bastin[2], Joachim von Zanthier[1], and Girish S. Agarwal[3] — [1]Institut für Optik, Information und Photonik, Max- Planck-Forschungsgruppe, Universität Erlangen-Nürnberg, Germany — [2]Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège, Belgium — [3]Department of Physics, Oklahoma State University, Stillwater, OK, USA

We propose a technique to image arbitrary objects, e.g. an aperture, with sub-wavelength resolution using incoherent light. The method employs two photons spontaneously emitted by two atoms acting as the light source of our setup. The photons irradiate an aperture and are subsequently detected by two detectors in the far field region. We demonstrate that for certain detector positions $\mathbf{r}_1$ and $\mathbf{r}_2$ the second order correlation function $G^{(2)}(\mathbf{r}_1, \mathbf{r}_2)$ offers full information of the aperture, even if of size $\lambda/2$. The result corresponds thus to a 2-fold increase in spatial resolution in comparison with the classical intensity pattern. Unlike in the classical case, the two photons can take different but indistinguishable quantum paths. Our method makes explicit use of the second order interferences between these paths and it is thereby able to obtain a resolution beyond the classical limit.

Q 56.3 Fr 11:30 1A

Realization of two indistinguishable Fourier-limited solid state single-photon sources — Robert Lettow[1], Ville Ahtee[2], Alois Renn[1], Erkki Ikonen[2], •Stephan Götzinger[1], and Vahid Sandoghdar[1] — [1]Laboratory of Physical Chemistry, ETH Zürich, CH-8093 Zürich, Switzerland — [2]Metrology Research Institute, Helsinki University of Technology , FI-02015 TKK, Finland

Single-photon sources comprise an important building block in many quantum information processing schemes. The feasibility of such sources has been demonstrated in various systems. Single photons have also already been successfully used for applications in quantum cryptography. However, complex schemes of quantum information processing require a large number of indistinguishable photons from independent sources.

We demonstrate indistinguishable Fourier-limited single-photon sources based on two single molecules [1]. High resolution laser spectroscopy and optical microscopy were combined to identify individual molecules in two independent microscopes. The Stark effect was exploited to shift the transition frequency of a given molecule and thus obtain single-photon sources with perfect spectral overlap. The solid-state aspect of our system offers many advantages including well defined polarization and a nearly indefinite measurement time using the same single emitters. Our experimental arrangement sets the ground for the realization of quantum interference experiments with two independent solid state single-photon sources.

[1] R. Lettow et al., Optics Express 15, 15842 (2007).

Q 56.4 Fr 11:45 1A

Gequetschtes Licht bei 1550 nm — •Sebastian Steinlechner, Jessica Dück, Stefan Gossler, Moritz Mehmet, Karsten Danzmann und Roman Schnabel — Max-Planck-Institut für Gravitationsphysik (AEI) und Institut für Gravitationsphysik, Leibniz Universität Hannover

Die Empfindlichkeit von Gravitationswellendetektoren der zweiten Generation wird durch thermisches Rauschen sowie durch Quantenrauschen des Lichtfeldes limitiert sein.

Empfindlichkeiten unter dem Quantenrauschen können durch den Einsatz von nichtklassischem (gequetschtem) Licht erreicht werden. Entsprechende Experimente mit gequetschtem Licht wurden erfolgreich durchgeführt und die Umsetzung für den Detektor GEO 600 befindet sich derzeit im Aufbau. Vielversprechender Ansatz zur Verminderung des thermischen Rauschens ist die Kühlung der Interferometer-Testmassen. Die bisher verwendeten Fused-Silica-Substrate besitzen hohe optische Qualität, zeigen jedoch bei niedrigen Temperaturen inakzeptable mechanische Verluste. Aussichtsreichster Kandidat für kryogene Testmassen ist Silizium, das jedoch bei der bisher verwendeten Laserwellenlänge von 1064 nm nicht transparent ist. Dagegen wird im Bereich von 1550 nm ein extrem niedriger Absorptionskoeffizient erwartet. Vorhandene Techniken für die Erzeugung von gequetschtem Licht werden auf 1550 nm übertragen, um zusammen mit Silizum-Testmassen die Grundlage für kommende, kryogene Detektoren zu bilden.

Wir stellen das Konzept und erste Ergebnisse einer Quetschlichtquelle bei 1550 nm vor.

Q 56.5 Fr 12:00 1A

An entangled-pair photon source for single-photon single-atom interaction — •Albrecht Haase, Nicolas Piro, Morgan Mitchell, and Jürgen Eschner — ICFO - Institut de Ciencies Fotoniques, 08660 Castelldefels (Barcelona), Spain

We present a narrow-bandwidth source of entangled photon pairs, which will allow us to address the transitions D3/2-P3/2 and D5/2-P3/2 in single 40Ca+ ions at 850 and 854 nm wavelength, respectively. The source has been designed to emit photons with a high spectral power density into the absorption window of the Calcium ions, which has a bandwidth of ~20 MHz. We describe the setup and characterize the performance of the source. Its applications will be experiments towards the probabilistic entanglement of distantly trapped single atoms. As a first step we employ the temporal correlation of the photon pairs to study the triggered excitation of an ion. Additionally the source provides entanglement in the polarization degree of freedom of the photons, which we have observe with over 91% visibility. We propose schemes to transfer the entanglement to the internal states of the trapped ions.

Q 56.6 Fr 12:15 1A

Observation of polarization squeezing in PPKTP waveguides — Malte Avenhaus[1], Maria Chekhova[2], •Leonid Krivitsky[1], Gerd Leuchs[1], and Christine Silberhorn[1] — [1]University of Erlangen-Nurnberg, Institute for Optics Information and Photonics — [2]M.V. Lomonosov Moscow State University

We study the experimental configuration of generation of polarization-squeezed states based on interference effect involving two nonlinear crystals. Our experiment represents a generalization of the well developed method of polarization-entangled state generation at the single photon level for the case of high parametric gain. The high gain regime is achieved by using an efficient source based on periodically poled KTP crystal waveguide pumped by a femtosecond laser. We show that the effect of polarization entanglement observed at a single photon level transforms in observation of polarization squeezing at a high gain regime.

Q 56.7 Fr 12:30 1A

Spatial modes and spectral entanglement in PDC — •Andreas Eckstein, Andreas Christ, Thomas Lauckner, and Christine Siblerhorn — University Erlangen-Nuremberg, Max-Planck Research

Group IOIP, Integrated Quantum Optics Group

We present the observation of a picosecond beating in a Hong-Ou-Mandel (HOM) type experiment. To study the HOM interference, we implemented a PDC process in a PPKTP waveguide, pumped by a picosecond laser at 404nm. Both signal and idler photons are fed into a balanced beamsplitter, and coincident photons from its output ports are detected. Instead of a gaussian HOM dip, we observe a gaussian-enveloped beating signature of coincidence events. Unlike the experiment in [1], our setup exhibits anti-bunching without spectrally restricting the detector response function.

We attribute this behavior the fact that our waveguide is multimoded in the pump regime. The superposition of spatial pump modes inside the waveguide is translated into a frequency correlation between signal and idler photons via modal dispersion. Owing to the broadband nature of the PDC-generated photons, we propose a definition for broadband mode entanglement and explore the feasibility of this anti-bunching effect as an entanglement witness.

[1] Hong, C. K., Ou, Z. Y., and Mandel, L. *Phys. Rev. Lett.* **59**(18), 2044*2046 (1987).

Q 56.8 Fr 12:45 1A

Photon pair generation in photonic crystal fibres — •Christoph Söller, Leyun Zang, Myeong Soo Kang, Philip Russell, and Christine Silberhorn — Max Planck Research Group IOIP, Günther-Scharowsky-Str. 1 / Bau 24, 91058 Erlangen

Spontaneous four-wave mixing in photonic crystal fibres (PCF) is a new promising approach to generate photon pairs for quantum information applications. Tailoring of the PCF microstructure allows the realisation of a wide variety of dispersion profiles and offers the prospect to control the spectral properties of the generated photons to a high degree. We are working on the implementation of a PCF source optimized for quantum networks. By manufacturing appropriate fibres, we aim to realise a source that provides heralded single photon states without narrow bandpass filtering. The heralding signal photon is emitted at a wavelength in the Si-APD range to ensure efficient detection. The idler photon of the pair is generated at 1.55μm and can thus be transmitted with very low losses by telecom fibres. Spectral decorrelation of the pair photons ensures the indistinguishability of idler photons from different sources and permits quantum interference without narrow bandpass filters.