Q 51: Quantum information: Photons and nonclassical light III

Time: Thursday 16:30–18:30 Location: UDL HS3038

Q 51.1 Thu 16:30 UDL HS3038

A monolithic polarization-independent frequency filter system for experiments in quantum optics — •Christoph Berkemeier, Andreas Ahlrichs, Benjamin Sprenger, and Oliver Benson — AG Nano-Optik, Institut für Physik, HU Berlin

We present a filter system based on cascaded monolithic Fabry-Pérot cavities[1,2]. The resonance frequency can be selected by temperature-tuning of the cavity material. This results in excellent rms resonance frequency deviation of just 4.5 MHz in 20 h. By combining two filters we achieved an effective free spectral range of several hundred GHz with a linewidth of 200 MHz. The individual filters are coupled to single-mode fibers each with a transmission of up to 85 % on resonance. Undesired birefringence, which often plagues monolithic cavities, was avoided by stress-free mounting.
The system was used to filter photons of a cavity-enhanced parametric down-conversion source. It was applied as a high resolution monochromator to measure the comb-like spectrum of the generated photon pairs. The indistinguishability of the photons was verified with the Hong-Ou-Mandel effect, which was measured with a visibility of 96 %. We report experiments towards creating indistinguishable photons from dissimilar sources (e.g. quantum dots and the photon pair source).

[1] Ahlrichs et al., Appl. Phys. Lett. 103, 241110 (2013)
[2] Palittapongarnpim et al., Rev. Sci. Instrum. 83, 066101 (2012)

Q 51.2 Thu 16:45 UDL HS3038

Characterisation of Spatial Correlations of PDC in Waveguide Arrays — •Regina Kruse, Fabian Katzschmann, Benjamin Brecht, Linda Sansoni, and Christine Silberhorn — Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn

Integrated optics form a compact, stable and flexible platform for the development of quantum information devices. Especially arrays of weakly coupled waveguides became the focus of attention in the context of continuous-time quantum walks [1,2]. Integrating the photon-pair generation into the quantum walk geometry allows for a flexible generation of highly complex photonic quantum states [2,3].

Here, we investigate the spatially resolved second-order correlation function of a parametric down-conversion process, integrated into a coupled waveguide array. We develop a theoretical framework to analyse spatial correlations and present a fully integrated, loss-independent correlation measurement scheme.

[1] A. Peruzzo et al., Science 329 (1500), 2010
[2] A. Solntsev et al., PRL 108 (023601), 2012
[3] R. Kruse et al., NJP 15 (083046), 2013

Q 51.3 Thu 17:00 UDL HS3038

Experimental Generation of Amplitude Squeezed Vectorial Modes — •Vanessa Chille[1,2], Stefan Berg-Johansen[1,2], Marion Semmler[1,2], Christoph Marquardt[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Günther-Scharowsky-Straße 1/Building 24, Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Staudtstraße 7/B2, Erlangen, Germany

We present a proof-of-principle experiment in which we generate amplitude-squeezed Laguerre-Gauss modes with complex polarization structures. They possess radial indices up to 1 and azimuthal indices up to 3, and a quantum noise reduction of up to -0.9(1) dB. In our setup, we use a non-interferometric approach in which the light is modulated twice with the help of a spatial light modulator used in a double reflection technique. The experiment is designed to minimize loss, which would degrade the squeezed state. The quantum noise reduction is achieved by exploiting the optical Kerr effect in an optical fiber in a Sagnac loop. The spatial light modulator allows for switching flexibly between different higher-order modes. The polarization structure is analysed in detail by studying the spatial distribution of the Stokes parameters. We discuss imperfections in polarization and intensity patterns and explain their origin.

Q 51.4 Thu 17:15 UDL HS3038

Distribution of squeezed states of light through optical fibers — •Jan Gniesmer, Vitus Händchen, Tobias Eberle, and Roman Schnabel — Albert-Einstein-Institut, Institut für Gravitationsphysik, Leibniz Universität Hannover

Entanglement-based continuous-variable (CV) quantum key distribution networks rely on the efficient distribution and detection of quadrature entangled states. The distribution itself can be realized by coupling light at 1550nm to standard optical fibers. This talk presents our recent results on table-top squeezed-light distribution over a 1km fiber. The experiment has been realized with a stand-alone receiver involving a balanced homodyne detector and a polarisation control scheme. The talk also gives an outlook to the applications of these results to CV quantum key distribution.

Q 51.5 Thu 17:30 UDL HS3038

The electronic structure of the silicon vacancy color center in diamond — •Jonas Nils Becker[1], Christian Hepp[1], Tina Müller[2], Victor Waselowski[3], Benjamin Pingault[2], Adam Gali[4,5], Jeronimo Rios Maze[3], Mete Atatüre[2], and Christoph Becher[1] — [1]Universität des Saarlandes, Saarbrücken, Germany — [2]Cavendish Laboratory, University of Cambridge, United Kingdom — [3]Pontificia Universidad Catolica de Chile, Santiago, Chile — [4]Budapest University of Technology and Economics, Budapest, Hungary — [5]Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Budapest, Hungary

The negatively charged silicon vacancy (SiV) color center in diamond is a promising candidate for a solid state single photon source. However, the electronic structure of the defect has not been investigated in detail so far. We here examine the fluorescence spectra of single SiV centers fabricated by ion implantation in single crystalline bulk diamond as well as of an SiV ensemble in a low strain, CVD-grown, reference sample at cryogenic temperatures and in varying external magnetic fields. Additionally, we investigate the polarization properties of the four fine structure components in the spectra of single SiV centers at zero field. A comparison to simulated spectra and polarizations obtained from a group theoretical model shows a good agreement with the experimental data. Furthermore, we show that this model is capable to explain recently discovered spin selective excitation of the SiV center. The model can be extended to reproduce differences in spectra and polarizations for SiV centers in strained crystal environments such as nanodiamonds.

Q 51.6 Thu 17:45 UDL HS3038

Mapping Spin Coherence of a Single Rare-Earth Ion in a Crystal onto a Single Photon Polarization State — •Kangwei Xia[1], Roman Kolesov[1], Rolf Reuter[1], Mohammad Jamali[1], Rainer Stöhr[1], Tugrul Inal[1], Petr Siyushev[1], Nadezhda Kukharchyk[2], Andreas Wieck[2], and Jörg Wrachtrup[1] — [1]3. Physikalisches Institut, Universität Stuttgart, Stuttgart, Deutschland — [2]Angewandte Festkörperphysik, Ruhr-Universität Bochum, Bochum, Deutschland

Here, we report on optical detection of a single photostable Ce3+ ion in an yttrium aluminum garnet (YAG) crystal and on its magneto-optical properties at room temperature. The spin quantum state of the emitting level of a single cerium ion in YAG can be initialized by a circularly polarized laser pulse. Coherent precession of the electron spin is read out by observing temporal behavior of circularly polarized fluorescence of the ion. This implies direct mapping of the spin quantum state of Ce3+ ion onto the polarization state of the emitted photon and represents the quantum interface between a single spin and a single photon. Furthermore the nanoscalar engineering of RE ions in crystalline hosts has been demonstrated. Using ion implantation, cerium ions can be implanted in a YAG crystal with nanoscalar precision.

Q 51.7 Thu 18:00 UDL HS3038

Triplet-Triplet-Relaxation Induced Enhancement of Saturation Emission of a Molecular Single Photon Emitter — •B. Stender[1], S. F. Völker[2], C. Lambert[2], and J. Pflaum[1,3] — [1]Experimental Physics VI, University of Würzburg, D-97074 Würzburg — [2]Institute of Organic Chemistry, University of Würzburg, D-97074 Würzburg — [3]ZAE Bayern, D-97074 Würzburg

Previous reports on molecular based single photon sources utilized non-interacting host-guest systems. In this work we present an universal approach to enhance the emission of a single squaraine dye molecule by its interaction with a polymeric matrix. Analyzing the squaraine photon statistics in two different matrices we found an independent depopulation rate of the first excited singlet state of $k_{21} = (2.3 \pm 0.1) \cdot 10^8 s^{-1}$ corresponding to a lifetime of $t_{21} = 4.3$ ns. On longer time scales however, matrix assisted relaxation process between higher triplet states of the molecular quantum emitter and the first excited triplet state of the matrix provide an additional decay channel. By this relaxation the depopulation rate of the first excited triplet state of the molecule decreases by more than one order of magnitude to $k_{31} = (0.2 \pm 0.8) \cdot 10^4 s^{-1}$ as compared to the intrinsic rate of $k_{31} = (5.0 \pm 1.0) \cdot 10^4 s^{-1}$ for a non-interacting system. As a result the fluorescence intensity at saturation is enhanced by about 15% from $1.5 \cdot 10^6$ cts/s to $1.7 \cdot 10^6$ cts/s. Therefore, this mechanism provides access to spectroscopic features of single photon emitters that could not be investigated so far due to their low emission intensity in standard non-interacting matrices.

Q 51.8 Thu 18:15 UDL HS3038

A quantum pulse gate for high-dimensional time-frequency quantum information coding — •Benjamin Brecht[1], Vahid Ansari[1], Georg Harder[1], Andreas Eckstein[1,2] und Christine Silberhorn[1] — [1]Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn — [2]Laboratoire Matériaux et Phénomènes Quantiques, Université Paris Diderot - Paris 7, Bâtiment Condorcet, Case courrier 7021, 75205 Paris, France

We implement a quantum pulse gate (QPG), which facilitates a controlled single-mode operation on the intricate time-frequency (TF) structure of ultrafast quantum pulses. This structure lends itself to high-dimensional information coding, similar to comparable approaches based on spatial field distributions. In contrast to those however, TF modes are compatible with single-mode fiber networks.

We experimentally retrieve the TF modes of the QPG and demonstrate genuine single-mode operation on input pulses attenuated to the single-photon level, as well as a high degree control over the QPG TF structure. The QPG constitutes an important building block for high-dimensional TF quantum communication and information applications.